A Report on Field Research in Soils

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Soil Series 118

A Report on Field Research in Soil Science

The 1988 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, Soil Scientists at the branch stations of Crookston, Lamberton, Morris, and Waseca; Becker and Staples experimental sites; and Soil and Crop area agents. Associated personnel from the Soil Conservation Service, and the Soil and Water Research group of the ARS-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 farmers, county agents, 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 1987 experiments and should be regarded on this basis. Since most data are from only 1987 studies, conclusions may not be conclusive and thus are not for further publication without the written consent of the individual researchers involved.

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SPRING 1988 SOIL MOISTURE SITUATION

Prepared by G.J. Spoden, Ass't. State Climatologist, Dept. Natural Resources,
and D.L. Ruschy, R.R. Swerman and D.G. Baker, Soil Science Department, Univ. of MN

The generally very good crop season of 1987 was not the result of the 1987 precipitation, which was below average in many areas, see Fig. 1, but rather can be attributed to the soil moisture reserves remaining from the wet autumn of 1986. Due to the good crops and low 1987 rainfall amounts, the current soil moisture reserves have been seriously depleted in many parts of the state. Thus the 1988 growing season precipitation will assume a greater than usual importance.

The soil moisture situation for May 1, 1988, will almost surely show a drastic change from that of the recent past. For example, during the last 8-10 years Minnesota has been unusually wet, with many areas receiving 120 - 130% of their normal annual precipitation each year. The precipitation patterns shown in Fig. 2 are for the departure of the 1982-1986 annual total precipitation from the 1951-1980 normal. The wet period that Fig. 2 illustrates came to an abrupt end in late September, 1986, over many parts of the state.

Of consequence to the recharge of lakes and streams is what happens with respect to the hydrologic year precipitation, the 12-month period October 1986 - September 1987, which is shown in Fig. 3 as the departure from normal. The precipitation in the southern two-thirds of the state was at least 4-inches below normal, while in a large area in central and east-central Minnesota the precipitation was at least 8-inches below normal. The only large area having above normal precipitation occurred in the middle of the northern part of the state. Within this area are a few small areas that received about 4-inches above normal precipitation. The remainder of this area is only just above normal.

The soil moisture outlook for most of the northern part of the state can be characterized as normal to somewhat above average. No problems are foreseen as long as 1988 precipitation is near normal.

Due to low soil moisture reserves the southern one-half of the state, with the general exception of the extreme southeast, will be highly dependent upon spring and summer rains. Their amount and timing will be critical. The estimated amount of water that will be added to the soils between November 1, 1987 and April 30, 1988 is shown in Fig. 4. Except for the far north, the smallest addition to soil moisture reserves, about 2.0 - 2.5 in. will be added in the west central and Red River Valley regions. It is in west central Minnesota where the fall 1987 soil moisture reserves were generally the lowest.

The amounts shown in Fig. 4 include the following sources of water: November rains; 15% of the measured water content of December - February snows; 15% of the normal March precipitation (this article is prepared in February 1988 so estimates are required); and the April precipitation that is expected with a 50% probability.

Only 15% of the over-winter precipitation enters the soil on the average, as most of it runs off before the soils have thawed in early spring. The April precipitation amount was estimated to be the median or 50% value of the historical total. There is one chance in three that the April amount would be about 0.75 in., 1.50 in., and 2.5 in. higher in the northwest, the center, and the southern part of the state, respectively. There is also one chance in three that the April rains will be lower by the same amounts.

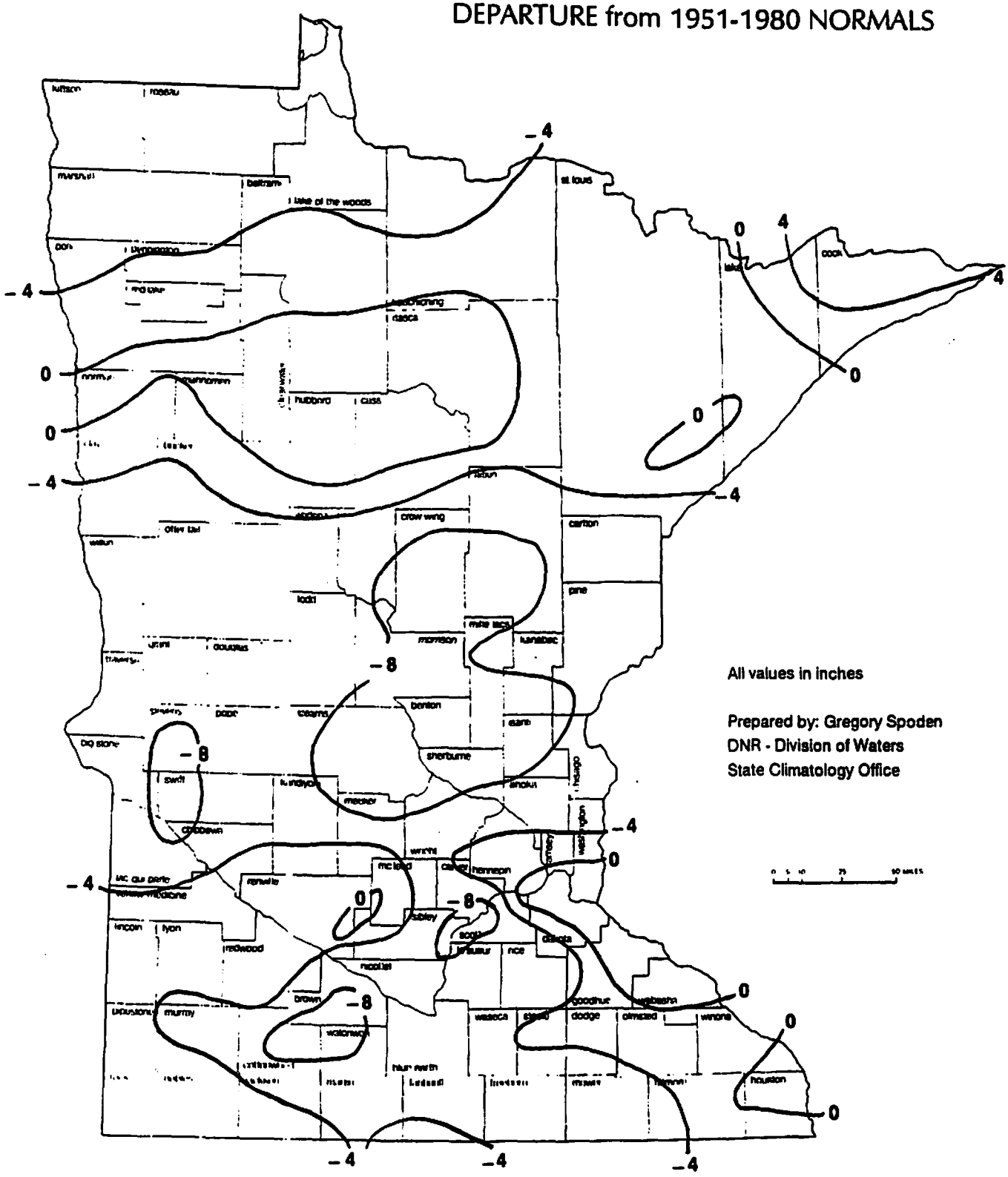
The November 1987 rains that occurred were generally sufficient to wet only the top 6-12 inches of the soil before the soils froze. As a result the subsoils in many areas remain extremely low in moisture. And until the soils are completely thawed in the spring, the rains that occur will largely run off.

As most people realize, weather forecasts beyond a few days are most unreliable. Thus, no statement can be made with any confidence about the 1988 season. It can be stated, however, that the wet period of about 8-10 years that we have experienced was most unusual and cannot be expected to continue. Thus, as a result of the unusually low soil moisture reserves in some areas of the state, particularly the west central and parts of the south-central and southwest, the spring and summer rains will be more critical than usual.

FIGURE 1

ANNUAL PRECIPITATION FOR 1987

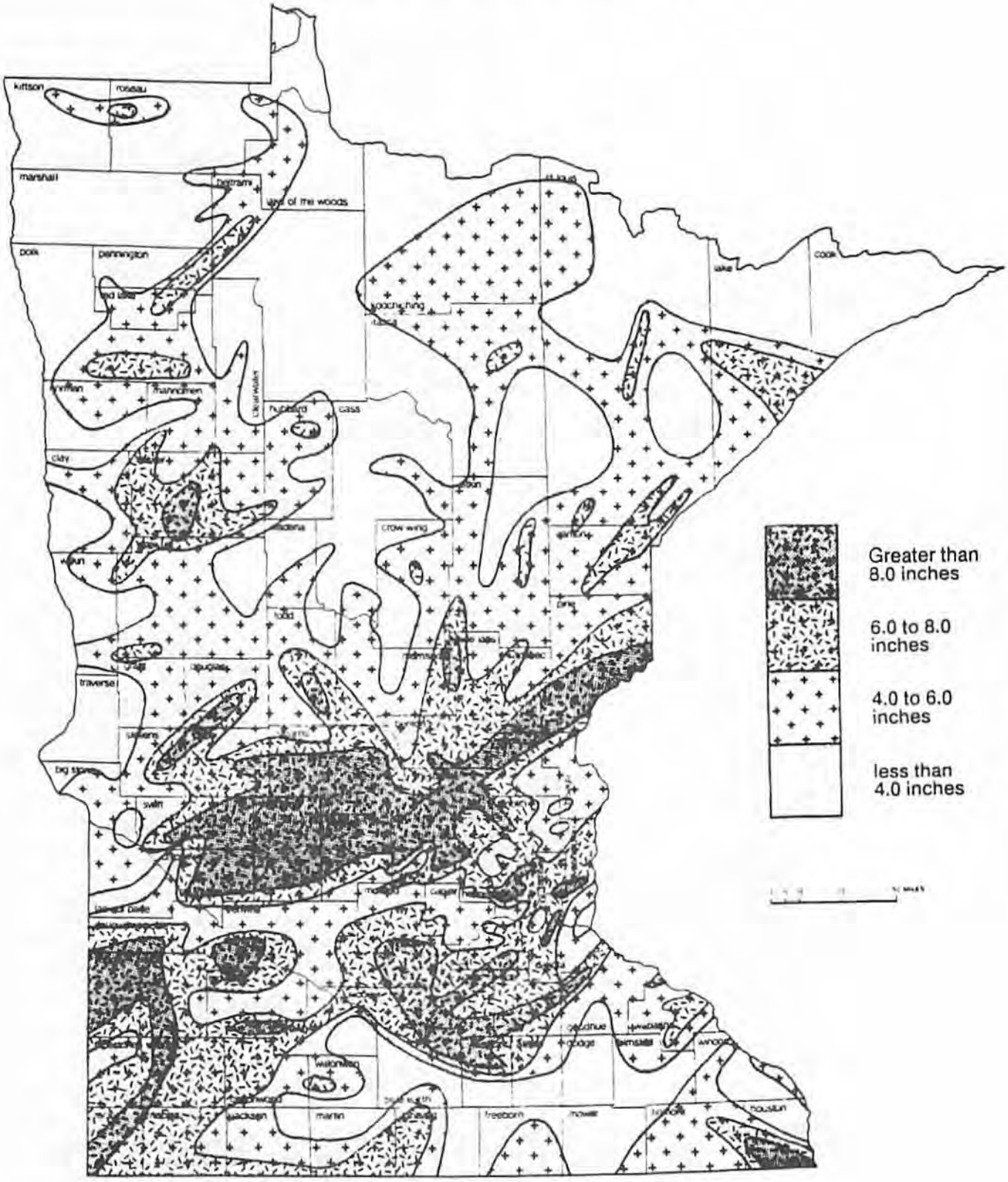
DEPARTURE from 1951-1980 NORMALS



Data: National Weather Service, Soil & Water Conservation Service, DNR Forestry, Metropolitan Mosquito Control, Backyard Raingage Network, Future Farmers of America, KSTP-TV, Deep Portage Conservation Reserve, Minnesota Association of Watersheds

FIGURE 2

AVERAGE ANNUAL DEPARTURE FROM NORMAL PRECIPITATION FOR 1982 - 1986 (5 YEARS)

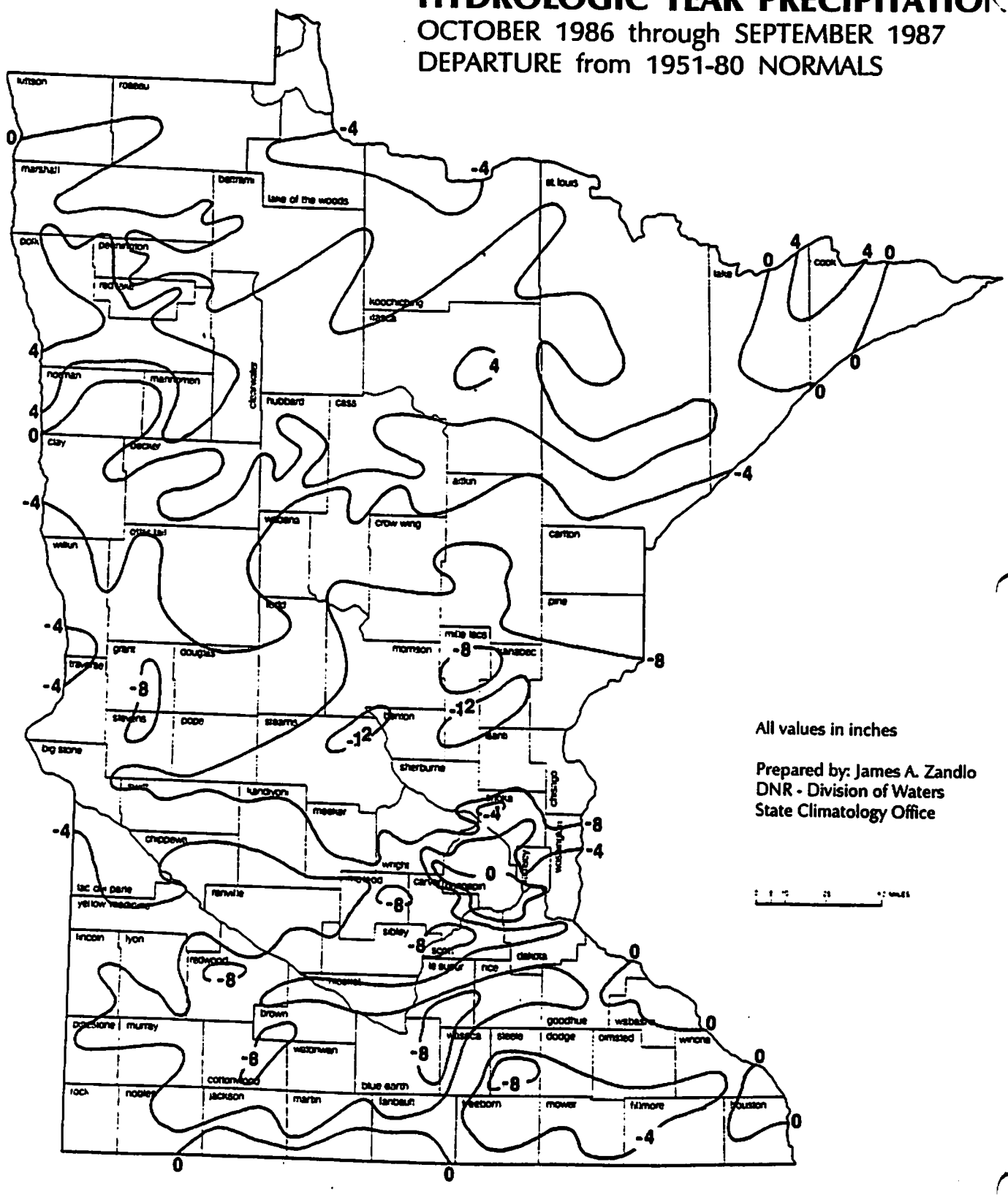


Prepared by: DNR, Division of Waters, State Climatology Office

FIGURE 3

HYDROLOGIC YEAR PRECIPITATION

OCTOBER 1986 through SEPTEMBER 1987
DEPARTURE from 1951-80 NORMALS

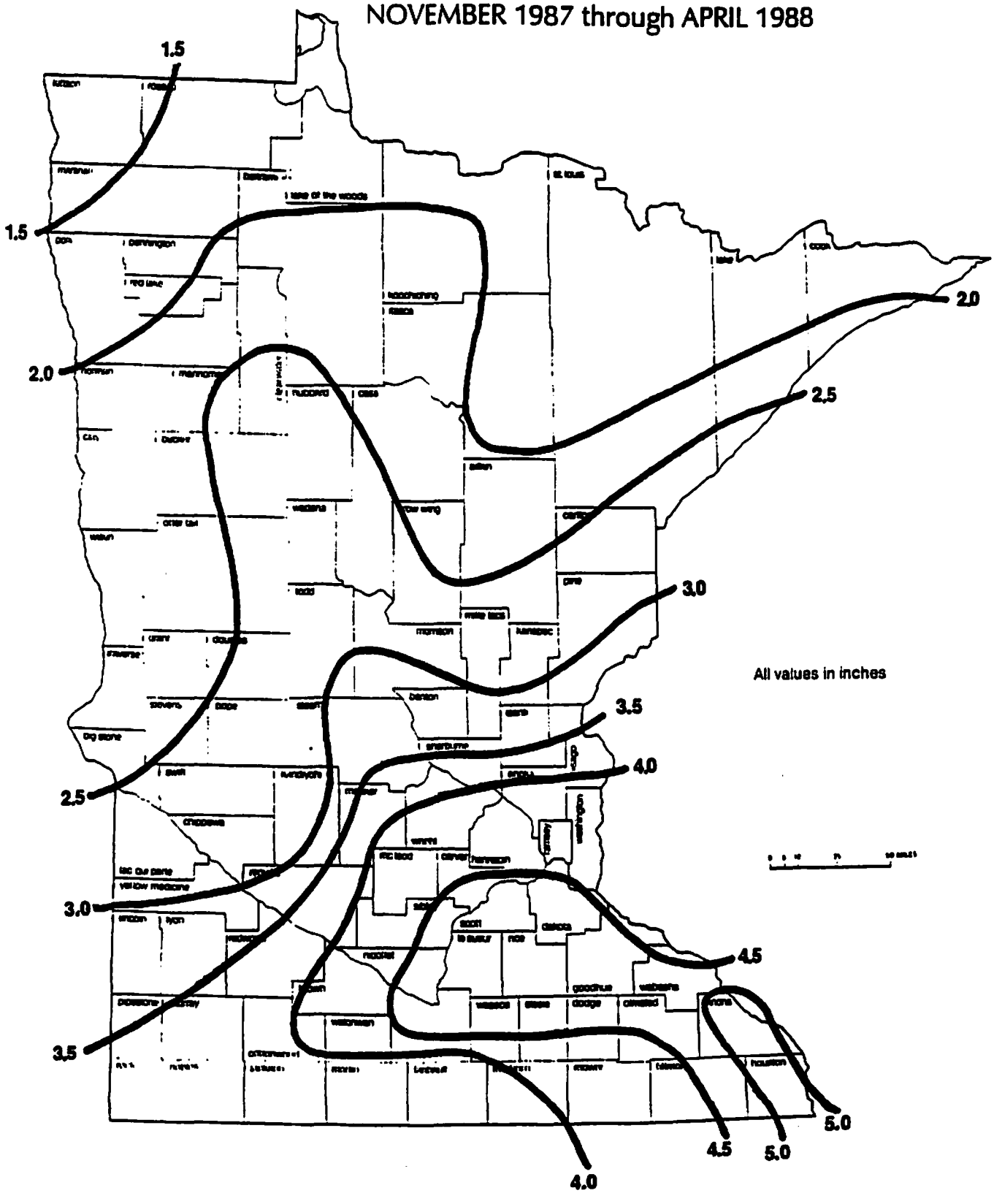


Data: National Weather Service, Soil & Water Conservation Service, DNR Forestry, Metropolitan Mosquito Control, Backyard Raingage Network, Future Farmers of America, KSTP-TV, Deep Portage Conservation Reserve, Minnesota Association of Watersheds

FIGURE 4

POTENTIAL SOIL MOISTURE RECHARGE

NOVEMBER 1987 through APRIL 1988



THE DENSITY OF FRESHLY FALLEN SNOW AND THE SNOWPACK

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In the course of modeling soil frost depth and duration, a series of snow density measurements were taken of both freshly fallen snow and the snow that had accumulated. Some interesting results were obtained which will be of interest to those concerned with water supplies and the insulating value of snow. It might also be of interest to little boys and girls who make snowballs and snowmen (snowwomen?).

The objectives are two-fold. One objective is to determine how the density of snow varies with the air temperature at the time the snow falls. The second, and more important objective, is to find how the snowpack density changes with time. The initial density (that is, the water content) varies with the atmospheric temperature at the time of the snowfall. Upon reaching the earth's surface a change or metamorphosis in the crystalline structure of the snow begins. The rate of this change (or metamorphosis) is primarily a function of the temperature and wind conditions during the life of the snowpack.

Snow sampling devices not unlike large cookie cutters were constructed. The shallow-snow sampler measured 23 cm (9.1 in) on a side and was 20 cm (8 in) deep. A larger one was made for deeper snow. Each density measurement consisted of at least 3 subsamples. Freshly fallen snow was sampled as close to the end of the snowfall as possible. No measurement was made more than 24 hours after the snowfall.

The first year, 1984-85, had little snow cover and did not result in many good measurements of the accumulated snow. However, the 1985-86 winter was one of a deep and persistent snow cover which provided excellent opportunities for both the newly fallen snow and snowpack density measurements. The 1987-88 winter (still incomplete as this is written) has not been very satisfactory in terms of fresh snow densities. However, it has been quite satisfactory in terms of the accumulated snow, since there have been extended periods of sufficient snow depth and continuity to provide a marked metamorphosis of the snow structure.

In Fig. 1 it is shown how the density of freshly fallen snow varies with the air temperature. The least dense snow is associated with a temperature of about 10°F (-12°C). The density increases with temperatures that are both higher and lower than 10°F. Snow with the highest water content (maximum density) is right at the freezing point. Almost every child knows this snow is the best to work with. For reasons that are not clear at this time the greatest variability in the density measurements apparently occurs at about 21°F.

Snow density is a function of the kind of snow crystals that are formed within particular temperature ranges. Snow crystals that typically form at about 10°F (-12°C) have a fern-like dendritic structure and make the fluffiest of snows.

The density of the snowpack during each of the three winters is shown in Fig. 2. In general an increase in the density occurs as the snow ages. However, density changes during any one season are quite irregular, since the deposition of new snow on aged snow will result in a temporary decrease in the overall density. But as the fresher snow undergoes a metamorphosis, along with the continuing one in the underlying older snow, the entire snowpack increases in density. As indicated earlier this change is due to wind action and partial melting. Both change the physical structure. An additional factor is the compression of the snowpack caused by successive snowfalls on the earlier deposits.

During the 3 years the mean change in density has been 300 kg/m^3 (14.4 lbs/ft^3) over the 122 days between Nov. 20 and March 22. At a density of about 14.4 lbs/ft^3 the snowpack is no longer snow-like, but it resembles a loosely packed pile of dry shelled corn. For this reason one observer calls snow in this physical state "corn snow". At greater densities than this the snow no longer resembles snow but various states of ice.

It is our intention to correlate the change in the snowpack density with melting degree days, or a similar factor, in order to obtain a better predictor of the ageing process than simply the duration (in days) of the snowpack.

Fig. 1. Density of fresh snows measured at St. Paul, 1984-85, 1985-86, and 1987-88. The curved line represents the mean density for the indicated temperatures.

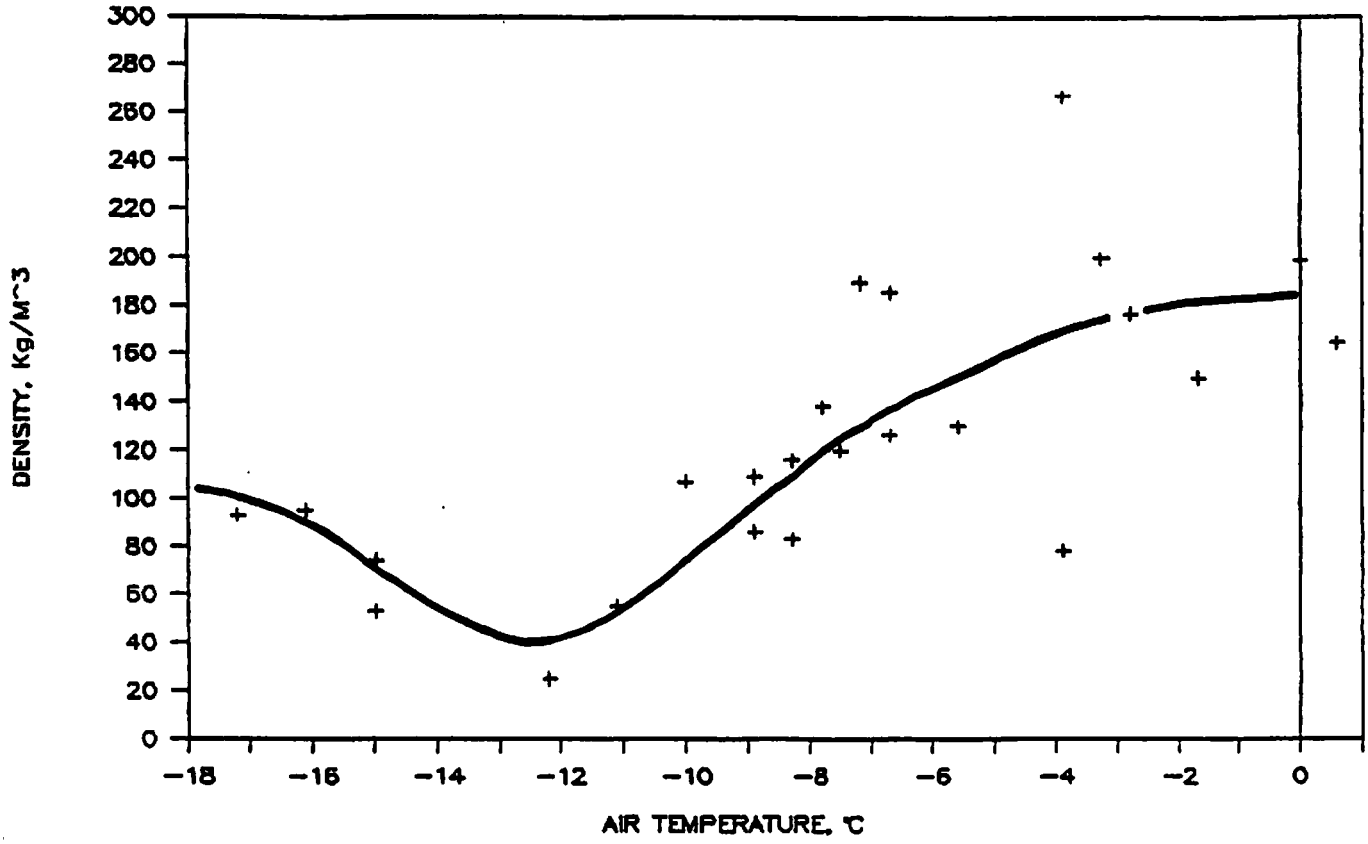
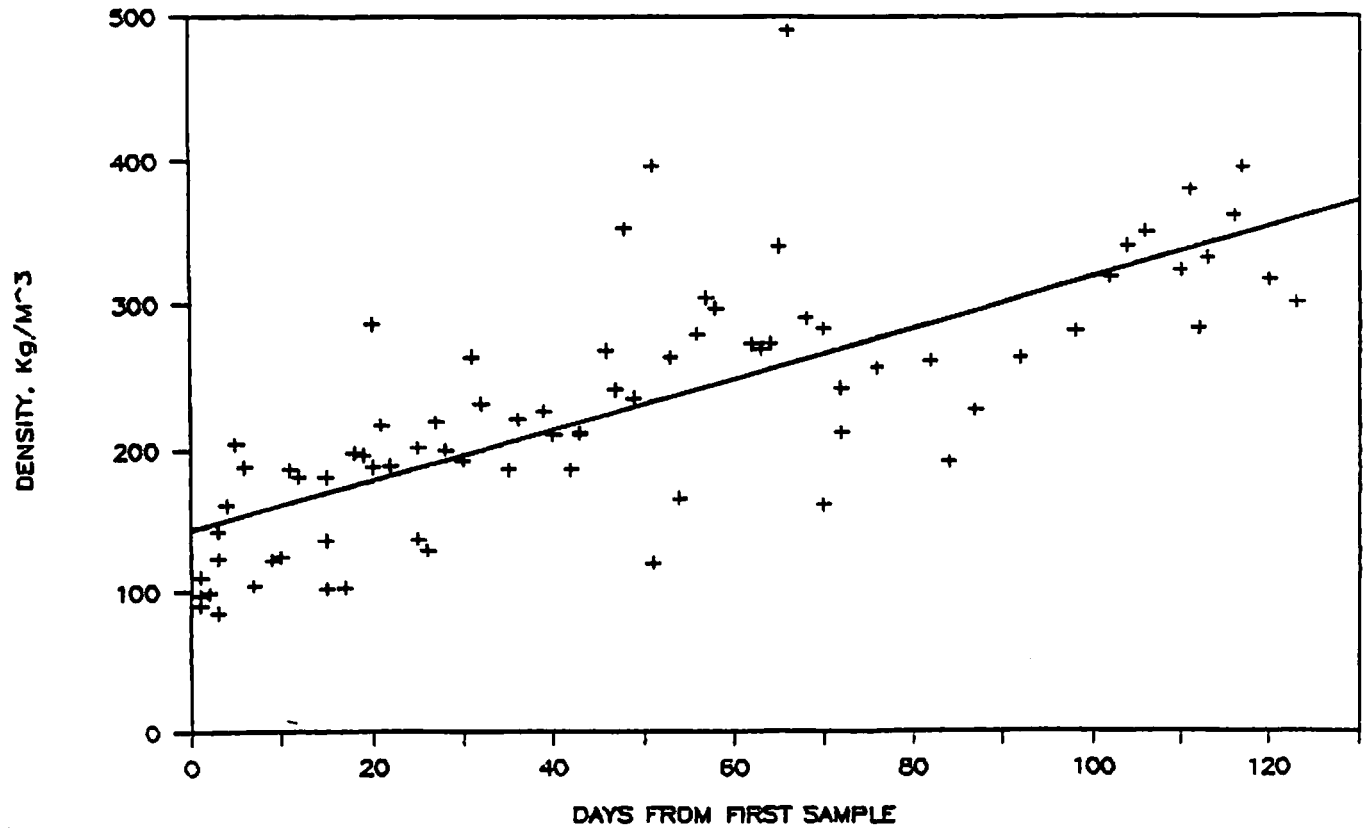


Fig. 2. The change in the density of the snowpack (accumulated snow) with time during the three winters of 1984-85, 1985-86, and 1987-88. The straight line is the mean of the indicated measurements.



MANAGEMENT OF UAN ON THE COARSE TEXTURED IRRIGATED SOIL OF MINNESOTA FOR EFFICIENT CORN PRODUCTION BECKER, MN 1987

G.L. Malzer and T. Graff

Nitrogen (N) fertilizer management decisions are major considerations that all producers must address. These management decisions include many aspects of N fertilization including rates, forms, methods and time of application, equipment, and additives. Although these factors are important for all corn producers, they become especially important for the producers on the coarse textured irrigated soils. Since these soils are highly responsive to fertilizer N, and highly susceptible to N loss, poor management can result in significant yield reductions, reduced profits, and increased nitrate contamination of ground water. The use of nitrification inhibitors in the management programs should also be considered as a management tool to minimize the N loss and add flexibility to the overall N management program. Although most nitrification inhibitors are applied with anhydrous ammonia, they can also be applied with other fertilizer products such as urea, or urea-ammonium nitrate solution (UAN). The objectives of these experiments are to evaluate several aspects of UAN management including: timing of application, method of application, split vs. single applications and the contribution of nitrification inhibitors in these possible management combinations.

Experimental Procedures

Two separate experiments were established at the Sand Plain Research Farm near Becker, Minnesota in 1985 this is the third and final year of these experiments.

Experiment 1 consisted of 25 treatments with four replications arranged in a randomized complete block design. Treatment variables included factorial combinations of six N rates of UAN (100, 134, 168, 202, 235, and 269 kg/ha) and four methods of application (2/3 of N rate early 1/3 late, all late, 2/3 early with DCD 1/3 late, and 2/3 early with N-Serve 1/3 late), plus a zero N control. Early N treatments were applied at the 4-5 leaf growth stage (May 28) while late applications were made at the 8-9 leaf growth stage (June 11). All treatments were injected into the soil on 76 cm centers approximately 8 cm deep and 18 cm away from the row. Nitrification inhibitors were mixed with the UAN prior to application and were applied at rates of 7.84 kg/ha for DCD and 0.56 kg/ha a.i. for N-Serve.

Experiment 2 consisted of 19 treatments with four replications in a randomized complete block design. Treatment variables included factorial combinations of three rates of N as UAN (100, 168, and 235 kg/ha), two methods of application (broadcast vs. injected), and two times of application (4-leaf and 8-leaf growth stages). Nitrification inhibitor (DCD and N-Serve similar to above) treatments were included to provide comparisons for all injected N treatments at the four-leaf growth stage.

Experiment 1 and 2: Prior to planting, broadcast applications of potassium-magnesium-sulfate (336 kg/ha 0-0-22), and (280 kg/ha 0-14-42) were made and incorporated by plowing. Corn (Pioneer 3906 - 95 day relative maturity) was planted on April 27th in 0.76 m rows at a population of 75,800 seeds/ha. Starter fertilizer was applied at the rate of 185 kg/ha 8-10-30, side banded at planting. A tank mix of Atrazine (2.24 kg/ha) and (Dual 1.68 kg/ha) was applied on April 30th for weed control.

Leaf samples from opposite and below the ear at mid-silking were obtained on July 13th, dried and analyzed for N. Total dry matter production and grain yields were determined on September 15 and 16th by hand harvesting 9.29 m^2 of plot area. Ears were separated from the stalks, field weights obtained, and samples removed for moisture and N determination. Grain yields were adjusted to 15.5% moisture.

The irrigation program was started on May 2nd and continued through August 25th with a total of 32.6 cm being applied through irrigation. An additional 36.3 cm of water was obtained during the growing season as rainfall.

General Results

The 1987 growing season provided excellent conditions for high yields. The distribution of precipitation in 1987 could be characterized as being relatively dry during the months of May and June with no single rainfall at any time during the growing season in excess of one inch. With this rainfall distribution significant nitrate leaching would not be expected to occur. Likewise, the impacts of nitrogen management techniques such as time of application, placement, and use of nitrification inhibitors would be expected to have minimal influence on grain yield and N utilization. The results of experiment 1 are presented in tables 1 and 2 and experiment 2 are presented in tables 3 and 4.

Experiment 1 Yield increases in excess of 90 bu/A were associated with fertilizer nitrogen application. The optimum rate of fertilizer N application was 150 lbs/A (168 kg/ha), similar to what was found in both 1985 and 1986. Time of N application (split vs. all late sidedressed) had no influence on grain yield, but the all late N application did reduce stover yield and total dry matter production by the crop. Although time of N application did not influence N concentration in the plant tissue it did result in a reduced amount of N contained in the stover and a trend for reduced total N removal by the total crop. The use of nitrification inhibitors had no influence on crop yield, nitrogen concentrations in the tissue, or total N removal by the crop.

Experiment 2 The apparent optimum N rate in experiment 2 was similar to that obtained in experiment 1 (150 lbs/A). Nitrification inhibitors had no influence on grain yields, but did increase total dry matter production and N concentration in the tissue. The result was an increase in N uptake by the crop. The nitrification inhibitor DCD appeared to be more effective than N-Serve in this respect. Time of N application had no influence on grain yield or N removal suggesting that early season N losses were minimal. Injected applications of UAN increased grain yields, N concentration in the tissue and overall N removal by the crop. Since leaching losses appeared to minimal, the decreased efficiency associated with the broadcast application of UAN could be due to volatilization, increased immobilization of N in the soil, or positional unavailability. Although it is not possible to differentiate these processes in this experiment, previous experimental results at this location under similar experimental conditions would suggest that volatilization losses are minimal.

Table 1. Influence of N-Rates, nitrification inhibitors and method of application on grain yield, and dry matter production on irrigated corn Becker, MN 1987.

Treatments					Grain		Dry Matter Production		
N-Rates	Split 1	Inh.	Split 2	Meth.	Yield		Grain	Stover	Total
kg/ha	kg/ha		kg/ha		Bu/A	mt/ha	---------mt/ha---------		
Control	----	---	----	---	96.2	6.0	5.08	6.14	11.24
100	67	---	34	1	171.7	10.8	9.09	8.36	17.45
100	----	---	100	2	168.6	10.6	8.94	7.97	16.91
134	90	---	44	1	183.1	11.5	9.70	8.74	18.44
134	----	---	134	2	177.6	11.1	9.41	8.27	17.67
168	112	---	56	1	185.7	11.6	9.83	9.54	19.40
168	---	---	168	2	180.3	11.3	9.54	8.69	18.26
202	134	---	68	1	185.1	11.6	9.81	9.39	19.20
202	----	---	202	2	179.2	11.2	9.50	8.06	17.56
235	157	---	78	1	184.4	11.6	9.77	9.14	18.93
235	----	---	235	2	184.2	11.5	9.74	8.98	18.75
269	179	---	90	1	188.1	11.8	9.97	9.27	19.24
269	----	---	269	2	183.2	11.5	9.70	8.74	18.44
100	67	DCD	34	3	176.4	11.1	9.34	8.65	17.99
100	67	NS	34	4	171.8	10.8	9.09	8.15	17.27
134	90	DCD	44	3	175.2	11.2	9.30	9.09	18.39
134	90	NS	44	4	184.4	11.6	9.30	8.89	18.88
168	112	DCD	56	3	181.7	11.4	9.77	9.27	18.52
168	112	NS	56	4	186.3	11.7	9.63	9.61	19.15
202	134	DCD	68	3	180.1	11.3	9.88	8,87	19.15
202	134	NS	68	4	181.6	11.4	9.54	9.34	18.50
235	157	DCD	78	3	184.9	11.6	9.61	9.16	19.13
235	157	NS	78	4	183.1	11.5	9.79	9.16	18.88
269	179	DCD	90	3	188.6	11.8	9.70	9.30	19.29
269	179	NS	90	4	184.4	11.6	9.99	9.16	19.22
P-Value					99	99	99	93	99
BLSD (.05)					12.1	0.7	0.62		1.28
Main Effects									
Rates kg/ha									
100					172.1	10.8	9.11	8.28	17.40
134					180.1	11.3	9.54	8.73	18.34
168					183.5	11.5	9.72	9.09	18.83
202					181.5	11.4	9.60	9.04	18.61
235					184.1	11.5	9.74	9.16	18.90
269					186.1	11.7	9.85	9.18	19.04
P-Value					99	99	99	99	99
BLSD (.05)					5.5	0.3	0.29	0.19	0.49
Methods	Early	Late							
1	2/3	1/3			183.0	11.5	9.69	9.07	18.77
2	---	3/3			178.9	11.2	9.58	8.44	17.94
3	2/3 + DCD	1/3			181.2	11.3	9.58	9.13	18.74
4	2/3 + NS	1/3			181.9	11.4	9.69	9.00	18.63
P-value					67	67	67	99	99
BLSD (.05)								0.14	0.22
Rate X Method					4	4	3	49	13

Table 2. Influence of N-Rates, nitrification inhibitors and method of application on leaf, grain, and stover N content and total N removal by irrigated corn Becker, MN 1987.

Treatments					N-Concentration			N-Removal		
N-Rates	Split 1	Inh.	Split 2	Meth.	Leaf	Grain	Stover	Grain	Stover	Total
kg/ha	kg/ha		kg/ha							
Control	----	---	----	---	1.55	1.18	0.45	60.6	29.1	89.7
100	67	---	34	1	2.95	1.53	0.64	139.9	53.7	193.6
100	----	---	100	2	3.11	1.55	0.55	138.8	44.4	183.2
134	90	---	44	1	3.36	1.62	0.56	157.7	49.5	207.3
134	----	---	134	2	3.19	1.68	0.54	158.7	45.1	203.8
168	112	---	56	1	3.29	1.67	0.59	164.7	57.2	221.9
168	---	---	168	2	3.35	1.58	0.61	151.3	53.6	205.0
202	134	---	68	1	3.31	1.68	0.61	164.8	58.2	223.1
202	----	---	202	2	3.19	1.67	0.57	159.3	46.0	205.4
235	157	---	78	1	3.35	1.68	0.62	164.7	57.1	221.8
235	----	---	235	2	3.20	1.65	0.63	161.2	56.9	218.1
269	179	---	90	1	3.25	1.67	0.56	166.8	53.0	219.8
269	----	---	269	2	3.17	1.72	0.65	167.3	57.1	224.0
100	67	DCD	34	3	3.10	1.55	0.51	145.5	44.7	190.2
100	67	NS	34	4	2.99	1.55	0.51	141.2	41.7	182.9
134	90	DCD	44	3	3.12	1.60	0.63	148.9	57.3	206.2
134	90	NS	44	4	3.23	1.64	0.53	161.0	48.7	209.8
168	112	DCD	56	3	3.29	1.66	0.59	160.0	53.0	213.0
168	112	NS	56	4	3.35	1.66	0.59	164.4	54.8	219.3
202	134	DCD	68	3	3.42	1.67	0.65	160.1	62.9	223.1
202	134	NS	68	4	3.33	1.70	0.61	163.8	54.0	217.9
235	157	DCD	78	3	3.24	1.71	0.64	167.5	60.2	227.8
235	157	NS	78	4	3.31	1.72	0.64	166.9	59.1	226.0
269	179	DCD	90	3	3.39	1.73	0.68	173.1	63.7	236.9
269	179	NS	90	4	3.30	1.73	0.61	169.4	57.8	227.2
P-Value					99	99	99	99	99	99
BLSD (.05)					0.21	0.09	0.11	13.2	11.2	19.4
Main Effects										
Rates kg/ha										
100					3.04	1.54	0.50	141.3	46.1	187.4
134					3.22	1.63	0.56	156.5	50.1	206.7
168					3.32	1.64	0.59	160.0	54.6	214.8
202					3.31	1.68	0.61	161.9	55.3	217.8
235					3.27	1.69	0.63	165.8	58.2	223.4
269					3.28	1.71	0.62	169.1	57.9	227.0
P-Value					99	99	99	99	99	99
BLSD (.05)					0.10	0.04	0.04	6.3	5.2	9.2
Methods	Early	Late								
1	2/3	1/3			3.25	1.64	0.60	159.7	54.7	214.5
2	---	3/3			3.20	1.64	0.59	156.1	50.5	206.6
3	2/3 + DCD	1/3			3.26	1.65	0.62	159.1	57.0	216.1
4	2/3 + NS	1/3			3.25	1.66	0.58	161.0	52.6	213.8
P-value					47	40	73	66	97	90
BLSD (.05)									4.7	
Rate X Method					66	20	86	14	68	7

Table 3. Influence of N rates, nitrification inhibitors, method, and time of application on grain yield and dry matter production on irrigated corn Becker MN 1987.

	Treatments			Grain		Dry Matter Productoin		
N-Rate	Method	Inh.	Time	Yields		Grain	Stover	Total
kg/ha				Bu/A	mt/ha	---------mt/ha---------		
Control	------	----	---	90.7	5.7	4.79	6.25	10.74
100	Broadcast	----	1	159.5	10.0	8.44	7.82	18.92
100	Broadcast	----	2	164.9	10.3	8.74	7.77	19.57
100	Injected	----	1	175.4	11.0	9.30	8.51	20.82
100	Injected	----	2	176.7	11.1	9.36	8.65	20.97
100	Injected	DCD	1	178.9	11.2	9.48	8.58	21.22
100	Injected	NS	1	172.8	10.8	9.14	8.42	20.47
168	Broadcast	----	1	179.2	11.2	9.50	8.60	21.27
168	Broadcast	----	2	181.8	11.4	9.63	8.00	21.58
168	Injected	----	1	185.2	11.6	9.81	8.80	21.98
168	Injected	----	2	181.4	11.4	9.61	7.59	21.53
168	Injected	DCD	1	188.8	11.8	10.01	9.34	22.43
168	Injected	NS	1	189.5	11.9	10.04	9.43	22.48
235	Broadcast	----	1	179.8	11.3	9.52	8.65	21.32
235	Broadcast	----	2	173.3	10.9	9.18	8.29	20.57
235	Injected	----	1	191.4	12.0	10.15	9.43	22.73
235	Injected	----	2	181.8	11.4	9.63	8.85	21.58
235	Injected	DCD	1	186.5	11.7	9.88	9.43	22.13
235	Injected	NS	1	196.7	12.3	10.42	9.45	23.33
P-Value				99	99	99	99	99
BLSD (.05)				10.7	0.7	0.56	0.18	1.09
Factorial Arrangement (N-Rate X Inhibitor DCD and N-Serve)								
N-Rate								
100				175.9	11.0	9.31	8.53	17.87
168				186.2	11.7	9.85	9.09	18.97
235				189.1	11.8	10.01	9.29	19.30
P-Value				99	99	99	99	99
BLSD (.05)				4.4	0.2	0.20	0.12	0.40
Inhibitor								
None				182.0	11.4	9.63	8.84	18.48
DCD				184.4	11.6	9.78	9.11	18.90
N-Serve				186.3	11.7	9.87	9.11	18.99
P-Value				87	87	88	91	95
BLSD (.05)								0.09
N-Rate X Inhibitor				92	92	93	73	88
Factorial Arrangement (N-Rate X Method X Time)								
N-Rate								
100				169.1	10.6	8.96	8.19	17.15
168				181.9	11.4	9.63	8.55	18.18
235				181.6	11.4	9.60	8.80	18.43
P-Value				99	99	99	99	99
BLSD (.05)				5.2	0.3	0.26	0.35	0.56
Method								
Broadcast				173.1	10.8	9.16	8.19	17.36
Injected				182.0	11.4	9.63	8.48	18.48
P-Value				99	99	99	99	99
Time								
Early				178.4	11.2	9.45	8.62	18.09
Late				176.7	11.1	9.34	8.40	17.76
P-Value				56	56	58	89	83
Rate X Method				86	86	87	26	65
Rate X Time				88	88	87	63	82
Method X Time				68	68	68	46	11
Rate X Method X Time				5	5	4	46	15

Table 4. Influence of N rates, nitrification inhibitors, method, and time of application on leaf, grain, and stover N content and N removal by irrigated corn Becker MN 1987.

Treatments				N-Concentration			N-Removal		
				----------%----------			----------kg/ha----------		
N-Rate	Method	Inh.	Time	Leaf	Grain	Stover	Grain	Stover	Total
Control	------	----	---	1.53	1.23	0.40	58.9	24.9	83.9
100	Broadcast	----	1	2.81	1.39	0.44	117.6	35.0	152.7
100	Broadcast	----	2	2.83	1.33	0.46	117.0	36.1	153.1
100	Injected	----	1	3.08	1.48	0.50	138.7	43.3	182.0
100	Injected	----	2	3.09	1.51	0.58	142.4	50.3	192.8
100	Injected	DCD	1	3.09	1.57	0.54	149.1	47.0	196.1
100	Injected	NS	1	3.17	1.53	0.48	140.1	40.6	180.8
168	Broadcast	----	1	3.05	1.65	0.55	157.8	47.52	205.3
168	Broadcast	----	2	3.13	1.60	0.53	148.6	42.1	190.8
168	Injected	----	1	3.27	1.66	0.56	158.0	47.1	205.1
168	Injected	DCD	1	2.84	1.71	0.62	160.2	49.5	209.7
168	Injected	NS	1	3.40	1.73	0.54	171.1	58.1	229.3
235	Broadcast	----	1	3.28	1.60	0.55	173.7	51.9	225.7
235	Broadcast	----	2	3.33	1.62	0.55	152.7	48.1	200.9
235	Injected	----	1	3.11	1.66	0.55	148.9	46.1	195.0
235	Injected	----	1	3.22	1.70	0.56	169.3	52.1	221.4
235	Injected	----	2	3.26	1.70	0.67	164.4	50.4	214.8
235	Injected	DCD	1	2.84	1.63	0.59	168.5	63.4	231.9
235	Injected	NS	1	3.33	1.36	0.47	170.5	56.0	226.6
P-Value				99	99	99	99	99	99
BLSD (.05)				0.37	0.11	0.10	13.5	9.0	18.2
Factorial Arrangement (N-Rate X Inhibitor DCD and N-Serve)									
N-Rate									
100				3.11	1.52	0.53	142.5	45.8	187.0
168				3.19	1.67	0.56	165.7	51.6	217.5
235				3.16	1.67	0.59	168.1	55.4	223.6
P-Value				23	99	99	99	99	99
BLSD (.05)					0.04	0.04	5.4	4.3	7.7
Inhibitor									
None				3.13	1.60	0.55	155.4	48.7	204.2
DCD				3.11	1.66	0.61	162.8	56.2	219.0
N-Serve				3.26	1.63	0.54	161.3	49.5	211.0
P-Value				51	93	99	97	99	99
BLSD (.05)						0.04	6.7	4.7	8.9
N-Rate X Inhibitor				80	82	81	79	87	79
Factorial Arrangement (N-Rate X Method X Time)									
N-Rate									
100				2.95	1.43	0.50	128.9	41.2	170.1
168				3.07	1.61	0.54	156.1	46.4	202.8
235				3.23	1.64	0.55	158.8	49.1	208.0
P-Value				99	99	99	99	99	99
BLSD (.05)				0.18	0.05	0.04	7.6	4.2	10.4
Method									
Broadcast				3.04	1.52	0.51	140.4	42.4	183.0
Injected				3.13	1.60	0.55	155.4	48.7	204.2
P-Value				75	99	97	99	99	99
Time									
Early				3.13	1.56	0.52	148.9	45.4	194.5
Late				3.04	1.56	0.54	146.9	45.6	192.7
P-Value				75	14	70	46	10	32
Rate X Method				79	77	95	88	86	91
Rate X Time				43	55	40	26	69	48
Method X Time				46	85	94	53	82	46
Rate X Method X Time				90	17	58	25	34	33

Influence of Nitrogen Application Time and Nitrification Inhibitor Rate on Sweet Corn Production on an Irrigated Sand

C. J. Rosen

With excessive rainfall, coarse-textured soils are subject to leaching of nitrate-N from the root-zone. Because N loss through the growing season can depress yields and contaminate groundwater, the practice of sidedressing and/or use of nitrification inhibitors are important considerations for growers on the central sand plains of Minnesota. Maintaining N in the relatively nonleachable ammonium form through use of a nitrification inhibitor may be one means of reducing nitrate-N leaching and N fertilizer inputs. Another factor to consider is whether hybrids respond differently to ammonium-N compared to nitrate-N. Selecting hybrids that respond to ammonium nutrition may enhance the effectiveness of nitrification inhibitors. The objectives of this study were to 1) determine the effects of N fertilizer application time and nitrification inhibitor rate on soil levels of nitrate-N and ammonium-N and 2) compare the response of two sweet corn hybrids to these treatments. Results presented here are from the second year of the study.

EXPERIMENTAL PROCEDURES

The experiment was conducted at the Sand Plains Research Farm in Becker, MN. Prior to planting and fertilizer application, the soil (Hubbard loamy sand) had the following test values (0-6"): pH, 6.3; Bray P1, 105 lb/A; ammonium acetate extractable K, 234 lb/A. The previous crop at this site was rye. Prior to planting 150 lb/A potassium-magnesium sulfate (0-0-22) was broadcast and incorporated.

Treatments consisted of two hybrids 'Code 5' (early season maturing) and 'Jubilee' (mid-season maturing), 150 lb N/A as anhydrous ammonia either preplant or split applied (75 lb N/A preplant and 75 lb N/A sidedressed) and three rates of N-Serve (0, 0.5, or 1.0 lb ai/A). For both hybrids, a control, which did not receive N or an inhibitor, was also included. A split-plot design with four replications was used with timing and inhibitor rate as main plots and hybrid as subplots. Preplant treatments were applied April 24, 1987. Both hybrids were planted April 29 with a banded application of 150 lb/A 0-14-42. Stands were thinned to approximately 24,000 plants/A with spacing set at 30" rows. The sidedress treatments were applied June 9 (10-12 leaf stage). The split N treatments had half the inhibitor applied preplant and the remainder applied with the sidedress. Soil samples were collected in the anhydrous ammonia bands (samples bulked over hybrid) May 27, July 10 and August 5 and stored moist at 4°C until extracted with 2N KCl for nitrate-N and ammonium-N determination. Whole plant samples collected at the 10-12 leaf stage (before sidedress application) and leaf samples opposite and above the ear at mid-silking were dried and ground for subsequent nutrient determination. From May through July, precipitation totalled 12.3". This rainfall was supplemented with an overhead irrigation system to supply 1 inch of water per week.

Code 5 was harvested on July 22 and Jubilee was harvested July 30. Total green yield, husked yield and stover yield were obtained by harvesting two 15 ft center rows within each plot. Subsamples of ears, husk, and stover were taken to determine % moisture for N uptake calculations. As a measure of product quality, % kernel moisture and % usable ears (5.5" or greater with unfilled tip removed - CCC eligible) were determined.

RESULTS

Both N timing and nitrification inhibitor rates had significant effects on levels of soil ammonium-N (Table 1) and nitrate-N (Table 2). Because samples were taken in the anhydrous ammonia band, values presented are valid for that area and do not represent average levels through the field. The control plot, as expected, had relatively low levels of nitrate-N and ammonium-N at all sampling dates and depths. Differences in the N treated plots were most apparent at the second and third sampling date. Ammonium-N increased significantly with split applications and with increasing inhibitor rate at the 0-6" depth. At times it was difficult to locate the band from the preplant applications. Therefore, some samples from the preplant applications may not have been entirely from the band. In contrast to ammonium-N, nitrate-N levels decreased with inhibitor rate at the 6-12" and 12-14" depths at the second and third planting dates. Nitrate-N increased when applications were split. This may have been in part due to the inability to locate the band in some of the preplant treatments. Overall, these data indicate that N-Serve suppressed nitrification which resulted in relatively high ammonium-N soil levels in N-Serve treated plots.

Yield of Jubilee was greater than that of Code 5 regardless of treatment (Table 3). This hybrid difference was due in part to earlier maturity of Code 5 and a higher % moisture at time of harvest of Code 5. As expected, both hybrids yielded poorly when nitrogen was omitted. Split application of nitrogen resulted in greater unhusked (green), husked yield and % COC eligible ears compared to preplant application. Nitrification inhibitor rate had no effect on green yield, but husked yield tended to increase with inhibitor rate. The significant interaction between hybrid and inhibitor rate was due to a more linear response to inhibitor rate by Jubilee compared to a more quadratic response by Code 5. Inhibitor rate had no effect on the % COC eligible ears. This is in contrast to the results from last year where Code 5 had a greater number of eligible ears with increasing inhibitor rate. Except for a hybrid difference, there was no treatment effect on ear length.

Nitrogen composition of and uptake by the two hybrids are presented in Table 4. Nitrogen concentration and uptake was significantly reduced when nitrogen was not applied. Concentrations of N in plants sampled at the 8-10 leaf stage were not significantly affected by inhibitor rate or N timing. Concentrations of N in stover, husk and ears were not affected by inhibitor rate or split applications. Total N removed in ears, husk and stover was not consistently affected by inhibitor rate and split application. Mid-silk leaf elemental concentrations are presented in Table 5. Except for the control plots, all leaf N levels were in the optimum range for sweet corn production. In general, increasing inhibitor rate decreased leaf Ca, Mg, Fe and Mn.

GENERAL COMMENTS

Overall responses this year to inhibitor and split application were much less than those of the previous year. Precipitation during this growing season was about half that of the previous season. In addition, none of the rainfall events this year exceeded more than one inch over a 24 hour period. It is probable that there was less leaching of nitrate this year compared to last year. Extractable ammonium levels significantly increased with inhibitor rate; however, hybrids responded similarly to the different treatments. These results suggest that unless significant leaching of nitrate occurs during the season, the probability of a response to inhibitor or split N applications is low.

The assistance of Tom Graff with inhibitor and nitrogen applications is gratefully acknowledged.

Table 1. Influence of timing of N fertilizer application (150 lb. N/A) and rate of nitrification inhibitor on soil ammonium - N levels at three depths. The control did not receive any nitrogen or inhibitor treatment.

		Sampling Data								
		May 27			July 10			August 5		
Timing	NI rate (lb. ai/A)[1]	0-6"	6-12"	12-24"	0-6"	6-12"	12-24"	0-6"	6-12"	12-24"
		ppm-NH_4-N								
control	0	1.0	0.2	0.3	0.8	0.6	1.0	0.8	0.8	1.0
preplant	0	31.7	82.8	2.0	1.0	8.2	2.0	0.8	2.9	1.8
preplant	0.5	22.8	69.0	1.8	11.7	21.2	2.5	1.8	9.2	1.4
preplant	1.0	14.8	39.6	3.6	0.9	4.7	1.9	0.8	4.8	3.0
split	0	14.2	41.0	1.2	131.9	16.8	6.8	6.3	11.6	2.8
split	0.5	4.5	20.2	0.5	163.9	8.6	18.5	50.6	4.8	2.5
split	1.0	28.2	46.8	5.0	218.3	13.4	9.9	65.2	20.8	3.0
Statistics (not including control)										
Timing										
preplant		23.1	63.8	2.4	4.6	11.4	2.2	1.2	5.6	2.1
split		15.6	36.0	2.2	171.3	12.9	11.7	40.7	12.4	2.8
Significance		NS	NS	NS	**	NS	++	**	++	NS
NI Rate										
0		22.9	61.9	1.6	66.5	12.5	4.4	3.6	7.3	2.3
0.5		13.6	44.6	1.1	87.8	14.9	10.5	26.2	7.0	2.0
1.0		21.5	43.2	4.3	109.6	9.0	5.9	33.0	12.8	3.0
Significance		NS	NS	*	*	NS	NS	*	NS	NS
Linear		NS	NS	*	**	NS	NS	**	NS	NS
Quad		NS	NS	++	NS	NS	NS	++	NS	NS
Time x NI Rate										
Significance		+	NS	NS	*	*	NS	*	++	NS

[1] NI - nitrification inhibitor (N-Serve)

** = <.01, * = .01-.05, ++ = .05-.1, + = .1-.2, NS = >.2

Table 2. Influence of timing of N fertilizer application (150 lb. N/A) and rate of nitrification inhibitor on soil nitrate - N levels at three depths. The control did not receive any nitrogen or inhibitor treatment.

		Sampling Data								
		May 27			July 10			August 5		
Timing	NI rate(lb. ai/A)[1]	0-6"	6-12"	12-24"	0-6"	6-12"	12-24"	0-6"	6-12"	12-24"
		ppm-NO_3-N								
control	0	6.6	5.9	1.8	4.4	2.3	1.2	3.3	2.2	0.8
preplant	0	18.9	34.5	9.0	7.2	17.6	14.5	5.2	11.2	8.6
preplant	0.5	15.0	14.4	2.5	12.1	18.6	6.0	6.0	7.3	4.0
preplant	1.0	20.6	29.2	5.2	7.1	4.0	2.9	5.2	3.6	2.0
split	0	22.9	44.9	5.0	70.5	46.4	15.6	16.4	22.0	15.7
split	0.5	18.8	25.3	3.4	152.6	33.1	12.6	13.9	11.0	5.6
split	1.0	30.5	35.8	9.1	145.4	42.8	12.1	31.2	13.3	8.4
Statistics (not including control)										
Timing										
preplant		18.2	26.0	5.6	8.8	13.4	7.8	5.5	7.4	4.9
split		24.1	35.3	5.8	122.8	40.8	13.4	20.5	15.4	9.9
Significance		NS	+	NS	*	**	**	++	**	**
NI Rate										
0		20.9	39.7	7.0	38.9	32.0	15.1	10.8	16.6	12.1
0.5		16.9	19.8	2.9	82.4	25.8	7.5	10.0	9.2	4.8
1.0		25.6	32.5	7.2	76.3	23.4	9.2	18.2	8.4	5.2
Significance		NS	++	+	NS	NS	**	NS	*	**
Linear		+	+	NS	NS	*	**	NS	*	**
Quad		*	**	*	NS	NS	+	NS	NS	*
Time x NI Rate										
Significance		NS	NS	NS	NS	+	+	NS	NS	+

[1] NI - nitrification inhibitor (N-Serve)
** = <.01, * = .01-.05, ++ = .05-.1, + = .1-.2, NS = >.2

Table 3. Nitrogen fertilizer timing (150 lb. N/A) and nitrification inhibitor rate effects on yield and quality of two sweet corn hybrids. The control did not receive any nitrogen or inhibitor treatment.

Timing	NI rate (lb. ai/A)[1]	Hybrid	Yield Green	Yield Husked	Ear Length	Kernal Moisture	COC Eligible
			-----(T/A)-----		(inches)	(%)	(%)
control	0	Code 5	0.6	0.3	2.2	82.7	00.0
preplant	0	Code 5	7.6	4.7	8.2	82.6	91.0
preplant	0.5	Code 5	7.8	4.7	8.0	83.6	75.8
preplant	1.0	Code 5	7.5	4.6	8.4	84.7	90.0
split	0	Code 5	7.6	4.7	8.4	84.1	89.8
split	0.5	Code 5	8.4	5.3	8.4	82.1	90.0
split	1.0	Code 5	7.8	5.0	8.5	83.0	91.2
control	0	Jubilee	2.1	1.5	5.9	75.6	17.5
preplant	0	Jubilee	8.9	6.2	7.6	77.1	87.5
preplant	0.5	Jubilee	9.8	6.6	7.8	77.8	88.8
preplant	1.0	Jubilee	9.7	6.7	7.9	77.8	87.5
split	0	Jubilee	10.1	6.6	7.7	78.8	93.8
split	0.5	Jubilee	9.9	6.6	7.7	77.2	96.2
split	1.0	Jubilee	10.0	7.3	7.8	76.2	95.0
Statisitics (not including control)							
Main Effects							
Hybrid							
Code 5			7.8	4.8	8.3	83.4	88.0
Jubilee			9.7	6.7	7.7	77.5	91.4
Significance			**	**	**	**	++
Timing							
preplant			8.5	5.6	8.0	80.6	86.8
split			9.0	5.9	8.1	80.2	92.7
Significance			*	**	NS	NS	*
NI Rate							
0			8.6	5.6	8.0	80.6	90.5
0.5			9.0	5.8	8.0	80.2	87.7
1.0			8.7	5.9	8.1	80.4	90.9
Significance			NS	*	NS	NS	NS
Linear			NS	**	NS	NS	NS
Quad			*	NS	NS	NS	+
Interactions							
Hybrid X Timing			NS	NS	NS	NS	NS
Hybrid X NI Rate			NS	*	NS	NS	+
Timing X NI Rate			NS	NS	NS	++	NS
Hybrid X NI Rate X Timing			++	*	NS	NS	NS

[1] NI - nitrification inhibitor (N-Serve)
** = <.01, * = .01-.05, ++ = .05-.1, + = .1-.2, NS = >.2

Table 4. Nitrogen fertilizer timing (150 lb. N/A) and nitrification inhibitor effects on N composition of and uptake by two sweet corn hybrids. The control did not receive any nitrogen or inhibitor treatment.

Timing	NI rate (lb. ai/A)[1]	Hybrid	% N Whole Plant (6-8 leaf)	% N Ear (Harvest)	% N Husk (Harvest)	% N Stover (Harvest)	N Content Ear (lb N/A)	N Content Husk (lb N/A)	N Content Stover (lb N/A)	Total N Uptake lb. N/A
control	0	Code 5	3.82	1.58	.70	0.68	1.8	7.5	35.9	45.1
preplant	0	Code 5	3.41	1.84	.80	1.72	38.7	8.1	90.6	137.4
preplant	0.5	Code 5	4.27	1.50	.77	1.73	29.1	5.3	85.7	120.1
preplant	1.0	Code 5	4.28	1.84	.74	1.72	35.6	6.4	97.2	139.2
split	0	Code 5	3.69	1.78	.60	1.43	28.8	14.6	72.0	128.9
split	0.5	Code 5	4.22	1.79	.73	1.78	43.5	5.4	85.9	134.8
split	1.0	Code 5	4.11	1.82	.78	1.72	39.4	6.3	87.0	132.7
control	0	Jubilee	3.89	1.34	.60	0.55	9.4	4.4	21.4	35.2
preplant	0	Jubilee	4.19	1.89	.94	1.40	55.5	10.5	78.8	144.8
preplant	0.5	Jubilee	4.10	1.84	.96	1.37	61.1	8.3	77.4	146.7
preplant	1.0	Jubilee	4.24	1.86	.82	1.36	63.8	6.6	82.2	152.6
split	0	Jubilee	4.13	1.86	.91	1.50	59.7	8.5	92.5	160.7
split	0.5	Jubilee	4.22	1.89	1.02	1.53	60.7	8.4	91.8	160.9
split	1.0	Jubilee	4.12	1.93	.90	1.34	71.4	7.5	78.4	157.4
Statisitics (not including the control)										
Main Effects										
Hybrid										
		Code 5	4.10	1.76	.77	1.72	37.2	6.6	90.4	134.2
		Jubilee	4.17	1.88	.93	1.41	62.0	8.3	83.5	153.8
		Significance	NS	+	**	**	**	**	+	**
Timing										
		preplant	4.08	1.79	.84	1.55	47.3	7.5	85.3	140.1
		split	4.18	1.85	.86	1.59	51.9	7.4	88.6	147.9
		Significance	NS	NS	NS	NS	*	NS	NS	+
NI Rate										
		0	4.00	1.85	.87	1.57	47.7	8.8	89.4	145.9
		0.5	4.20	1.75	.87	1.60	48.6	6.8	85.2	140.6
		1.0	4.19	1.86	.81	1.53	52.6	6.7	86.2	145.5
		Significance	NS	NS	++	NS	+	NS	NS	NS
		Linear	NS	NS	*	NS	++	**	NS	NS
		Quad	NS	NS	+	NS	NS	+	NS	NS
Interactions										
Hybrid X Timing			NS	NS	NS	NS	NS	NS	NS	NS
Hybrid X NI Rate			NS	NS	**	NS	+	NS	NS	NS
Timing X NI Rate			NS	NS	NS	NS	NS	NS	NS	NS
Hybrid X NI Rate X Timing			+	NS	NS	NS	++	NS	NS	NS

[1]NI - nitrification inhibitor (N-Serve)
** = <.01, * = .01-.05, ++ = .05-.1, + = .1-.2, NS = >.2

Table 5. Influence of timing of N fertilizer application (150 lb. N/A) and rate of nitrification inhibitor on leaf elemental concentration at mid-silking. The control did not receive any nitrogen or inhibitor treatment.

Timing	NI rate (lb. ai/A)[1]	Hybrid	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
			%					ppm				
control	0	Code 5	1.75	0.30	2.25	0.45	0.33	56	30	13	4	10
preplant	0	Code 5	3.30	0.32	2.03	0.61	0.40	93	114	23	9	8
preplant	0.5	Code 5	3.20	0.31	2.03	0.54	0.36	86	102	28	9	8
preplant	1.0	Code 5	3.29	0.34	2.11	0.58	0.40	88	86	23	10	8
split	0	Code 5	3.20	0.32	2.02	0.59	0.40	89	112	23	10	8
split	0.5	Code 5	3.30	0.33	2.05	0.60	0.41	89	80	24	10	9
split	1.0	Code 5	3.13	0.32	2.02	0.58	0.39	84	77	26	9	9
control	0	Jubilee	1.22	0.29	2.45	0.46	0.40	57	25	10	3	8
preplant	0	Jubilee	2.72	0.30	2.09	0.72	0.51	87	129	32	9	9
preplant	0.5	Jubilee	2.84	0.30	2.06	0.70	0.49	83	115	37	9	10
preplant	1.0	Jubilee	2.73	0.31	2.14	0.65	0.48	84	100	29	9	10
split	0	Jubilee	2.93	0.31	2.14	0.74	0.56	86	108	23	10	9
split	0.5	Jubilee	2.86	0.31	2.13	0.71	0.53	83	87	27	10	10
split	1.0	Jubilee	2.68	0.31	2.12	0.65	0.49	84	80	27	9	9
Statisitics (not including the control)												
Main Effects												
Hybrid												
Code 5			3.23	0.32	2.04	0.58	0.39	88	95	24	9	8
Jubilee			2.79	0.31	2.11	0.70	0.51	84	103	29	9	9
Significance			**	*	*	**	**	*	++	**	NS	*
Timing												
preplant			3.01	0.31	2.08	0.64	0.44	87	107	29	9	9
split			3.02	0.32	2.08	0.64	0.46	86	91	25	9	9
Significance			NS	NS	NS	+	**	NS	**	++	NS	NS
NI Rate												
0			3.04	0.31	2.07	0.67	0.47	89	116	25	9	9
0.5			3.05	0.31	2.07	0.64	0.45	85	96	29	9	9
1.0			2.96	0.32	2.10	0.61	0.44	85	86	26	9	9
Significance			++	NS	NS	**	*	*	**	NS	NS	NS
Linear			NS	NS	NS	**	*	++	**	NS	++	NS
Quad			NS	NS	NS	NS	NS	NS	NS	*	NS	NS
Interactions												
Hybrid X Timing			NS	NS	NS	NS	NS	NS	+	**	NS	NS
Hybrid X NI Rate			NS	NS	NS	++	+	NS	NS	NS	NS	NS
Timing X NI Rate			++	+	+	++	++	NS	NS	NS	++	NS
Hybrid X NI Rate X Timing			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1] NI - nitrification inhibitor (N-Serve)
** = <.01, * = .01-.05, ++ = .05-.1, + = .1-.2, NS = >.2

1987 WEATHER DATA
NORTHWEST EXPERIMENT STATION, CROOKSTON, MN

T.E. Cymbaluk

The weather for 1987 will be known as a warm year when compared with the 90-year average. Ten of the 12 months were above normal in regard to temperature, accounting for the average annual temperature to be 4.8 degrees above normal. January, February, April, and December were well above normal, with the average monthly readings deviating 10.7, 16.7, 8.9, and 7.0 degrees, respectively. August and October were the only two months below normal. The highest temperature for 1987 occurred on July 16 at 97 degrees F. The lowest temperature for 1987 occurred on January 22 at -25 degrees F.

The last frost of the spring was April 21, 1987 (29 degrees F) and the first hard killing frost occurred October 1, 1987 (28 degrees F). This made a 162-day frost-free period for 1987, the second highest frost-free period on record. The highest frost-free period on record is 167 days set in 1922.

The ground frost reached a maximum depth of 30 inches by the end of February. Surface thaw had begun by the end of March, by mid to late April, the ground frost was gone.

The 1987 precipitation was 1.25 inches less than the 90-year average. Seven of the 12 months had precipitation below normal. The greatest amount of precipitation that occurred in a single day was received on May 20, accumulating 2.23 inches of rain.

With little snow, a warm winter and early warm spring temperatures made it possible for a early planting season in 1987. By the first of May, most of the small grain crops had been planted. Because of a lack of moisture there was little tillering in the small grain crops.

Table 1. Weather summary for 1987 with 90-year averages for precipitation and mean temperatures.

Month	Precipitation 1987	Precipitation 1890-1979	Mean Temperatures 1987	Mean Temperatures 1890-1979
	--------inches--------		--------degrees F------	
January	0.21	0.56	14.4	3.7
Febuary	1.07	0.59	24.8	8.1
March	0.45	0.84	28.0	22.9
April	0.29	1.57	50.3	41.4
May	4.37	2.59	60.0	54.6
June	1.04	3.56	67.5	64.4
July	5.20	3.09	72.5	69.6
August	3.13	2.90	64.7	67.4
September	1.64	2.16	58.1	57.5
October	0.36	1.43	40.4	45.3
November	0.55	0.78	30.8	26.7
December	1.11	0.60	18.5	11.5
Total	19.42	20.67	Mean 44.2	39.4

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Table 2. Records broken or matched at the Northwest Experiment Station, Crookston, MN in 1987.

Highest Maximum Temperature			Highest Minimum Temperature		
Date	Old Record	New (1987)	Date	Old Record	New (1987)
	---------degrees F---------			----------degrees F---------	
Febuary 7	41 (1898)	42	January 5	27 (1902)	27
March 20	57 (1946)	58	April 18	55 (1931)	60
April 26	79 (1977)	79	December 7	32 (1935)	32
May 8	89 (1895)	89	December 8	30 (1952)	31
May 10	86 (1976)	92			
July 31	96 (1936)	96			

RESIDUAL SOIL N, FERTILIZER N, AND INOCULATION EFFECTS ON SOYBEAN PRODUCTION IN NORTHWESTERN MINNESOTA

J.A. Lamb and T.E. Cymbaluk

OBJECTIVE: The overall objective of this study is to measure the effect of residual NO_3^--N, fertilizer N and seed inoculation on soybean production in the Red River Valley of Minnesota.

MATERIALS AND METHODS: Two sites were located in 1987. The NO_3^--N (0-2') contents were 164 and 40 lbs A^{-1} for Marshall and West Polk County sites, respectively. The N fertilizer (urea) treatments (0, 30, 60, 90 and 120 lbs N A^{-1}) and inoculation treatment (none and inoculated) were applied and the plots planted to McCall soybean May 19 and June 1 at the Marshall and West Polk County locations, respectively. The most recent matured trifoliate leaves were sampled at 50% bloom for N analysis on July 30. The plots were harvested by plot combine September 14 and 21 at Marshall and West Polk locations, respectively.

RESULTS AND DISCUSSION: Table 1 lists the grain yield, trifoliate leaf N contents and statistical analyses for the 1987 locations. In 1987 we had two very different locations with regard to soil NO_3^--N contents. The West Polk location with soil NO_3^--N of 40 lb·A^{-1} (0-2') had a significant grain yield increase from fertilizer N which was not maximized by a 120 lb N A^{-1}. The use of inoculum did effect grain yield at the lower N rates but at 60 lb N A^{-1} there was no difference in grain yield from inoculum. The trifoliate leaf N concentrations were only effected by N fertilization and not by inoculum.

The Marshall County location had an extremely high soil NO_3^--N content of 164 lb A^{-1}. Because of this there was no yield response to N fertilization or inoculation. The trifoliate leaf N concentrations were increased (P=0.10) but no response occurred to inoculum treatment. These results support the use of a soil NO_3^--N test to determine if soybean plants will respond to N fertilization. Even though a visual examination of plants in the inoculated treatment indicated that nodules had been formed, evidently their ability to provide N to the plant is reduced by both high residual soil NO_3^--N contents and the addition of N fertilizer.

The authors would like to acknowledge the cooperation received from Curt Knutson, Dwight Anderson, and Ray Thompson in this study in 1987.

Table 1. Grain yields, trifoliate leaf N concentrations, and statistical analyses for 1987.

	West Polk			Marshall			West Polk			Marshall		
	NO	2X	$\bar{X}$	NO	2X	$\bar{X}$	NO	2X	$\bar{X}$	NO	2X	$\bar{X}$
	--------Grain Yield, bu A^{-1}----------						----------Leaf Concentration, %--------					
0	28.5	32.1	30.0	32.8	31.4	32.1	4.87	4.80	4.83	5.68	5.67	5.68
30	31.0	32.0	31.5	31.6	33.5	32.6	5.33	5.00	5.16	5.77	5.51	5.64
60	33.8	34.2	34.0	33.1	29.9	31.5	5.61	5.16	5.39	5.84	5.72	5.78
90	35.1	34.6	34.8	34.8	32.4	33.6	5.62	5.21	5.42	5.66	5.84	5.75
120	38.5	37.1	37.8	33.9	32.4	32.4	5.88	5.79	5.83	5.89	5.79	5.84
$\bar{X}$	33.4	34.0		33.2	31.6		5.46	5.19		5.77	5.70	
I		NS			NS			NS			NS	
N Rate		**			NS			**			NS	
Lin		**			NS			**			++	
Quad		NS			NS			NS			NS	
I * NR		*			NS			*			NS	
C.V.		4.7			6.9			7.2			3.6	

**, *, and ++ are 0.01, 0.05, and 0.10 significance levels, respectively.

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USE OF ACID BASED FERTILIZERS FOR MORE EFFICIENT SOYBEAN PRODUCTION IN NORTHWESTERN MINNESOTA

J.A. Lamb, T.E. Cymbaluk, and G.W. Rehm

OBJECTIVES: The primary objective of this study is to evaluate low pH fertilizers as carriers for micronutrients for soybean production in northwestern Minnesota. Particular objectives include 1) determine if low pH fertilizer increases the uptake of Zn and Fe in soybeans grown on calcareous soils, 2) determine the effect on soybean nodulation by the addition of micronutrients in different fertilizer carriers, and 3) determine effect of acid fertilizer on soybean yields.

MATERIALS AND METHODS: This study was located at two sites; West Polk County - Knutson site, and Marshall County - Anderson site. The soil test information is reported in Table 1. McCall soybeans were planted on May 20, 1987, and June 1, 1987 at the West Polk County and Marhall County sites, respectively. The fertilizer treatments listed in Table 2 were applied as a starter placement 2" x 2" from the row. The treatments were in a randomized complete design with four replications. Whole plant samples and population counts were taken three weeks after emergence. The Marshall County and West Polk County plots were harvested September 14 and September 21, 1987, respectively.

RESULTS AND DISCUSSION: West Polk County Location: Even though the soil P test was 14 lb A^{-1}, there was not a positive grain yield response at this location, Table 3. Actually, the treated plants yielded significantly less than the check. Forage yield, population, Zn uptake, plant Fe concentration and Fe uptake were not effected by the treatments. Plant P was on the average negatively effected by the addition of zinc in either the acid or nonacid carriers. The treatments caused a trend in lower P uptakes when compared to the check ($P=0.10$). The plant Zn concentration was on the average significantly lower for the treated plant when compared to the untreated check plants.

Marshall County Location: This location had a very low phosphorus soil test of 9 lb A^{-1}, Table 4. Similar to the West Polk site, no grain yield response occurred. Forage yield and plant population were uneffected by the treatments. Both plant P concentration and uptake were significantly increased by the application of P by either carrier. There was no difference between carriers. Plant Zn concentration and uptake were increased when Zn was added to the carrier. Acid x Fe and Fe x zinc interactions occurred with the Zn concentration. The Zn by Fe interaction is interupted as without Fe in the fertilizer the increase in plant Zn concentration from the addition of Zn is greater than in the presence of Fe (11 ppm vs 5 ppm). The acid by Fe interaction reveals that when Fe is added to the acid carrier, the Zn concentration is decreased (6 ppm) and with the nonacid carrier it is increased 2 ppm. The plant Fe concentrations and uptakes were increased with the use of fertilizer when compared to the check. No fertilizer treatment significantly did better than the rest.

Originally the very acid fertilizers were developed to be used in higher pH soils to acidify the soil in a small area where nutrients such as P, Zn and Fe would be more available to the plant. This increased availability was then supposed to increase grain yields. From both 1986 and 1987 soybean studies over 4 locations in the Red River Valley, no grain yield increase has been documented. In fact, in 1987, one location had a yield decrease. The results from the nutrient data in 1987 were mixed. Of interest was the effect of the starter placement on population. Soybean seeds are sensitive to salt when it comes to germination. We did not see this effect with the 2" x 2" placement. The soils of the Red River Valley are so buffered with $CaCO_3$ that the amount of acid needed to neutralize them even in a band, would be larger than what could be economically supplied.

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Table 1. Soil test information for soybean fertilizer carrier study, 1987.

	Depth	West Polk	Marshall
	--in.--		
OM %	0-6	4.5	4.7
NO_3^--N lb A^{-1}	0-24	40	104
$NaHCO_3$P lb A^{-1}	0-6	14	9
K lb A-1	0-6	530	230
pH		8.2	8.0
Zn ppm		0.5	0.6
Fe ppm		4	5

Table 2. Treatments for acid fertilizer experiment in 1986.

Carrier	Micronutrient
1. Acid fertilzier	-
2. (7-28-0-4) pH <0	1 lb A^{-1} Zinc
3.	1 lb A^{-1} Iron
4.	1 + 1 lb A^{-1} Zinc + Iron
5. Non Acid 10-34-0 + 12-0-0-26)	-
6. pH=5.4 (7-28-0-4)	1 lb A^{-1} Zinc
7.	1 lb A^{-1} Iron
8.	1 + 1 lb A^{-1} Zinc + Iron
9. Check (no fertilizer)	

Table 3. Treatment means and statistical analyses for grain yield, forage yield, small plant P, Zn, and Fe concentrations and uptakes and population for West Polk County location in 1987.

	Grain Yield bu A-1	Forage Yield lb A^{-1}	Plant P ppm	P Uptake lb A-1	Plant Zn ppm	Zn Uptake lb A-1	Plant Fe ppm	Fe Uptake lb A-1	Population plants A-1
Acid	29.8	132	2979	0.39	23.3	0.003	546	0.07	115,434
Acid + Zn	30.6	132	2601	0.34	19.6	0.003	504	0.07	114,345
Acid + Fe	31.2	122	2946	0.36	21.1	0.003	349	0.04	106,722
Acid + Zn + Fe	31.0	125	2471	0.31	19.5	0.002	600	0.08	112,167
Nonacid	30.6	127	2739	0.35	20.5	0.003	426	0.06	111,078
Nonacid + Zn	30.5	113	2458	0.27	18.8	0.002	395	0.05	107,811
Nonacid + Fe	31.5	120	2610	0.31	20.7	0.002	511	0.06	111,078
Nonacid + Zn + Fe	30.5	127	2772	0.35	21.9	0.003	565	0.07	103,455
Check	32.0	128	2888	0.37	23.2	0.003	416	0.05	109,626
Check vs Rest	*	NS	NS	NS	*	NS	NS	NS	NS
Acid	NS	NS	NS	NS	NS	NS	NS	NS	NS
Iron	NS	NS	NS	NS	NS	NS	NS	NS	NS
Zinc	NS	NS	*	NS	NS	NS	NS	NS	NS
Acid * Fe	NS	NS	NS	NS	NS	NS	NS	NS	NS
Acid * Zn	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fe * Zn	NS	NS	NS	NS	NS	NS	NS	NS	NS
Acid * Fe * Zn	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.	5.2	14.2	10.1	12.6	11.0	16.7	40.3	47.2	13.0

* is 0.05 significance level.

Table 4. Treatment means and statistical analyses for grain yield, forage yield, small plant P, Zn, and Fe concentrations and uptakes and populations for Marshall County location in 1987.

	Grain Yield bu A-1	Forage Yield lb A^{-1}	Plant P ppm	P Uptake lb A-1	Plant Zn ppm	Zn Uptake lb A-1	Plant Fe ppm	Fe Uptake lb A-1	Population plants A-1
Acid	28.7	177	3923	0.70	24.3	0.004	251	0.04	68,607
Acid + Zn	27.7	185	4212	0.78	39.6	0.007	423	0.08	72,963
Acid + Fe	27.8	199	4419	0.88	23.6	0.005	285	0.06	79,497
Acid + Zn + Fe	27.8	163	4338	0.72	27.6	0.005	267	0.04	64,251
Nonacid	29.4	157	4758	0.74	24.0	0.004	281	0.04	75,504
Nonacid + Zn	28.6	194	4105	0.79	30.4	0.006	240	0.05	74,052
Nonacid + Fe	30.0	175	4544	0.79	26.9	0.005	286	0.05	71,874
Nonacid + Zn + Fe	29.3	185	4053	0.75	32.2	0.006	275	0.05	76,230
Check	28.3	164	3580	0.59	25.1	0.004	223	0.04	75,141
Check vs Rest	NS	**	**	*	NS	*	*	NS	NS
Acid	NS	NS	NS	NS	NS	NS	NS	NS	NS
Iron	NS	NS	NS	NS	NS	NS	NS	NS	NS
Zinc	NS	NS	NS	**	*	NS	NS	NS	NS
Acid * Fe	NS	NS	NS	**	NS	NS	NS	NS	NS
Acid * Zn	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fe * Zn	NS	NS	NS	*	NS	NS	NS	NS	NS
Acid * Fe * Zn	NS	NS	NS	NS	NS	*	NS	NS	NS
C.V.	9.3	19.7	11.7	22.7	13.1	27.4	25.5	36.4	13.1

** and * are 0.01 and 0.05 significance levels, respectively.

FOLIAR NITROGEN APPLICATION ON SUGARBEET - TIMING AND RATE

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OBJECTIVE: In recent years a growing concern among producers has been the premature yellowing or N deficiency, of sugarbeet fields. Many questions have arisen concerning the use of a foliar N application to correct this situation. Because of the possible detrimental effects on sugarbeet quality, a cooperative study was started with the objective of determining the effects of foliar N application on sugarbeet yield and quality after early yellowing under optimum fertilizer application and under inadequate N conditions.

PROCEDURE: The second year of this study was established at the Northwest Experiment Station, on a soil NO_3^--N test, 0-2 ft, of 40 lb A^{-1}. Table 1 lists the soil and foliar N treatments. The soil N treatments were applied fall, 1986 as Urea and incorporated. Six replications of ACH 164 were planted April 27 in randomized complete block design. The plots were overplanted and thinned to 125 plants per 100 foot of row. The foliar treatments were Urea-ammonium nitrate solution (UAN, 28% N) applied as 20 lb A^{-1} increments on June 30, July 16, and August 3.

Table 1. Treatments for foliar N trial, NWES 1987.

		Foliar			
	Soil Preplant	6/30	7/15	7/30	
Treatment	lb N A^{-1}	------	lb N A^{-1}	-----	Total
1	0	0	0	0	0
2	0	0	0	20	20
3	0	0	20	20	40
4	0	20	20	20	60
5	0	0	0	0	0
6	100	0	0	20	20
7	100	0	20	20	40
8	100	20	20	20	60

Petiole and blade samples were taken 10 days after the final treatment for N determination. Roots and tops were hand harvested September 25. The quality was determined by American Crystal Sugar research quality lab at Moorhead, MN. Brei samples were taken and N was determined on them at J.T. Moraghan's lab at NDSU.

RESULTS AND DISCUSSION: The root yield and recoverable sugar per acre were increased by the addition of soil N, but not by the use of foliar N. The response to soil N was 2.6 tons A^{-1} and 784 lb sugar A^{-1}. Even with the treatment receiving no preplant N, the addition of foliar did not significantly effect root yield, sugar content, recoverable sugar per acre or per ton. The recoverable sugar per ton was significantly decreased by the 100 lb N A^{-1} soil applied treatment. This decrease was caused by the increase in Na and Amino-N contents which measure reduced quality by the N fertilizer (Table 3). The foliar treatments caused a trend towards poorer quality, but this did not result in significantly lower recoverable sugar. In 1987, the use of foliar N did not increase the value of the crop at either soil N level, Table 4. It is not advisable to use a foliar N treatment on sugarbeets. The top growth Table 2 was significantly increased with increasing N application either soil, foliar, or both.

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Table 2. Sugarbeet root and top yield, sugar content, recoverable sugar per ton, and recoverable sugar per acre, MWES 1987.

Soil N	Foliar	Yield	Sugar	Recoverable Sugar	Recoverable Sugar/Ton	Top Yield
lb N A^{-1}	lb N A^{-1}	T A^{-1}	%	lb A^{-1}	lb Ton^{-1}	lb A^{-1}
0	0	14.5	19.3	5207	360	1953
0	20	15.8	19.3	5663	358	2178
0	40	15.7	19.2	5563	355	2191
0	60	16.4	18.9	5748	349	2440
100	0	18.2	19.2	6452	355	2848
100	20	17.6	18.9	6133	348	3104
100	40	18.4	18.9	6340	347	3017
100	60	18.5	18.8	6373	344	3481
	0	16.4	19.3	5830	358	2401
	20	16.7	19.1	5898	353	2641
	40	17.1	19.1	5952	351	2604
	60	17.5	18.9	6061	347	2961
	0	15.6	19.1	5540	355	2190
	100	18.2	18.9	6324	349	3112
Soil N		**	NS	**	*	**
Foliar N		NS	NS	NS	NS	++
S x F		NS	NS	NS	NS	NS
C.V.%		12.8	2.7	12.9	3.3	18.8

**, *, and ++ are 0.01, 0.05, and 0.10 significance levels, respectively.

Table 3. Sugarbeet root impurities, NWES 1987.

Soil N	Foliar	Na	K	Amino-N	Index
lb N A^{-1}	lb N A^{-1}	---------ppm--------			
0	0	225	1933	347	462
0	20	208	1967	365	475
0	40	276	1919	370	485
0	60	282	1957	369	498
100	0	265	1822	415	492
100	20	321	1855	422	518
100	40	301	1878	479	547
100	60	366	1847	484	560
	0	245	1878	381	477
	20	265	1911	394	497
	40	289	1899	425	516
	60	324	1902	427	529
	0	249	1943	362	480
	100	313	1850	450	529
Soil N		**	**	**	**
Foliar N		NS	NS	NS	++
S x F		NS	NS	NS	NS
C.V.%		27.6	5.5	14.9	10.0
L.S.D. 0.05		46	62	36	30

**, *, and ++ are 0.01, 0.05, and 0.10 significance levels, respectively.

Table 4. Economic analyses of foliar N study, NWES 1987.

Soil N	Foliar	Net Beet Payment	
lb N A^{-1}	lb N A^{-1}	Net per ton	Net per acre
0	0	$44.82	$649
0	20	44.53	706
0	40	43.93	687
0	60	42.69	703
100	0	43.80	795
100	20	42.42	747
100	40	42.17	766
100	60	41.50	771
	0	44.31	722
	20	43.48	727
	40	43.05	727
	60	42.10	737
	0	43.99	686
	100	42.47	770

TIMING OF NITROGEN APPLICATION ON SUGARBEET

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OBJECTIVE: Nitrogen fertilizer management has received considerable attention from sugarbeet producers in the past because of the quality payment system. The producer in the Red River Valley area has gone from a situation of too much residual soil N to, in most cases, a manageable to deficit situation. Much concern has grown because of this shift in N situation about sugarbeet prematurely yellowing. The split application of nitrogen may provide an avenue of delaying the yellowing, allow more efficient use of the fertilizer, and not decrease quality. This study was designed with the objective to evaluate the effect of split application of soil N.

PROCEDURE: Plots were established at the Northwest Experiment Station, Crookston, MN, and the Mike Schjeken farm, Sacred Heart, MN. At both locations the Urea Ammonium Nitrate solution (UAN, 28%N) was used as an N source and knife in between the rows four inches deep at four dates. The NWES dates were April 27, June 5, June 25, and July 14. Because of rain, the Schjeken farm dates were delayed May 5, July 2, July 24, and August 3. The total amount of N applied was 80 lb A^{-1}. The soil tests were 41 and 43 NO_3^--N (0-2') A^{-1} at NWES and Schjeken location, respectively. KW 3265 was planted April 28 (NWES) and May 5 (So. MN). The treatments (Table 1) were arranged in a randomized complete block design with four replications. The sugarbeets were harvested September 24 (NWES) and 22 (So. MN) and the quality was determined at American Crystal Sugar's Tare Lab, East Grand Forks, MN.

RESULTS AND DISCUSSION: NWES: The results from Crookston are summarized in Table 1. In 1987 a yield andquality response occurred from N fertilization except for K concentration of the brei. There were no significant differences between the N application treatments for any of the measured variables.

Southern Minnesota: Table 2 lists the results for 1987. Except for a significant decrease in brei K concentration, there was no response to the use of nitrogen fertilizer. This was not expected with a soil test of 43 pounds NO_3^--N A^{-1} in the 0-2' depth. Significant differences between application times were with root yield and recoverable sugar per acre. The 20-20-20-20 treatment yield was less than the other treatments. Because of the late application dates, the plants were disrupted by the fertilizer applicator shanks and caused the lower tonage and sugar yield.

The soil N mineralization for 1987 was greater than in other years. This probably masked the effects of the fertilization particularly at the later dates.

Please refer to title page of this publication for information regarding application and use of this article.

Table 1. Sugarbeet yield and quality as effected by N applications, NWES, 1987, Crookston, MN.

Application Date				Yield	Sugar	Recoverable Sugar	Recoverable Sugar/Ton	Na	K	Amino-N	Index
4/2	6/5	6/25	7/14	T/A	%	lb/A	lb/Ton	-------ppm-----			
0	0	0	0	15.9	18.1	5358	338	223	1818	273	438
20	20	20	20	19.8	17.2	6257	316	438	1595	370	529
40	40	0	0	20.2	17.7	6607	328	290	1745	330	482
40	0	40	0	19.7	17.6	6374	324	328	1830	345	516
40	0	0	40	19.7	16.6	5981	303	393	1835	403	592
0	40	40	0	19.1	18.0	6380	333	303	1775	365	503
0	40	0	40	19.0	17.2	6004	317	353	1720	333	509
0	0	40	40	19.5	16.9	6041	310	395	1768	385	559
80	0	0	0	20.0	17.6	6454	324	365	1770	360	525
0	80	0	0	19.2	17.3	6156	320	328	1678	325	488
0	0	80	0	19.6	17.7	6370	326	335	1835	363	522
0	0	0	80	19.4	17.6	6293	325	348	1733	345	504
Treatment				++	NS	NS	NS	NS	NS	NS	NS
Check vs Rest				**	++	**	++	*	NS	*	*
C.V.%				8.5	4.1	8.7	5.1	33.0	7.7	19.9	19.6
LSD.05				2.36	1.0	775	24	162	194	100	108

**, *, and ++ are 0.01, 0.05, and 0.10 significance levels, respectively.

Table 2. Sugarbeet yield and quality as effected by N application, Mike Schjeken Farm, 1987, Sacred Heart, MN.

Application Date				Yield	Sugar	Recoverable Sugar	Recoverable Sugar/Ton	Na	K	Amino-N	Index
4/2	6/5	6/25	7/14	T/A	%	lb/A	lb/Ton	------ppm-----			
0	0	0	0	20.6	14.7	5336	258	243	2615	453	802
20	20	20	20	18.9	14.4	4830	253	243	2368	485	793
40	40	0	0	22.8	15.1	6033	265	253	2595	555	836
40	0	40	0	24.4	15.0	6549	268	203	2300	405	691
40	0	0	40	21.7	15.3	5975	275	190	2280	380	656
0	40	40	0	22.1	15.0	5875	270	278	2385	430	740
0	40	0	40	21.6	15.2	5830	266	243	2348	493	753
0	0	40	40	24.1	15.2	6554	272	215	2223	438	691
80	0	0	0	20.6	15.2	5573	270	218	2470	413	717
0	80	0	0	22.4	15.5	6163	275	238	2473	485	752
0	0	80	0	24.5	15.2	6720	274	193	2275	415	678
0	0	0	80	21.2	14.8	5571	263	190	2270	458	726
Treatment				++	NS	*	NS	NS	**	NS	NS
Check vs Rest				NS	NS	NS	NS	NS	**	NS	NS
C.V.%				11.2	4.4	12.8	5.5	22.3	5.7	16.4	11.2
LSD.05				3.6	0.9	1092	21	72	197	107	118

**, *, and ++ are 0.01, 0.05, and 0.10 significance levels, respectively.

THE EFFECTS OF SULFUR APPLICATION ON SUGARBEET

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OBJECTIVE: Determine if sugarbeets grown in Minnesota would respond to sulfur. Earlier data (15-20 years ago) indicated that no response in yield occurred when sulfur was applied. The sugarbeet industry has changed since then. Payment on quality, varietal changes, and environmental quality are examples of these changes. Many questions have arisen about sulfur in the past 2-3 years.

PROCEDURE: This study was conducted at two locations in 1987, the Northwest Experiment Station and Southern Minnesota on the Mike Schjeken farm. The soil characteristics are listed in Table 1.

Table 1. Soil characteristics for sulfur study.

	Depth	NWES	So. MN
NO_3^--N	0-24"	40	43
$NaHCO_3$ P	0-6"	9	18
K	0-6"	250	473
S	0-6"	NA	16 ppm
pH	0-6"	8.1	7.8

Elemental sulfur at rates 0, 25, and 50 pounds per acre was spread and incorporated prior to planting in the spring of 1987. Four replications in a randomized complete block design were used at both locations. Maribo 403 was planted April 23 at NWES and May 5 at Southern Minnesota. The plots were overplanted and thinned back to 125 plants per 100 feet of row. The experiment was harvested and quality run on September 16 and 22 for NWES and Southern Minnesota, respectively.

RESULTS AND DISCUSSION: The concern about the need of sulfur for sugarbeets has been, for the most part, unneeded. Tables 2 and 3 list the 1987 results. No response for any characteristic occurred. These results are similar to the 1986 results from NWES. The heavy textured soils of Minnesota normally have enough sulfur made available from the organic matter during the growing season to supply the crop. If a producer was growing sugarbeets on a lower organic matter and sandy textured soil, there may be a cause for concern. A soil test in this case would help indicate if sulfur should be used on a trial basis. The heavy textured soils, high clay contents, are normally underlayed with gypsum which is $CaSO_4$ and a good natural source of sulfur.

Please refer to title page of this publication for information regarding application and use of this article.

Table 2. Sugarbeet yield and quality parameter means and statistical analyses for sulfur study, NWES, 1987.

Sulfur Rate	Root Yield	Root Sugar	Recoverable Sugar	Recoverable Sugar/Ton	
lb/A	lb/A	%	lb/A	lb/Ton	Index
0	17.7	17.9	5774	328	542
25	17.0	17.7	5513	324	543
50	16.4	17.9	5408	329	515
Statistical Analyses					
Sulfur	NS	NS	NS	NS	NS
Linear	NS	NS	NS	NS	NS
Quadratic	NS	NS	NS	NS	NS
C.V. %	10.4	2.7	8.1	4.1	11.4

Table 3. Sugarbeet yield and quality parameter means and statistical analyses for sulfur study, southern Minnesota, 1987.

Sulfur Rate	Root Yield	Root Sugar	Recoverable Sugar	Recoverable Sugar/Ton	
lb/A	lb/A	%	lb/A	lb/Ton	Index
0	18.8	16.1	5384	286	757
25	19.1	15.8	5311	279	767
50	19.6	16.1	5627	287	729
Statistical Analyses					
Sulfur	NS	NS	NS	NS	NS
Linear	NS	NS	NS	NS	NS
Quadratic	NS	NS	NS	NS	NS
C.V. %	9.0	3.1	9.2	4.0	9.8

PHOSPHORUS FERTILIZATION ON SUGARBEET

John A. Lamb, Soil Scientist
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OBJECTIVE: The objective of this study is to gather more soil test information for phosphorus on sugarbeet. In the economic situation we are currently facing in agriculture, a producer must fine tune inputs into sugarbeet production. To do this the database on which soil test recommendations are made must be continually under revision. This means continual updating with new varieties and under different environmental conditions.

PROCEDURE: Five phorphorus rates (0, 20, 40, 60 and 80 lb P_2O_5 A^{-1}) were applied and incorporated, spring 1987. Sugarbeet variety KW 3265 was planted in four replications April 23, 1987 at the Northwest Experiment Station. The $NaHCO_3$ P soil test was 9 lb A^{-1}. Nitrogen was applied to all plots at 120 lb N A^{-1} (soil NO_3^--N 0-2' + fertilizer N) the previous fall. Plots were thinned to a uniform stand of 125 plants per 100 feet of row. Harvest occurred September 16 and quality determined at the American Crystal Sugar Quality Lab, East Grand Forks, MN.

RESULTS AND DISCUSSION: The results are listed in Table 1. Phosphorus even on a very low soil test did not effect sugarbeet yield or quality. This nonresponse is somewhat unsettling because under most conditions at a 9 lb A^{-1} soil test a response should have occurred. This suggests one of two things: 1) the soil test method is not calibrated well enough for this set of conditions, or 2) the early warm temperatures and above-normal summer temperatures caused the soil organic matter to mineralize P for plant use. More information is needed to understand the role of organic P in the P nutrition of crops grown in the Red River Valley.

Table 1. The effect of phosphorus on sugarbeet yield and quality parameters, NWES, 1987.

	Root		Recoverable		
P Rate	Yield	Sugar	Sugar	Sugar/Ton	
lb P_2O_5/A	lb/A	%	lb/A	lb/Ton	Index
0	21.9	16.6	6561	300	623
20	22.7	16.7	6796	299	709
40	22.1	16.8	6750	305	593
60	23.3	16.0	6618	285	719
80	23.3	16.8	6996	300	699
Statistical Analyses					
Phoshorus	NS	NS	NS	NS	NS
Linear	NS	NS	NS	NS	NS
Quadratic	NS	NS	NS	NS	NS
C.V. %	6.9	3.4	7.1	4.5	12.2

Please refer to title page of this publication for information regarding application and use of this article.

HIGH PHOSPHORUS AND POTASSIUM RATES ON CONTINUOUS SPRING WHEAT

J.A. Lamb and T.E. Cymbaluk

OBJECTIVE: This study was designed to determine the effect of P and K rate combinations on spring wheat yield, nutrient uptake, and soil test P and K levels over an extended period of time. The P and K rate combinations used were selected to provide information on response curves and "maintenance" rates for both elements.

EXPERIMENTAL PROCEDURE: Ten treatments consisting of P and K combinations and applications made to date are shown in Table 1. Treatments applied in the fall of 1986 were broadcast and plowed down. Nitrogen, as urea, was fall applied at 100 lb N A^{-1} and incorporated with a field cultivator on October 14, 1986. Marshall wheat was planted on April 15, 1987 and harvested for grain yield on July 24, 1987. Whole plant samples were taken at soft dough July 6, 1987 for elemental analyses and used to determine forage yields, P, and K uptakes. Soil samples were taken after crop removal to measure the residual effects of the treatments. The plant samples are in the process of being analyzed at the time of this report so will not be reported.

Table 1. Phosphorus and potassium treatment combinations at Crookston in the high P and K study.

	Application Date					
Treatment No.	Spring 1980 Fall 1985	Fall 1980 Fall 1986	Fall 1981	Fall 1982	Fall 1983	Fall 1984
	P_2O_5 lb A^{-1} + K_2O lb A^{-1}					
1	0 + 0	0 + 0	0 + 0	0 + 0	0 + 0	0 + 0
2	0 + 100	0 + 100	0 + 100	0 + 100	0 + 100	0 + 100
3	50 + 100	50 + 100	50 + 100	50 + 100	50 + 100	50 + 100
4	100 + 100	100 + 100	100 + 100	100 + 100	100 + 100	100 + 100
5	150 + 100	0 + 100	0 + 100	150 + 100	0 + 100	0 + 100
6	100 + 0	100 + 0	100 + 0	100 + 0	100 + 0	100 + 0
7	100 + 50	100 + 50	100 + 50	100 + 50	100 + 50	100 + 50
8	100 + 150	100 + 0	100 + 0	100 + 150	100 + 0	100 + 0
9	150 + 100	0 + 0	0 + 0	0 + 0	0 + 0	0 + 0
10	100 + 150	0 + 0	0 + 0	0 + 0	0 + 0	0 + 0

RESULTS AND DISCUSSION: Table 2 lists the grain yield, grain protein, soil pH, $NaHCO_3$ P, and exchangeable K for 1987. The grain yields indicate a significant response to P fertilizer application which has increased the soil test P level in treatments 3 through 10 over check treatments 1 and 2. The soil test values (0-6") taken after the growing season reflect the elevated P levels. Potassium treatments did not effect the grain yield although the treatments have effected the soil test K values. Grain protein was not effected by the treatments.

Please refer to title page of this publication for information regarding application and use of this article.

Table 2. Treatment means and statistical analyses for grain yield, grain protein content, soil pH, $NaHCO_3$-P, and exchangeable K in 1987.

Treatment No.	Grain Yield	Grain Protein	pH 0-6"	$NaHCO_3$ P 0-6"	Exchangeable K
	bu A^{-1}	%		----------ppm----------	
1	35.4	12.9	8.1	4.7	147
2	37.7	12.8	8.1	4.0	202
3	52.4	12.5	8.1	19.7	189
4	45.7	12.7	8.1	33.0	184
5	49.1	12.4	8.0	16.5	195
6	46.0	12.8	8.1	25.9	130
7	47.6	12.5	8.0	27.4	155
8	48.6	12.0	8.0	39.2	165
9	43.0	13.2	8.1	12.7	135
10	47.8	12.6	8.1	9.9	152
Statistical Analyses					
TRT	*	NS	NS	**	**
C.V.	13.8	5.9	0.6	26.0	8.9
LSD .05	9.1	-	-	7.4	21

** and * are 0.01 and 0.05 significance levels, respectively.

RESIDUAL NITROGEN STUDY AT LAMBERTON[1]

J.A. STARICKA AND W.W NELSON

Objectives: 1) Determine the N-rate response for corn in a corn-soybean rotation under the climatic and soil conditions in southwestern Minnesota. 2) Determine if high rates of nitrogen on corn have an influence on soybean yields the following year.

Methods & Materials: The experiment was initiated in 1984 on a Normania loam. Each plot is 30 by 48' with 8 replications each arranged in a randomized block design. In 1984, all 8 blocks were planted in corn. Starting in 1985, half the blocks have been in corn, the other half in soybeans, alternating each year. The treatments consist of six N-rates ranging from 0 to 400 #/Ac applied side dress as urea during the corn year. Additional management data is given in Table 1.

Results: Yields are given in Table 2. Because of the amount of data, only treatment averages, versus individual plot data, will be given here.

In corn, there was a significant response to nitrogen each year. The yield of the check treatment increased each year which may be due in part to earlier planting dates each year. Also the N-rate at which maximum yield was reached decreased each year. The reason for this has not been determined. The highest corn yields were obtained in 1986, the year which had the greatest growing season precipitation (Table 3).

In soybeans, there has not been a response to nitrogen any of the 3 years. Similar to corn, highest yields of soybeans were obtained in 1986.

Soil nitrate samples have been taken each fall in 1-ft increments to 5 foot in the 0, 100, and 400 #N/ac treatment corn plots (Table 4). Between 1984 and 1985 the nitrate level increased in the 0 to 3-ft depth of the 0 and 100 #N/ac treatments but decreased in the 0 to 5-ft depth. The nitrate level increased in all 1-ft increments of the 400 #N/ac treatment. The nitrate levels in the 1-ft increments below 1 foot varied greatly between replications in the 400 #N/ac treatment both years.

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[1]Please refer to the title page of this publication for information regarding application and use of this article.

Table 1a: Corn Management Information

Item		1984	1985	1986	1987
Fall Primary Tillage:		Moldboard	Soil Saver	Soil Saver	Soil Saver
Secondary Tillage	Type:	Disk Twice	Digger Twice	Digger Twice	Disk Twice
	Date:	15 & 18 May	10 May	6 & 7 May	23 & 27 April
Seed	Hybrid:	P 3732	P 3732	P 3732	P 3732
	Rate:	26,000 ppa	26,000 ppa	26,000 ppa	26,000 ppa
	Date:	18 May	13 May	8 May	29 April
Herbicide	Brand:	Sutan-Bladex	Lasso-Bladex	Eradicane-Bladex	Eradicane-Bladex
	Rate:	2.5 & 1.5 #/ac	2.5 & 1.5 #/ac	2.5 & 1.5 #/ac	2.5 & 1.5 #/ac
	Date:	15 May	10 May	6 May	23 April

Table 1b: Soybean Management Information

Item		1985	1986	1987
Fall Primary Tillage:		Soil Saver	Soil Saver	Soil Saver
Secondary Tillage	Type:	Digger Twice	Disk Twice, Digger	Disk Twice
	Date:	10 May	7 May	2 May
Seed	Variety:	Corsoy 79	Corsoy 79	Hardin
	Rate:	63 #/ac	56 #/ac	60 #/ac
	Date:	13 May	8 May	4 May
Herbicide	Brand:	Treflan-Amiben	Treflan-Amiben	Treflan-Amiben
	Rate:	0.75 & 2.5 #/ac	0.75 & 2.5 #/ac	0.75 & 2.5 #/ac
	Date:	10 May	7 May	2 May

Table 2: Corn and Soybean Yields

N-Rate	Corn Yields 1984	1985	1986	1987	Soybean Yields 1985	1986	1987
	Bu/Ac						
0	42	57	97	116	44.4	52.9	43.6
50	64	101	131	127	40.5	54.0	45.1
100	77	127	146	138	42.3	52.8	45.3
200	67	130	151	133	43.4	54.1	44.3
300	83	139	148	129	42.7	52.4	45.0
400	88	139	151	132	42.0	53.2	44.9
LSD(5%)	14	17	12	7	NS	NS	NS

Corn yields are average of 8 replications (1984), 4 replications (1985), or 2 samples from 4 replications (1986 & 1987). Soybean yields are average of 2 samples from 4 replications.

Table 3: Growing season precipitation.

	1984	1985	1986	1987	27-yr Avg.
	inches				
April	4.80	4.07	7.58	0.86	2.74
May	2.74	4.46	2.49	2.34	3.22
June	7.92	4.15	3.20	2.02	3.65
July	2.78	2.37	7.21	6.02	4.00
Aug.	2.51	6.15	3.71	1.54	2.66
Total	20.75	21.20	24.19	12.78	16.27

Table 4: Soil nitrate test results.

Depth	0 #N/ac 1984	1985	100 #N/ac 1984	1985	400 #N/ac 1984	1985
Feet	ppm					
0 to 1	1.7	2.6	3.2	2.6	10.1	27.2
1 to 2	0.8	2.1	1.4	2.8	17.6	23.3
2 to 3	1.4	1.5	2.3	2.8	8.1	13.7
3 to 4	3.5	1.7	3.8	2.2	4.2	12.1
4 to 5	4.8	2.0	4.2	2.3	4.6	7.7
Total	12.2	9.9	14.9	12.7	44.6	84.0

TWENTY-EIGHT YEARS OF FIELD EXPERIMENTATION WITH NITROGEN SOURCE, PLACEMENT, AND TIME OF APPLICATION TO A WEBSTER LOAM AT THE SOUTHWEST EXPERIMENT STATION LAMBERTON, MN[1]

J. A. Staricka and W. W. Nelson

(Annual reports of this experiment have been included in most of the University of Minnesota Soil Science Department 'Blue Books' and much of this information will not be included here).

The fertilizer treatments have now been applied annually to the same plot area for 28 years. Each plot is 20' by 77.5' with the four replications arranged in a randomized block. After ear corn removal and stalk cutting, the fall treatments are broadcast on their respective plots and the entire area is then moldboard plowed to approximately 12 inches deep. The fall surface treatments are then broadcast with no further working of the plow area. Spring treatments are broadcast before seedbed preparations in late April or early May. The corn is planted in 30-inch rows at a plant population of 26,000 plants/A, using a band starter fertilizer of 8-24-12 at a rate of 180#/A over the entire experimental area, thus supplying an additional 14 #N/A to all plots. Sidedress treatments are broadcast in June.

1987 results: The 1987 yields from this experiment are given in Table 1. The one-way analysis of variance (Table 2) indicates a significant treatment effect. The LSD for yield (95% conf. level) = 12.7 bu/ac.

Also included in Table 1 are the 27-yr averages. (In 1976, no yields were obtained due to drought, thus only 27 years of data exist). The overall average corn yield and the yield averages for all treatments were all above their corresponding 27-yr average. The trends in yield observed in 1987 follow the trends of the 27-yr averages closely. The greatest response is to increasing N-rates. There is a moderate response to delayed application time, with the exception of the fall surface treatments. There is little difference in yield between ammonium nitrate and urea treatments.

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[1]Please refer to the title page of this publication for information regarding application and use of this article.

Table 1. Influence of nitrogen form, rate, and time of application on grain yield on a Webster loam, Southwest Experiment Station, Lamberton, MN 1987.

Nitrogen Treatment			1987					27-yr
Rate	Form	Time	Rep. 1	Rep. 2	Rep. 3	Rep. 4	Avg.	Avg.
#N/Ac			Bu/Ac @ 15.5 % moisture					
--	Check	----	98.9	90.1	79.2	96.3	91.1	66.0
40	Ammonium Nitrate	Fall	132.4	124.9	109.0	113.4	119.9	84.4
40	Urea	Fall	121.8	111.1	112.1	118.6	115.9	88.1
40	Ammonium Nitrate	Fall Surface	149.3	115.7	121.9	101.6	122.1	81.6
40	Urea	Fall Surface	117.7	117.5	123.2	111.0	117.4	87.2
80	Ammonium Nitrate	Fall	135.0	131.8	127.4	131.2	131.4	105.0
80	Urea	Fall	131.1	123.5	141.7	146.7	135.8	104.2
160	Ammonium Nitrate	Fall	144.9	141.0	140.6	139.9	141.6	112.1
160	Urea	Fall	154.9	138.9	144.7	145.0	145.9	114.2
40	Ammonium Nitrate	Spring	111.7	109.4	102.5	120.7	111.1	95.6
40	Urea	Spring	132.4	141.4	111.6	125.5	127.7	94.1
80	Ammonium Nitrate	Spring	136.3	155.1	132.9	137.2	140.4	107.7
80	Urea	Spring	141.2	132.8	134.8	147.2	139.0	109.4
40	Ammonium Nitrate	Side Dress	116.8	121.3	135.7	116.9	122.7	97.9
40	Urea	Side Dress	124.0	121.3	129.0	129.0	125.8	98.3
80	Ammonium Nitrate	Side Dress	128.5	119.4	142.5	132.6	130.8	104.0
80	Urea	Side Dress	153.9	147.0	138.0	151.2	147.5	112.8
160	Ammonium Nitrate	Side Dress	151.7	166.7	161.1	158.7	159.6	117.1
	Average		132.4	128.3	127.1	129.0	129.2	98.9
	LSD (5%)						12.7	

Table 2. One-way analysis of variance.

Source	DF	Sum of Squares	Mean Square	F-Value	Probability
Treatment	17	16989	999.4	12.49	0.00
Error	54	4322	80.0		
Total	71	21311			

WEST CENTRAL EXPERIMENT STATION
WEATHER SUMMARY - 1987

		Precipitation			Temperature			Soil Temperature (10 cm depth)	
Month	Period	1987	100-yr. av.	Dev. from av.	1987	100-yr. av.	Dev. from av.	1987	10 yr. av.
January	1-31	0.63	0.68	-0.05	17.9	8.0	+ 9.9	24.5	20.7
February	1-28	0.32	0.67	-0.35	29.5	12.8	+16.7	26.7	23.9
March	1-31	1.57	1.13	+0.44	32.2	26.7	+ 5.5	30.0	29.2
April	1-10	T	0.57	-0.57	43.5	38.0	+ 5.5	37.2	
	11-20	0.33	0.64	-0.31	55.4	44.4	+11.0	46.0	
	21-30	0.06	1.05	-0.99	54.6	48.3	+ 6.3	51.2	
Total or av.		0.39	2.26	-1.87	51.2	43.6	+ 7.6	44.7	41.4
May	1-10	0.12	0.77	-0.65	60.1	52.0	+ 8.1	54.4	
	11-20	0.36	0.95	-0.59	62.7	55.8	+ 6.9	60.2	
	21-31	2.44	1.25	+1.19	60.3	60.0	+ 0.3	58.9	
Total or av.		2.92	2.97	- .05	61.0	56.1	+ 4.9	57.5	57.1
June	1-10	0.16	1.29	-1.13	65.4	63.0	+ 2.4	64.6	
	11-20	1.70	1.30	+0.40	71.8	66.3	+ 5.5	71.2	
	21-30	0.01	1.37	-1.36	66.8	68.1	- 1.3	73.3	
Total or av.		1.87	3.96	-2.09	68.0	65.8	+ 2.2	69.7	69.3
July	1-10	0.69	1.44	-0.75	68.7	70.1	- 1.4	72.7	
	11-20	0.30	1.06	-0.76	69.8	71.4	- 1.6	70.2	
	21-31	0.82	1.01	-0.19	76.9	71.4	+ 5.5	79.6	
Total or av.		1.81	3.51	-1.70	72.0	70.9	+ 1.1	74.3	76.7
August	1-10	0.28	1.04	-0.76	70.0	70.4	- 0.4	75.6	
	11-20	0.67	0.93	-0.26	67.4	69.0	- 1.6	72.5	
	21-31	0.51	1.04	-0.53	59.9	66.9	- 7.0	65.0	
Total or av.		1.46	3.01	-1.55	65.6	68.7	- 3.1	70.8	73.9
September	1-30	2.89	2.20	+0.69	59.0	59.0	0	60.8	61.5
October	1-31	0.42	1.74	-1.32	41.7	47.2	- 5.5	43.0	47.8
November	1-30	0.82	0.97	-0.15	35.0	29.7	+ 5.3	35.0	33.6
December	1-31	0.67	0.68	-0.01	20.9	15.2	+ 5.7	28.7	23.4
April-Aug. Growing Season		8.45	15.71	-7.26	63.6	61.0	+ 2.6	63.5	63.8
January-December Annual		15.77	23.78	-8.01	46.2	42.0	+ 4.2	47.3	46.7

ALFALFA FERTILITY-MANAGEMENT STUDY
MORRIS, MN 1987

S. D. Evans, C. C. Sheaffer, and G. A. Reginbal

OBJECTIVES: With the newer alfalfa management procedures, higher yields have resulted. In many cases this might put the plant under greater stress, so it is important to investigate the effect of P and K fertilization on alfalfa yield and stand longevity. Therefore, a study was set up at Morris in 1983 to investigate the effect of (1) P and K fertilization, (2) alfalfa cutting schedule, and (3) variety on alfalfa.

MATERIALS AND METHODS: The experiment was located on a Tara silt loam (Pachic Udic Haploboroll) site that tested medium in Bray P (19 lbs/acre) and high in exchangeable K (234 lbs/acre). The experiment was direct seeded on May 23-24, 1983. The design was a split-split plot with four replications. The main plots were cutting schedule. The first split was P and K fertilizer and the second split was variety. In 1983 the area was harvested but no yields were taken and no fertilizer applied. In 1984-86 the cuttings were taken as scheduled. Fertilizer was applied by hand after the first cutting except for the 300- and 400-lb K rates where 200 lbs/acre were applied after the first cutting and the remainder after the second cutting. In the spring of 1987 the plots were evaluated on May 7 and winter injury and percent stand notes were taken. In 1987 all plots were cut only three times on the 3-cut schedule to measure the residual effect of previous treatments. Yields were taken with a small flail chopper, weighed and a moisture sample collected from each plot. Samples of the Answer variety were saved for possible chemical analysis. The harvest dates in 1987 were June 3, June 30, and August 6. The plots were undercut on September 22 and a stand count taken.

RESULTS AND DISCUSSION: The yields for 1987 are given in Tables 1 and 2. The ANOVA results given in Table 3 show that the cutting schedule from 1984-86 had a highly significant effect on total 1987 yields. Those on the previous 4-cut schedule at 1/2 bud yielded only 1.69 tons/acre while those on the 3-cut schedule at 1/10 bloom yielded 2.98 tons/acre. The variety effect showed up as highly significant with Vernal outyielding Answer by .19 tons/acre. There was a highly significant effect of fertilizer with both P and K bringing about yield increases. The application of 100 lbs P_2O_5/acre doubled the yield over where no P was applied. The application of 400 lbs K_2O/acre increased the yield about 30% over the treatment with no K added. There was some indication of an interaction between cutting schedule and PK fertility. It appears that the treatments that had been on the 3-cut schedule were able to take better advantage of the extra P compared to those that had been on the 4-cut schedule. The fertilizer and variety effects on individual cuttings are shown in Tables 5 and 6.

The ANOVA's of the injury rating and stand evaluations are given in Table 6. All main effects were significant and the cutting schedule by variety interaction was significant for the first two variables. It can be seen in Table 7 that the 4-cut system resulted in a higher injury rating, a lower stand, and a lower plant count than the 3-cut system. The results of the fertilizer variable (Table 8) is not completely clear. The increased P appeared to reduce the injury, the stand, and the plant count. The addition of K also reduced the injury, but higher stand count. It appears that either the 50- or 100-lb K rate was sufficient. There was no effect of K on plant count. In Table 9 it can be seen that Vernal had a lower injury rating, a higher stand, and a slightly higher plant than Answer.

Table 1. Effect of cutting schedules, P and K fertilization and varieties on alfalfa yields at Morris in 1987.

Fertilizer Rate		3-cut+ Variety			4-cut+ Variety			Average over Fertilizer
P_2O_5	K_2O	Vernal	Answer	Average	Vernal	Answer	Average	
- - lb/acre - -		- - - - - - - - - - - - - - Dry Matter (T/acre) - - - - - - - - - - - - - -						
0	200	1.82	1.91	1.87	1.10	0.90	1.00	1.43
50	200	3.26	2.87	3.06	1.81	1.75	1.78	2.42
100	200	4.02	3.78	3.90	2.06	2.03	2.05	2.97
50	0	2.59	2.32	2.46	1.55	1.50	1.52	1.99
50	100	3.21	2.91	3.06	1.58	1.40	1.49	2.28
50	200	3.40	3.02	3.21	1.97	1.75	1.86	2.53
50	300	3.23	2.79	3.01	2.04	1.58	1.81	2.41
50	400	3.26	3.31	3.28	1.95	1.97	1.96	2.62
Average		3.10	2.86	2.98	1.76	1.61	1.69	2.33
CV = 10.6%								

+All plots were cut only 3 times in 1987. The 3-cut and 4-cut systems were used in 1984, 1985, and 1986.

Table 2. Effect of P and K fertilization and variety on alfalfa yields at Morris in 1987.

Fertilizer Rate		Varieties	
P_2O_5	K_2O	Vernal	Answer
- - - - lb/acre - - - - -		- - - Dry Matter (T/acre) -	
0	200	1.46	1.41
50	200	2.54	2.31
100	200	3.04	2.91
50	0	2.07	1.91
50	100	2.40	2.16
50	200	2.69	2.38
50	300	2.64	2.18
50	400	2.61	2.64
Average		2.43	2.24
CV = 10.6%			

Table 3. Effect of cutting schedule, P and K fertilization and variety on alfalfa yields.

Variable	Signif. level+
	- - % - -
Cutting Schedule (CS)	>99
PK Treatment (PK)	>99
CS x PK	>92
Variety (V)	>99
CS x V	69
PK x V	80
CS x PK x V	28

+Probability that differences are not due to chance.

Table 4. Effect of P and K fertilization and variety on alfalfa yields by individual cuttings in 1987.

Variable	3-cut Schedule			4-cut Schedule		
	1st	2nd	3rd	1st	2nd	3rd
	- - - - - - - - signif. level (%)+ - - - - - - - -					
PK Treatment (PK)	>99	>99	>99	98	>99	>99
Variety (V)	>99	>99	78	86	98	93
PK x V	49	83	69	54	18	84

+Probability that differences are not due to chance.

Table 5. Effect of P and K fertilization and variety on alfalfa dry matter percentage by individual cuttings in 1987.

Variable	3-cut schedule			4-cut schedule		
	1st	2nd	3rd	1st	2nd	3rd
	- - - - - - - - signif. level (%)+ - - - - - - - -					
PK Treatment (PK)	>99	>99	82	80	>99	>99
Variety (V)	61	77	2	86	85	23
PK x V	93	28	91	68	9	63

+Probability that differences are not due to chance.

Table 6. Effect of cutting schedule, P and k fertilization and varieties on alfalfa injury and stands at Morris in 1987.

Variable	5-7-87 Injury Rating[a]	5-7-87 Stand[b]	9-22-87 Plant Count[c]
	- - - - - signif. level[+] - - - - -		
Cutting Schedule (CS)	>99	>99	>99
PK Treatment (PK)	98	97	>99
CS x PK	60	54	98
Variety (V)	>99	>99	>99
CS x V	>99	>99	18
PK x V	58	75	21
CS x PK x V	79	61	92

[+]Probability that differences are not due to chance.

Table 7. Effect of cutting schedule on alfalfa injury and stands at Morris in 1987.

Cutting Schedule	Injury Rating[a]	Stand[b]	Plant Count[c]
	---	-%-	- no.-
3-cut	5.0	49	18
4-cut	8.0	20	12

Table 8. Effect of P and K fertilization on alfalfa injury and stands at Morris in 1987.

Fertilizer Rate P_2O_5	K_2O	Injury Rating[a]	Stand[b]	Plant Count[c]
- - lb/acre - -		- -	- % -	- no. -
0	200	6.4	41	20
50	200	6.5	35	14
100	200	5.9	37	13
50	0	7.4	28	14
50	100	6.6	33	15
50	200	6.6	36	15
50	300	6.6	33	13
50	400	6.4	34	14

Table 9. Effect of Variety on alfalfa injury and stand at Morris in 1987.

Variety	Injury Rating[a]	Stand[b]	Plant Count[c]
	- -	- % -	- no. -
Vernal	6.2	39	16
Answer	6.9	30	14

[a] 1= no winter injury, 3= no stand loss but 10-20% of the plants showing injury, 5= 10-20% of the plants dead, 7= 30-50% of the plants dead, 8= 80-90% of the plants dead.

[b] Percent stand on 5-7-87

[c] number of plants in a 20- by 18-inch area on 9-22-87.

CONTINUOUS CORN SILAGE
MORRIS, MN 1987

S. D. Evans

OBJECTIVES: This study was initiated in 1965 on a 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. Silage yield samples were collected on all plots and then on half the plots the entire plant was removed with standard silage harvesting equipment. On the remaining plots shelled corn yield samples were collected and then these plots were harvested with a standard corn combine. Half the plots received a fertilizer rate of 74 + 48 + 48 ($N + P_2O_5 + K_2O$ in lbs/acre) and the other half a rate of 148 + 96 + 96.

MATERIALS AND METHODS: The experiment is set up as a latin square with 4 treatments: (1) silage, low fertility, (2) silage, high fertility, (3) grain, low fertility, and (4) grain, high fertility. The experimental area has been moldboard plowed each fall. In the spring the soil is tilled with a field cultivator prior to planting. In 1987 the variety used was Dekalb 461 and was planted on April 27 @ 24,300 seeds/acre. Thimet was applied in the row at planting at 10 lbs/acre (1.5 lb/acre a.i.). The fertilizer was all applied the previous fall prior to plowing. Lasso @ 3 lbs/acre a.i. + Bladex @ 2.2 lbs/acre a.i. were applied broadcast on April 28. Silage yields were taken on August 25 and grain yields on September 23. Yields were also taken as in past years on an adjacent unfertilized area where only the grain is removed. These check yields are an average from two measured areas.

RESULTS AND DISCUSSION:

Grain and Silage Yields: The silage yields are given in Table 1. The only significant difference in silage yields in 1987 was that grain, high fertility, was lower yielding than all other treatments. This was not consistent with other years and there is no logical explanation. The 22-year average shows no effect of the silage vs. grain. However, the higher fertility level shows an increased yield over the low fertility level. The grain yields for both 1987 and the 22-year average show an advantage for the higher fertility level.

Soil Test Values: The results of the 1987 soil test values are given in Table 4. There were large differences in soil P and K levels due to fertilizer treatments. The P levels on plots receiving only 48 lbs P_2O_5/acre annually are in the medium range while plots receiving 96 lbs P_2O_5/acre are in the very high range. Soil test K levels are higher under the high fertility treatment and are considerably higher where only the grain has been removed compared to removing corn silage.

Table 1. Effect of removal of continuous silage or grain on silage yields.

Treatment	1987 Yield	1966-87 Yield
	- - - dry matter, tons/acre - - -	
Silage, Low fertility	7.64	5.45
Silage, High fertility	7.65	5.97
Grain, Low fertility	7.86	5.50
Grain, High fertility	6.73	5.85
Signif. levels (%):		
Treatment	93.5	>99
Year	- -	>99
Treatment x Year	- -	>99
LSD, treatment (.05)	0.86	0.22

Table 2. Effect of fertilizer level on grain yields.

Treatment	1987 Yield	1966-87 Yield
	- - - bu/acre @ 15.5 % M. - - - -	
Grain, Low fertility	128.6	88.6
Grain, High fertility	119.3	94.2

Table 3. Yields on an average of two unfertilized checks adjacent to the experimental area.

Treatment	1987 Yield	1966-87 Yield
Grain	97.7 bu/acre	46.6 bu/acre
Silage	4.28 tons/acre	3.53 tons/acre

Table 4. Soil test results from the experimental area, Fall 1987.

Treatment	pH	Bray P	Olsen P	Exch. K	Zinc
		- - - - -	lbs/acre	- - - - -	ppm
Silage, High fertility	8.0	19	15	213	1.8
Silage, Low fertility	8.0	65	49	248	1.8
Grain, Low fertility	8.1	33	20	275	1.8
Grain, High fertility	8.0	69	57	341	2.0
Check	8.1	10	6	210	1.7

MANURE RATE STUDY
MORRIS, MN 1987

S. D. Evans, P. R. Goodrich, G. L. Malzer and R. C. Munter

OBJECTIVES: This study was initiated in 1972 to investigate the effect of application of three rates of solid and liquid beef manure on corn growth and soil properties. The manure treatments were compared to commercial fertilizer and check treatments. Seven fall applications of manure were made from 1972 thru 1978 (application omitted in 1977). Fertilizer was applied to the commercial fertilizer treatment each year at the same rate. The treatments and abbreviations are as follows:

CHECK - CK - No fertilizer or manure
FERTILIZED - FE - 120 + 50 + 50 ($N + P_2O_5 + K_2O$) in lbs/acre/year
SOLID BEEF MANURE, RATE 1 - SB1 - 33 tons/acre annually (wet weight), total application of 233 tons/acre
SOLID BEEF MANURE, RATE 2 - SB2 - 67 tons/acre annually (wet weight), total application of 467 tons/acre
SOLID BEEF MANURE, RATE 3 - SB3 - 100 tons/acre annually (wet weight), total application of 700 tons/acre
LIQUID BEEF MANURE, RATE 1 - LB1 - 4530 gallons/acre annually, total application of 31700 gallons
LIQUID BEEF MANURE, RATE 2 - LB2 - 9060 gallons/acre annually, total application of 63400 gallons
LIQUID BEEF MANURE, RATE 3 - LB3 - 13580 gallons/acre annually, total application of 95100 gallons

MATERIALS AND METHODS: The plots were sampled in the fall of 1986 after corn harvest to a depth of 4 feet. Two cores were taken in each plot, separated into 1-foot increments and mixed. The samples were dried at 100oF. The samples were then tested for total inorganic nitrogen, nitrate nitrogen, and ammonium nitrogen. In the fall of 1986 the plots were moldboard plowed. In the spring of 1987 the area was field cultivated twice on April 22 and then planted to Pioneer 3790 @ 26,000 seeds/acre on April 23. Thimet was applied @ 10 lbs/acre (1.5 lbs/acre a.i.) in the row to the entire area at planting. The fertilized plots had received a broadcast application of 120 + 50 + 50 ($N + P_2O_5 + K_2O$) lbs/acre on October 29, 1986. Lasso @ 3 lbs/acre (a.i.) + Bladex @ 2.2 lbs/acre (a.i.) were broadcast on April 28. On June 9 plant heights were recorded and 10 plants were harvested for dry weight determination. Leaf samples were collected at mid-silk and analyzed for a number of elements. Silage yields were calculated from two 10-foot rows hand harvested on August 25. Two rows 34 feet long were harvested with a plot combine on September 23. Harvest weights were recorded with a weigh cell on the combine and a grain sample was saved for moisture determination in the lab. After grain harvest 0 to 8-inch soil samples were collected from all plots for P, K, and Zn determination. Deep soil samples were then taken for nitrogen analysis. The cores were separated into 1-foot increments to the 4-foot depth and then into 2-foot increments to the 18-foot depth. An attempt was made to get two complete cores/plot but rocks and other problems prevented this on some plots. Except for one plot, this was only a problem below the 12-foot depth. The two cores were mixed, subsampled, and dried at 100°F.

RESULTS AND DISCUSSION:

Fall 1986 Soil Samples: The results of the nitrate-nitrogen analyses are given in Table 1. There was a significant treatment x depth interaction. Levels in the manure treatments generally increased with rate and there tended to be more nitrate-nitrogen at the 4-foot level then higher in the profile. The levels in all manure treatments except SB3 are not greatly different from the fertilized treatment. There was no treatment effect on ammonium-nitrogen levels, but the depth effect was highly significant. Levels in the first foot averaged 11 ppm while the other 3 one-foot increments averaged 2 to 3 ppm.

Table 1. Effect of two types of cattle manure and commercial fertilizer on the nitrate-nitrogen level of a Tara soil profile - Fall 1986.

DEPTH INCREMENT	CK	FE	SB1	SB2	SB3	LB1	LB2	LB3	MEAN
- ft -				ppm NO_3-N					
0-1	5	9	6	6	13	5	12	6	5
1-2	3	17	11	5	17	11	27	13	12
2-3	3	17	18	21	40	13	15	14	12
3-4	3	25	25	39	71	10	37	28	23
Mean	3	17	15	18	35	9	23	15	

Signif. Level (%):

Replication	- 80	
Treatment	- 99	BLSD (.05)-2
Depth	- >99	BLSD (.05)-4
Trt. x depth	- >99	

Leaf Tissue Analysis: The nutrient concentration in the ear leaves at silking in 1987 is given in Table 2. There were significant treatment effects on P, K, Mg, Fe, and Zn. Phosphorus levels generally increased with manure rate, but SB1 and all LB treatments are slightly below the sufficient level. Potassium increased with manure and all manure treatments have adequate levels. Magnesium levels decreased with increasing manure rate, but all levels are sufficient. Zinc levels increase with manure rate, but some treatments are slightly below the sufficiency level of 20 ppm.

Table 2. Summary of analysis of corn leaves at silking - 1987.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
			%					ppm		
CK	2.03	0.18	1.75	0.50	0.38	107.9	16.7	7.4	59.6	5.6
FE	2.87	0.26	2.14	0.63	0.35	112.5	37.7	7.1	110.9	5.8
SB1	2.06	0.21	2.22	0.48	0.28	101.3	18.2	6.1	60.8	5.5
SB2	2.47	0.25	2.48	0.53	0.24	121.9	19.4	6.3	71.9	5.2
SB3	2.61	0.27	2.59	0.50	0.22	117.6	23.6	6.7	72.7	5.3
LB1	2.07	0.19	1.71	0.54	0.40	96.3	15.5	6.0	71.1	5.1
LB2	2.27	0.22	1.88	0.54	0.40	103.8	16.4	6.1	71.1	5.3
LB3	2.27	0.23	2.29	0.47	0.28	109.2	19.6	6.9	74.7	5.8
Signif. level (%)	86	98	>99	88	>99	98	>99	30	83	70
BLSD (.05)	NS	0.06	0.18	NS	0.07	14.3	4.3	NS	NS	NS
CV (%)	16.1	13.5	5.3	11.4	13.3	6.9	12.8	17.0	27.7	6.8

Plant and Yield Measurements: The early plant height, early dry weight, silage yields, and grain yields are given in Table 3. The early heights of the manure treatments were not significantly different from the fertilized treatment. All heights increased with manure rate, but the SB treatments are taller than FE and the LB treatments are shorter than FE. The only manure treatment with an early plant weight below FE was LB1. The SB2 and SB3 treatments are significantly heavier than FE. Grain yield generally increased with manure rate except for LB3. None of the manure treatments were significantly different in grain yield from FE. Silage yields increased with manure rate. There was a significant difference between the silage yield of LB1 and FE.