SOIL SERIES 114

A REPORT ON FIELD RESEARCH IN SOIL SCIENCE

The 1984 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 SEA-USDA, the Tennessee Valley Authority, The Departments of Agriculture and Natural Resources also contributed information.

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

The investigators also greatly appreciate the cooperation of many county agents, farmers, technical assitants, 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 1983 experiments only and should be regarded on this basis. Since most data are from only 1983 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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The Northward "Speed" of Spring

Earl L. Kuehnast, Donald G. Baker, and James Zandlo

The end of freezing atmospheric conditions in the spring results in dramatic changes at the earth's surface. Warmer air temperatures together with the increasing length of day and the attendant increase in available solar energy, eventually eliminate the snow cover. Once that stage is reached, soils and lake surface no longer have the insulative cover that snow provides. Thus snow-end date, ice-out day, and end of frozen soil have an expected correlation. However, the exact juxtaposition of these events in time, along with other factors such as total winter snow and soil moisture amounts, can produce widely varying consequences for residents of Minnesota. This complex of events has impacts on spring runoff and lake recharge as well as on soil and curface moisture and temperature conditions as related to agriculture and forestry. An iso-line map of "mean lake ice-out date" for a 20-year period, 1960-1979, is shown in Figure 1. The "ice-out date" was collected from 19 lakes generally with depths greater than 20 feet. These 19 lakes are distributed across the state and listed in Table 1. Lake ice-out data were in the most part collected by the Department of Natural Resources fisheries staff and field personnel and in general procured from reports in local newspapers. The observation of the "ice-out date" is subject to some error, probably of a day or so, due to the various methods of observing ice-out. For example, some observers wait until all of the ice has disappeared, others look for no ice between two pre-selected points of land, and some use a percentage of the ice melted, such as 90 percent, as the criterion.

The mean ice-out date of lakes moves progressively northward. Beginning on April 15 it is in the Twin Cities area and by May 5 it has moved into Canada. From this it can be calculated that "spring" moves northward from the Twin Cities at a rate of about 13 to 14 miles per day.

The "movement" of spring may also be monitored by examining the progression of isotherms northward. The mean daily air temperature on the mean date of ice-out for the Minneapolis-St. Paul area is 45°F. This mean 45°F isotherm can be found in Springfield, Missouri, on March 22 and in International Falls on May 2, which is close in time to the ice-out date there. Thus "spring" moves northward from Springfield to Minneapolis-St. Paul at a rate of 22 miles per day (525 miles in 24 days) and then northward from Minneapolis-St. Paul at a rate of about 16 miles per day (266 miles in 17 days). The decrease in the northward rate of movement of the 45°F air temperature line from Missouri to the Canadian Border is most probably due to the additional energy needed to melt the heavier snow cover in the forested area of central and northern Minnesota.

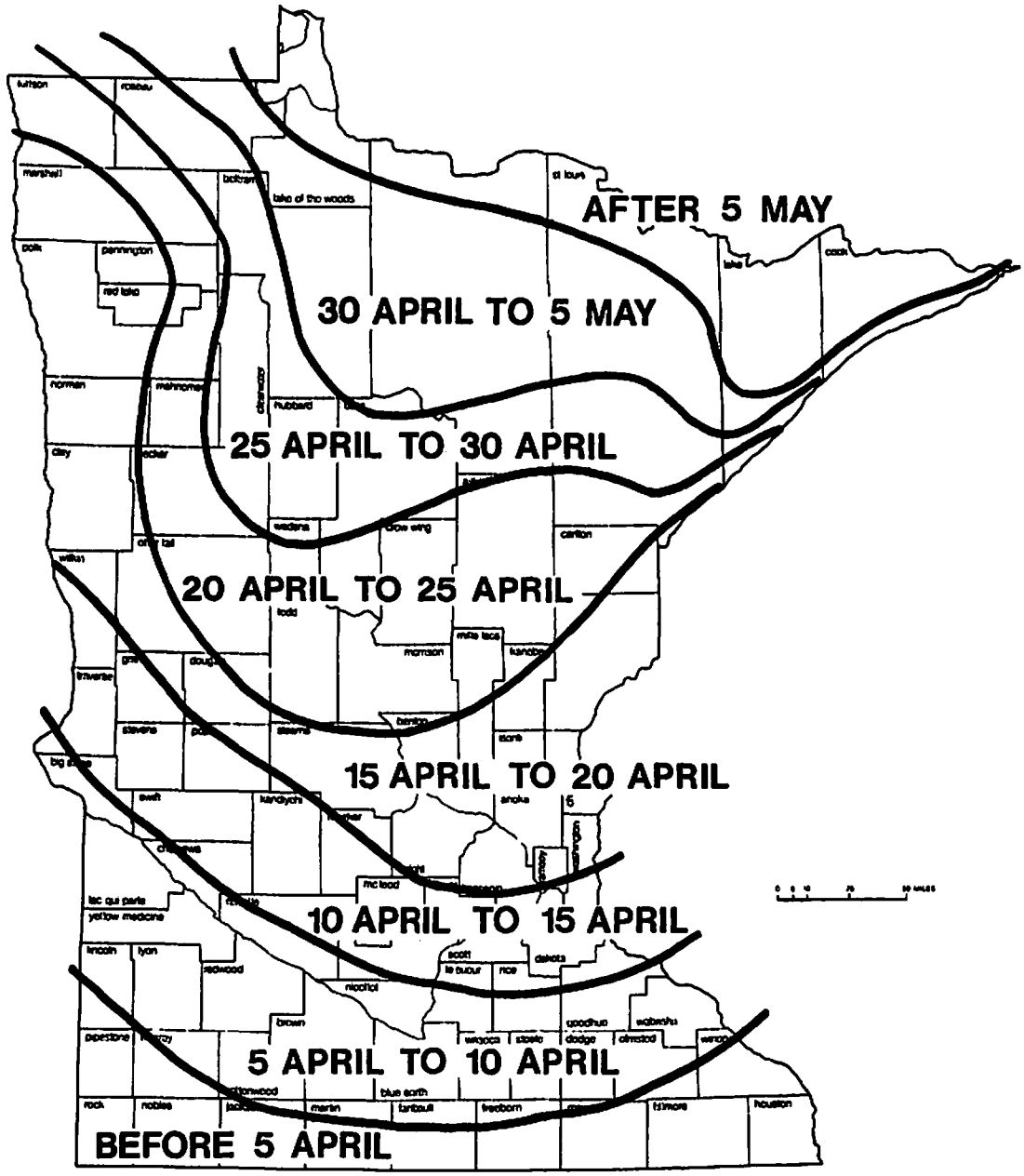
Five lakes - Minnetonka, Minnewaska, Osakis, Detroit and Vermilion - all with more than 70 years of ice-out information, show 1950 as the year with latest ice-out date and 1965 as the next latest. The years with the earliest ice-out dates were 1910, 1945, and 1981. However, old Fort Snelling temperature records dating back to 1819 show the winter of 1877-1878 as the warmest to date. The 1878 newspapers of that spring recorded Lake Minnetonka ice-out on March 11. The average range in dates between the earliest and latest ice-out date is approximately 40 days. The southern Minnesota lakes do not follow these ice-out patterns as well because the lakes are small and shallow, the area is subject to more southerly warm air advection, and the area has less snow cover. All of these factors permit the absorption of more solar radiation and heat energy than where there is a heavier snow cover to the north.

Table 1. Mean ice-out dates at selected lakes, 1959-1979.

Lake	County	Mean Ice-Out Date	Lake	County	Mean Ice-Out Date
Big Stone Lake	Big Stone	10 April	Lake Minnewaska	Pope	15 April
Clear Lake	Waseca	8 April	Lake Osakis	Todd-Douglas	22 April
Crane Lake	St. Louis	*5 May	Ox Lake (big)	Crow Wing	23 April
Detroit Lake	Becker	24 April	Shetek	Murray	8 April
Gull Lake	Cass-Crow Wing	23 April	Sandy Lake	Aitkin	21 April
Gunflint Lake	Cook	9 May	Sissaton	Martin	5 April
Leech Lake	Cass	29 April	Vermilion	St. Louis	2 May
Mille Lacs Lake	Mille Lacs	*25 April	Waconia	Carver	14 April
Lake Minnetonka	Hennepin	15 April	White Bear	Ramsey	16 April
Lake of the Woods	Lake of the Woods	*9 May			

* Estimated by local residents when less than 20 years of data were available.

FIGURE 1.


AFTER 5 MAY
30 APRIL TO 5 MAY
25 APRIL TO 30 APRIL
20 APRIL TO 25 APRIL
15 APRIL TO 20 APRIL
10 APRIL TO 15 APRIL
5 APRIL TO 10 APRIL
BEFORE 5 APRIL

Hydrologic Year Precipitation
(October 1982 - September 1983)

Earl L. Kuehnast and Donald G. Baker

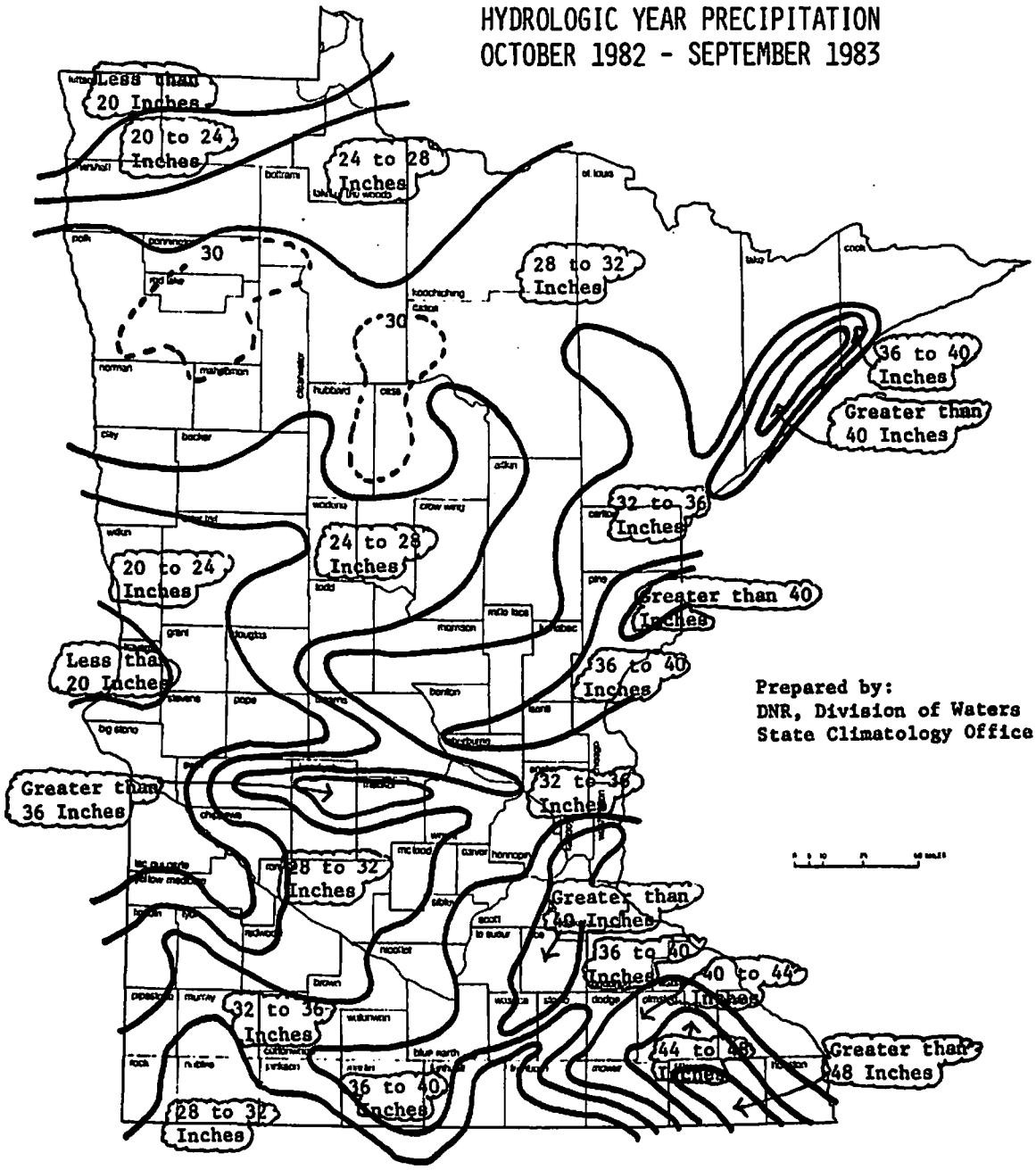
The custom has alwasy been to view climatic data, such as precipitation, on a calendar year basis. For some years the hydrologists have considered a more appropriate period for water supplies to be the October-September period. For example, rivers and streams ordinarily reach their lowest levels about in October, and only after supplies are replenished by late autumn rain and over-winter precipitation do rivers and lakes show increases.

For agriculture, too, the calendar year of January - December does not coincide with the water supply year. Our soil moisture measurements have shown that in most years the soils under full season crops reach their minimum water content in late August or early September. After this date the precipitation is ordinarily greater than the crop requires and soil reserves begin to be replenished. These replenished reserves are then available to the succeeding year's crop. As a result crop yields are more directly related to the September (or October) - August (or September) precipitation rather than that of the calendar year.

For this reason we are showing the October 1982 - September 1983 period in Figure 2. The excessive precipitation of the south-central and eastern part of the state is very apparent. The smallest amount recorded was at Caribou in northern Kittson county with but 15.52 inches and the highest was at Preston in Fillmore county with 51.67 inches.

The average hydrologic year precipitation for the state as a whole is 25.55 inches. For this latest hydrologic year it was 31.27 inches or 5.72 inches above average. The very wet areas across the state were: all of the Southeast District with central Fillmore county receiving 23-26 inches above average; parts of the South-Central District from Martin County northeastward; the Central District from western Kandiyohi east into Wright and Sherburne counties; then generally northeast into the East Central District through Isanti and Pine counties; then another very wet area beginning in the Northwest District in Polk and Norman counties extending eastward through Pennington, Red Lake, and Clearwater counties and parts of Beltrami, Hubbard, Cass and Itasca counties. The only areas of near average precipitation were a small strip in the northwest along the Canadian border and most of the West Central District.

FIGURE 2.
HYDROLOGIC YEAR PRECIPITATION
OCTOBER 1982 - SEPTEMBER 1983



Soil Moisture Situation, Spring 1984

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

This situation report is from a mathematically modeled soil moisture analysis that is based on more than 700 precipitation station data. The model estimates the amount of plant-available water that is contained within a 5-foot column of medium to fine textured soil. The indicated results should be adjusted according to whether the actual soil within a given area can hold more (a heavy or clay soil) or less (a light or sandy soil) than the basic 10 inches.

Almost all areas of the state entered the 1983-84 winter with the soils very high in soil moisture. Indeed the soils as of November 1, 1983, are at about the highest moisture content of the last 15 years as shown in Figure 3. Other years in which the soils entered the winter with high fall soil moisture were 1968, 1979, 1981, and 1982. This means that the state will have had four wet spring conditions in the last five years.

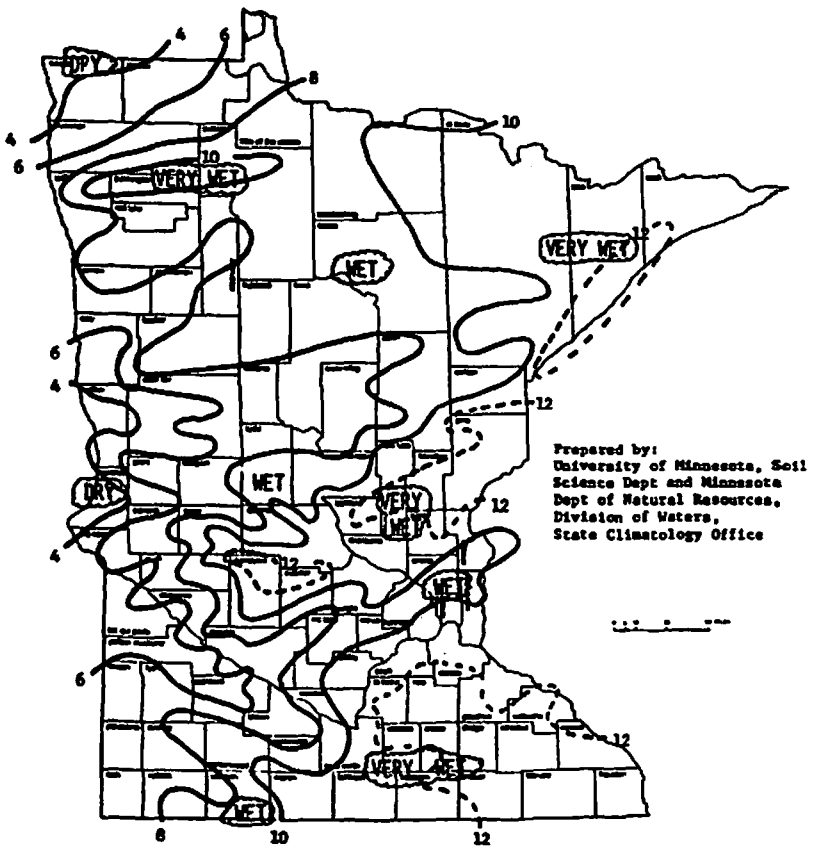
Areas with 10-inches of soil moisture on the map are considered to be at or near their maximum water holding capcity. Soils in the 8 to 10 inch areas should also be near maximum capacity this spring after the winter snow melt and the spring rain. Thus, all of Minnesota except the western 20 or 25 percent is expected to have soils at their maximum capacity this spring. The only areas expected to have a normal to less than normal water content are Kittson, Traverse and Wilken and parts of Redwood, Lyon, Yellow Medicine, Lac Qui Parle, Big Stone, Stevens, Grant, Ottertail, Clay, Marshall and Roseau counties.

The 1984 spring soil water outlook is very similar to the spring of 1983. The important difference between the two years is the early, heavy, and continuous snow cover amounting to anywhere from 10 or more than 20 inches that occurred across the state during the last eight days of November, 1983. This created a most unusual condition. The insulating blanket of snow has reduced the heat loss from the soils to such an extent that over more than two-thirds of the state there is virtually no frost in the soil, Figure 4. Exceptions are found in southwestern Minnesota as far east as Nicollet, Blue Earth, and Martin counties with 6-18 inches of frost. Extending northward along the North and South Dakota border in a band about 50-75 miles wide from approximately Lac Qui Parle county to the Canadian border, the frozen soil is from 18 to 48 inches deep.

At St. Paul, where a long soil temperature record exists, the snow cover since late November has remained greater than 10 inches for much of the winter. As a result the soil has remained above 32°F at all levels. Under average winter conditions the soil at St. Paul would be frozen to 42 inches in mid February and reach a maximum depth of 44 inches in the first week of March.

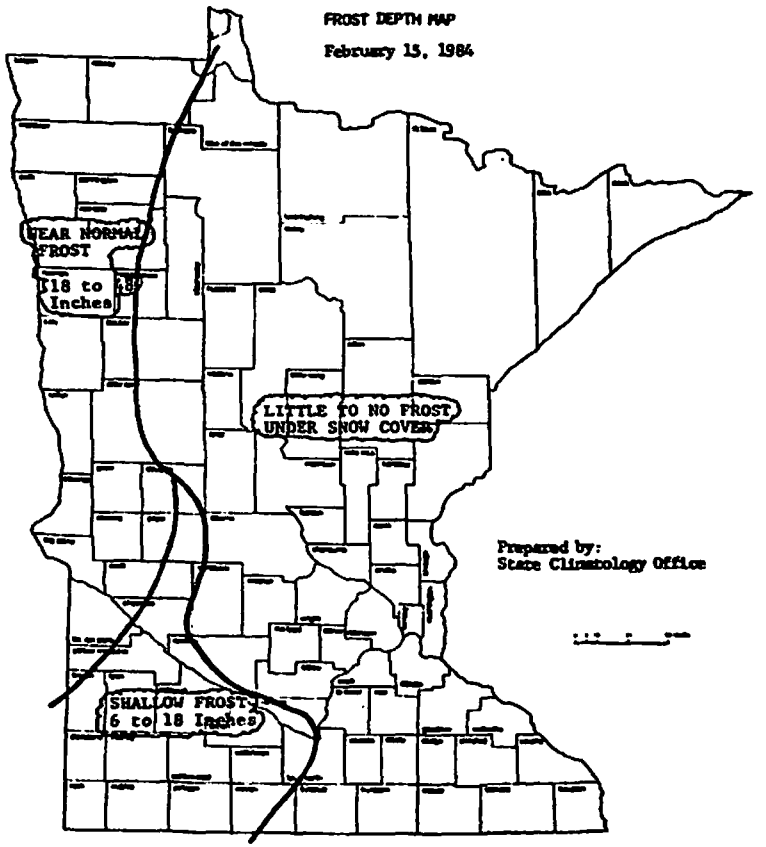
There are several important consequences arising from the deep and persistent snow cover and the shallow or non-existent soil frost. One is that a greater than average amount of snowmelt runoff in the spring can enter the soil - except in those areas where the soil is already wet. In the areas of well-drained and tiled soils much of the water will percolate into the lower profile or the tile drains and therefore should not be a factor in planting with normal spring weather. Areas of poorly drained soils with high moisture and little or no frost will experience a delayed planting season due to excessive moisture in the soil profile unless a drier than usual spring occurs.

Figure 3.



Plant available soil moisture on November 1, 1983 expressed in inches for the top five feet of medium to fine textured soils. Data derived from a soil moisture model based on precipitation from more than 700 weather stations.

Figure 4.



The Modification of Evapotranspiration Calculation Methods to Minnesota Conditions

Brenton S. Sharratt and Donald G. Baker

The monitoring of crop water use is not only important in terms of conserving water but also energy, since it assumes increasing importance as a dollar input when irrigation is practiced. The purpose of this study was to modify empirical evapotranspiration calculation methods that were developed in other regions so they could be used with confidence in Minnesota.

Alfalfa (Medicago Stiva L. "Blazer") was the crop grown on the agricultural weather station on the St. Paul campus of the University of Minnesota. The plot can be irrigated when desired, and there is a precision weighing lysimeter on the plot which permits determination of the water loss from the soil and alfalfa.

The weighing lysimeter consists of a heavy-gauge steel box that contains soil and in which the crop is grown. The surface area of the lysimeter is 30 sq. ft. and it measures 4 ft. deep. The lysimeter is surrounded by a plot of alflafa. The dimensions of the lysimeter are such that its contents - soil, soil moisture, and the crop - weigh more than 7 tons. The lysimeter is resting on a modified truck scale which is counterbalanced so that it becomes a precision scale. It is capable of detecting weight changes that are equivalent to the addition or subtraction of less than 0.001 in. of water.

The weighing lysimeter recording system provides an hourly output of the weight of the tank and its contents. This whole apparatus and system was used to determine the water consumed (the evapotranspiration) by the alfalfa crop. At the same time various meteorological parameters were also measured at the agricultural weather station.

Two evapotranspiratioon calculation methods were compared to the measured evapotranspiration. They were the Blaney-Criddle method and the Jenson-Haise method. The former requires only average daily air temperature and the latter requires daily total solar radiation and average daily temperature. A total of 64 days was available for the comparison in which no rain or irrigation occurred and no adjustments to the weighing lysimeter were required during the years 1981-1983. The alfalfa was planted in 1980 and it had been preceded by 4 years of soybeans. The lysimeter was installed in 1975.

Results indicate that the Jenson-Haise method did the better job of predicting water use of the alfalfa as shown in Table 1.

Table 1. Comparison of Two Evapotranspiration Calculation Methods.

Average Daily Water Use	Average Daily Difference Jenson-Haise	Average Daily Difference Blaney-Criddle
0.297 in.	0.084 $^{+}$ 0.057 in.	0.089 $^{+}$ 0.070 in.

The correlation between the calculated and measured data over the 3-year period was 0.87 and 0.77 for the Jenson-Haise and the Blaney-Criddle methods, respectively.

Based upon the measured data the Jenson-Haise calculation method was modified to:

$$\text{Potential Evapotranspiration} = (0.014\ T^{1} - 0.132)\ (SR)$$

where T^{1} is the average daily temperature and SR is the daily total solar radiation.

References:

Soil Conservation Science. 1979. Irrigation water requirements. U.S. Dept. Agric. Eng. Div., Tech. Release 21.

Jenson, M.E., and H.R. Haise. 1963. Estimating evapotranspiration from solar radiation. Amer. Soc. Civil Eng. Proc., Jour. Irrig. and Dain. Div. 89(IR-4):15-41.

INFLUENCE OF NITROGEN FORM, NITROGEN RATE, TIMING OF NITROGEN APPLICATION AND NITRIFICATION INHIBITORS FOR IRRIGATED CORN - BECKER, MN 1983

G.L. Malzer and T. Graff

Nitrogen management on the coarse textured irrigated soils of Minnesota is a major decision that all corn growers must make in their production system. Nitrogen management includes many aspects of nitrogen fertilization such as rates, forms, methods, times, equipment, and additives. Nitrogen fertilizer application is an essential component for top yields on these coarse textured soils, and many times the producer does not have the flexibility in nitrogen management that a producer on a finer textured soil might have. The use of nitrification inhibitors under irrigation also presents some new nitrogen management techinques that should be considered. The most common method for application of nitrification inhibitors is with simultaneous application of anhydrous ammonia. Under irrigation, nitrogen application may take place in several manners, ranging from one single application to multiple application, which may be facilitated through the irrigation water. With such management systems a variety of fertilizer nitrogen forms may be utilized. These management alternatives often add to the cost of production and require a reasonable amount of timeliness to avoid yield reductions. A new trial was established in 1982 to evaluate the significance of nitrogen rates, nitrogen form, timing of nitrogen application and the use of nitrification inhibitors for irrigated corn production.

Experimental Procedures

An experiment consisting of 25 treatments, with four replications was arranged in a randomized complete block design and established at the Sand Plain Research Farm near Becker, Minnesota. Variables in the experiment consisted of three nitrogen rates (0, 75, 150 #N/A), three nitrogen sources (anhydrous ammonia, urea and 28% nitrogen solution), two types of application (preplant or sidedress at 10-leaf growth stage) and three nitrification inhibitors (none, N-Serve and DCD). Due to the different types and rates of material utilized, the experiment was not conducted in a complete factorial arrangement. Modifications include: 1) Nitrification inhibitor treatments were applied only with preplant N applications; 2) only 28% N solutions and anhydrous ammonia were applied as sidedress N application; 3) N-Serve applications were made at 0.5 lbs. a.i./a rate of application; 4) the DCD treatments were applied as a percentage of the total N applied. Urea and 28% N solution were applied at rates of 10% DCDN while anhydrous ammonia was applied at a rate of 2.5% and 5% N as DCD. Urea was supplied by SKW containing 10% DCDN, applications of DCDL were made to 28% N solution and DCDG to anhydrous ammonia to obtain the appropriate concentration of DCDN.

Prior to planting, broadcast application of potassium-magnesium sulfate (300 #/a 0-0-22), potassium (225 #/a 0-0-60), and phosphorus (90 #/a 0-46-0) were made and incorporated by plowing. Nitrogen applications were made prior to planting (May 3rd) and at the 10-leaf stage of growth (June 23rd). Corn (Pioneer 3906 - 95 day maturity) was planted on June 4th in 30" rows at a population of 30,700 seeds/a. Starter fertilizer was applied at the rate of 165 #/a 8-10-30 side banded at planting. The insecticide Lorsband was banded at planting at the rate of 7#/a. A tank mix of Atrazine (2# ai/A) and Lasso (1½ #ai/A) was applied on May 4th for weed control.

Leaf samples from opposite and below the ear at mid-silking were obtained on July 21st, dried and analyzed for Kjeldahl nitrogen. Total dry matter production and final yields were determined on September 19th by hand harvesting 100 ft.^{2} of plot area. Ears were separated from the stalks, field weights of each obtained, and samples removed for moisture and nitrogen determination. Grain yields were adjusted to 15.5% moisture.

The irrigation program was started on July 8th and continued through August 25th with a total 10.31 inches being applied through irrigation. An additional 23.35 inches of water obtained during the growing season through rainfall. Over one-half of the growing season precipitation was obtained during the month of June. Over one-half of the June precipitation was obtained on June 20-21st.

General Results

The experimental results and statistical analysis are presented in Tables 1 and 2. Due to the incomplete factorial nature of the treatments the statistical analysis was conducted utilizing several different combinations of the treatments. The different methods included: 1) mean comparison of the 25 treatments, and factorial combinations including 2) two nitrogen rates with three nitrogen forms with and without N-Serve, 3) two N rates with two N forms applied at two

different times of application, 4) two N rates with four nitrification inhibitor treatments applied with anhydrous ammonia, and 5) two N rates with three nitrification inhibitor treatments with urea.

The information included in Tables 1 and 2 present information regarding grain, stover, and total dry matter production as well as nitrogen concentrations within the plant parts and N removal. This brief discussion will include evaluation of only grain yields.

The leaching losses of nitrate-N associated with early spring applications were extremely severe at this location in 1983. This is primarily the result of the major precipitation event that occurred approximately six weeks after the early nitrogen applications. This time period allowed for substantial nitrification of ammonium-N to nitrate-N so relatively large quantities of nitrate were lost by leaching. The extent of N loss on yield reduction can be evaluated by comparing the yields associated with preplant N applications with treatments applied at the 10-leaf stage of growth.

Nitrogen rate - Grain yields was significantly increased up through the highest rate of N application (150 #N/a). The factorial combinations for grain yield indicated significant interactions for N-rate x form x time and N rate x inhibitor with anhydrous ammonia. The first interaction would suggest that when N was applied at the low rate delayed application of anhydrous ammonia were superior to 28% N solution application, but at the higher rate of N application the delayed applications produced similar yields. The second interaction for grain yield (N-rate x inhibitor with anhydrous ammonia) would suggest that DCD was more effective in stopping nitrogen loss at the low N rate than was N-Serve, while at the high N rate both inhibitors provided significant yield increases.

Nitrogen Form - When nitrogen losses are minimal, different N fertilization materials tend to provide similar results. However, in 1983 leaching losses were very severe. Under the conditions anhydrous ammonia was superior to the other nitrogen materials. Broadcast forms of fertilizer N such as urea and 28% solution produced similar results. Although urea is 100% ammonium forming, it is possible that differential nitrification may take place due to the method of application (broadcast incorporated vs. injected).

Nitrification inhibitors - All nitrification inhibitors tested provided significant positive yield increases. At the low nitrogen rate (75 #N/A) N-Serve provided a yield increase only when it was used with 28% N solution. The product DCD provided significant yield increases at the low N rate for all three fertilizer products tested. At the higher N rate (150 #N/a) both nitrification inhibitors provided significant yield increases with all fertilizer materials. With anhydrous ammonia, N-Serve and DCD produced similar results. With 28% N solution and urea, DCD was superior to N-Serve.

Table 1. Influence of nitrogen form, nitrogen rates, nitrification inhibitors, timing of nitrogen application on yield grain, and dry matter production on irrigated corn. Becker, MN - 1983

Treatments				Grain	Dry Matter Production		
N-Rate	N-Form	Inhibitor	Time	Yields	Grain	Stover	Total
#/A				Bu/A	T/A		
Control	--------	----------	----	57.8	1.36	1.53	1.53
75	AA	----------	PPL	86.7	2.05	2.05	4.11
75	AA	----------	10-lf	142.5	3.37	2.06	5.43
75	28%	----------	PPL	64.6	1.52	1.90	3.43
75	28%	----------	10-lf	99.8	2.36	1.86	4.47
75	UREA	----------	PPL	71.7	1.69	1.90	3.75
75	AA	N-Serve	PPL	93.4	2.21	2.13	4.34
75	28%	N-Serve	PPL	92.3	2.18	1.95	4.14
75	UREA	N-Serve	PPL	84.7	2.00	1.94	3.94
150	AA	----------	PPL	106.6	2.52	2.21	4.73
150	AA	----------	10-lf	147.9	3.49	2.28	5.78
150	28%	----------	PPL	89.7	2.12	1.92	4.04
150	28%	----------	10-lf	153.4	3.63	2.34	5.98
150	UREA	----------	PPL	79.2	1.87	1.85	3.72
150	AA	N-Serve	PPL	129.1	3.05	2.42	5.48
150	28%	N-Serve	PPL	113.0	2.67	2.20	4.88
150	UREA	N-Serve	PPL	115.8	2.74	2.16	4.90
75	UREA	10% DCDN	PPL	104.2	2.46	1.94	4.41
75	AA	2.5% DCDG	PPL	117.1	2.77	2.14	4.91
75	AA	5% DCDG	PPL	128.7	3.04	2.39	5.43
75	28%	10% DCDL	PPL	93.5	2.21	2.02	4.23
150	UREA	10% DCDN	PPL	134.1	3.17	2.46	5.41
150	AA	2.5% DCDG	PPL	138.8	3.28	2.37	5.66
150	AA	5% DCDG	PPL	133.0	3.14	2.32	5.47
150	28%	10% DCDL	PPL	140.3	3.32	2.56	5.88
P-Value				99	99	99	99
BLSD(.05)				13.2	0.31	0.28	0.28
Factorial Arrangement (N-Rate X N-Form X Inhibitor)							
N-Rate							
75				82.2	1.94	1.98	3.95
150				105.5	2.49	2.13	4.63
P-Value				99	99	96	99
N-Form							
AA				103.9	2.46	2.20	4.66
28%				89.9	2.12	1.99	4.12
UREA				87.8	2.07	1.96	4.08
P-Value				99	99	98	99
BLSD (.05)				8.6	0.20	0.16	0.36
Inhibitor							
Control				83.1	1.96	1.97	3.96
N-Serve				104.7	2.47	2.13	4.61
P-Value				99	99	97	99
Rate X Form				37	37	32	48
Rate X Inhibitor				88	88	88	92
Form X Inhibitor				61	61	2	27
Rate X Form X Inhibitor				72	72	8	49

Table 1 continued on next page

Table 1 continued

Treatments N-Rate #/A	N-Form	Inhibitor	Time	Grain Yield Bu/A	Dry Matter Production Grain	Stover	Total
					T/A		
Factorial Arrangement (N-Rate X N-Form X Time)							
N-Rate							
75				98.4	2.32	1.97	4.36
150				124.4	2.94	2.19	5.13
P-Value				99	99	99	99
N-Form							
AA				120.9	2.86	2.15	5.01
28%				101.9	2.41	2.00	4.48
P-Value				99	99	96	99
Time							
PPL				86.9	2.05	2.02	4.08
10-1f				135.9	3.21	2.13	5.42
P-Value				99	99	91	99
Rate X Form				99	99	36	94
Rate X Time				74	74	94	82
Form X Time				12	12	75	71
Rate X Form X Time				99	99	86	95
Factorial Arrangement (N-Rate X Inhibitor with AA)							
N-Rate							
75				106.5	2.52	2.18	4.70
150				126.8	3.00	2.33	5.34
P-Value				99	99	95	99
Inhibitor							
Control				96.7	2.28	2.13	4.42
N-Serve				111.2	2.63	2.27	4.91
2.5% DCDG				128.0	3.02	2.25	5.28
5% DCDG				130.8	3.09	2.35	5.45
P-Value				99	99	76	99
N-Rate X Inhibitor				99	99	64	96
Factorial Arrangement (N-Rate X Inhibitor with Urea)							
N-Rate							
75				86.9	2.05	1.93	4.03
150				109.7	2.59	2.16	4.68
P-Value				99	99	97	98
Inhibitor							
Control				75.5	1.78	1.87	3.73
N-Serve				100.2	2.37	2.05	4.42
10% DCDN				119.1	2.82	2.20	4.91
P-Value				99	99	96	99
N-Rate X Inhibitor				90	90	92	82

Table 2. Influence of nitrogen form, nitrogen rates, nitrification inhibitors, timing of nitrogen application on leaf N content, grain N content and nitrogen removal by irrigated corn. Becker, MN - 1983

Treatments				N-Concentration			N-Removal		
N-Rate	N-Form	Inhibitor	Time	Leaf	Grain	Stover	Stover	Grain	Total
#/A				---------%---------			-------lbs/A--------		
Control	--------	----------	-------	1.19	1.25	0.46	14.4	34.0	48.4
75	AA	----------	PPL	1.58	1.22	0.47	19.6	50.1	69.8
75	AA	----------	10-1f	2.68	1.43	0.56	23.0	96.6	119.6
75	28%	----------	PPL	1.38	1.27	0.42	16.0	38.7	54.8
75	28%	----------	10-1f	2.17	1.31	0.53	19.9	62.0	81.9
75	UREA	----------	PPL	1.52	1.28	0.47	18.1	43.3	61.4
75	AA	N-Serve	PPL	2.04	1.30	0.43	18.2	57.5	75.8
75	28%	N-Serve	PPL	1.86	1.30	0.47	18.5	57.4	75.9
75	UREA	N-Serve	PPL	1.72	1.17	0.44	17.3	46.8	64.1
150	AA	----------	PPL	2.32	1.37	0.49	21.7	68.7	90.4
150	AA	----------	10-1f	2.83	1.51	0.62	28.4	105.9	143.3
150	28%	----------	PPL	1.72	1.28	0.42	16.2	54.6	70.9
150	28%	----------	10-1f	2.97	1.39	0.61	28.8	100.8	129.7
150	UREA	----------	PPL	1.68	1.23	0.43	16.2	46.0	62.2
150	AA	N-Serve	PPL	2.50	1.43	0.50	24.6	82.4	107.1
150	28%	N-Serve	PPL	2.30	1.21	0.49	21.8	64.9	86.7
150	UREA	N-Serve	PPL	2.40	1.28	0.52	22.9	70.2	93.2
75	UREA	10% DCDN	PPL	2.19	1.27	0.49	19.3	62.8	82.1
75	AA	2.5% DCDG	PPL	2.21	1.31	0.42	18.3	72.7	91.0
75	AA	5% DCDG	PPL	2.40	1.23	0.51	2.43	75.3	99.7
75	28%	10% DCDL	PPL	1.84	1.26	0.47	18.9	56.4	75.4
150	UREA	10% DCDN	PPL	2.90	1.45	0.61	30.6	92.0	122.6
150	AA	2.5% DCDG	PPL	2.52	1.36	0.49	23.4	89.0	112.4
150	AA	5% DCDG	PPL	2.63	1.38	0.52	24.3	87.3	111.7
150	28%	10% DCDL	PPL	2.65	1.42	0.51	26.2	94.7	120.9
P-Value				99	99	99	99	99	99
BLSD (.05)				0.26	0.17	0.08	4.7	10.4	12.7
Factorial Arrangement (N-Rate X N-Form X Inhibitor)									
N-Rate									
75				1.68	1.26	0.45	18.0	48.9	67.0
150				2.15	1.28	0.47	20.6	64.5	85.1
P-Value				99	63	87	98	99	99
N-Form									
AA				2.11	1.31	0.47	21.0	64.7	85.8
28%				1.81	1.26	0.45	18.1	53.9	72.1
UREA				1.83	1.24	0.47	18.6	51.6	70.2
P-Value				99	83	55	92	99	99
BLSD(.05)								5.7	7.8
Inhibitor									
Control				1.70	1.27	0.45	18.0	50.2	68.2
N-Serve				2.14	1.27	0.47	20.5	63.2	83.8
P-Value				99	15	85	97	99	99
Rate X Form				63	78	35	42	79	74
Rate X Inhibitor				56	28	96	53	78	90
Form X Inhibitor				56	28	85	53	21	97
Rate X Form X Inhibitor				95	87	56	29	93	93

Table 2 continued on next page

Table 2 continued

Treatments				N-Concentration			N-Removal		
N-Rate	N-Form	Inhibitor	Time	Leaf	Grain	Stover	Stover	Grain	Total
				----------%		--------	--------lbs/A--------		
Factorial Arrangement (N-Rate X N-Form X Time)									
N-Rate									
75				1.95	1.31	0.49	19.6	61.8	81.5
150				2.46	1.39	0.53	23.8	82.5	106.6
P-Value				99	96	89	99	99	99
N-Form									
AA				2.35	1.38	0.53	23.2	80.3	103.5
28%				2.06	1.31	0.49	20.2	64.0	84.3
P-Value				99	94	90	98	99	99
Time									
PPL				1.75	1.28	0.45	18.4	53.6	71.5
10-lf				2.66	1.41	0.58	25.0	91.3	116.4
P-Value				99	99	99	99	99	99
Rate X Form				50	64	1	28	97	96
Rate X Time				29	62	84	98	77	94
Form X Time				75	83	65	82	79	45
Rate X Form X Time									
Factorial Arrangement (N-Rate X Inhibitor in AA)									
N-Rate									
75				2.06	1.27	0.46	20.1	63.9	84.0
150				2.49	1.36	0.50	23.5	81.9	105.4
P-Value				99	99	95	99	99	99
Inhibitor									
Control				1.95	1.29	0.48	20.7	59.4	80.1
N-Serve				2.27	1.32	0.46	21.4	70.0	91.4
2.5% DCDG				2.37	1.33	0.45	20.8	80.8	101.7
5% DCDG				2.51	1.31	0.51	24.3	81.3	105.7
P-Value				99	14	84	81	99	99
N-Rate X Inhibitor				93	52	42	68	99	99
Factorial Arrangement (N-Rate X Inhibitor with Urea)									
N-Rate									
75				1.81	1.24	0.47	18.2	50.9	69.2
150				2.32	1.32	0.52	23.2	69.4	92.7
P-Value				99	94	97	99	99	99
Inhibitor									
Control				1.60	1.25	0.45	17.2	44.6	61.8
N-Serve				2.06	1.22	0.48	20.1	58.5	78.7
10% DCDN				2.54	1.36	0.55	24.9	77.4	102.4
P-Value				99	97	99	99	99	99
N-Rate X Inhibitor				97	96	97	98	99	99

HIGH CORN YIELD EXPERIMENTS ON THE COARSE TEXTURED SOILS OF MINNESOTA

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

The agricultural producer is becoming increasingly aware of the importance of management for maximum economic return. With the severe economic pressures producers are currently encountering, the tendency is to cut back on some of the variable inputs used in crop production. The lowering of production cost is a viable consideration in increasing economic return, as long as decreased production does not offset the benefit from decreasing the production cost. An alternative to the above approach is improved management. If a producer can obtain higher yields with relatively little change in inputs, higher economic returns would result. Management for higher production and at the same time highest economic return is very complicated and it takes a top manager to evaluate all of the alternatives which are available. A trial was established at the Sand Plain Research Farm near Becker, Minnesota to evaluate the impact of nine corn hybrids. The nine hybrids were evaluated under high population and high fertilization in a corn following corn and corn following soybean sequence.

Experimental Procedure

Two separate experiments consisting of nine treatments with four replications were arranged in randomized complete block designs. The treatments consisted of nine corn hybrids. The hybrids selected included Pioneer 3978, Pride 1142, A654XCM105 (85 day realative maturity - R.M.), Funks G4256, Trojan T950, LH39XA641 (95 day R.M.), Cargill 835, Pioneer 3901, and Mo17XA641 (95-100 day R.M.).

Prior to planting, potassium magnesium sulfate (300 #/a 0-0-22), phosphorus (80 #/a 0-46-0), potassium (275 #/a 0-0-60), boron (2 #/a as solubor) and zinc (10 #/a as $ZnCl_2$) was broadcast and incorporated into both experimental areas. Nitrogen was applied in split applications as anhydrous ammonia. The first application of nitrogen (175 #N/a) was made on May 20th (emergence) and contained N-Serve (0.5 #ai/a). A second application of N (100 #N/a) was made on June 23rd when the corn was at the 10-leaf growth stage.

Corn was planted on May 1st in 30 inch rows at a population of 46,000 seeds/a. After emergences the stand was thinned to 42,000 plants/a. Weed control was accomplished with a preemergence application of Lasso (1.5 #ai/A) plus Atrazine (2 #ai/a). To minimize corn bore damage, Lorsban was applied through the irrigation system on August 12th.

Leaf samples from opposite and below the ear at mid-silking were taken on July 19 (85-day R.M.) and on July 21st. Samples were dried ground, and analyzed for elemental concentrations. Grain yields and total dry matter production was measured on September 14th (85-day R.M.) and September 19th. Samples were obtained by hand harvesting 100 $ft.^2$ of plot area. From the above ground portion, ears were separated from the stalks and separate field weights, and samples obtained from each portion (grain and stover) for moisture determination and elemental concentrations. Grain yields were adjusted to 15.5% moisture.

The irrigation program was started on July 9th and continued through August 23rd with a total of 9.6 inches of water being applied through irrigation. An additional 23.5 inches of water was obtained during the growing season as rainfall. Over 50% of the growing season rainfall was obtained during the month of June and over 50% of the June precipitation was obtained on June 20-21.

Results and Conclusions

The specific results from both experiments are presented in Tables 1-6. In general, yield levels were very disappointing. Factors which may have been involved with the lower yields will be discussed later. It is interesting to note that grain yields were significantly influenced by hybrids when it was grown in a corn following corn sequence, but were not significantly different in a corn following soybean sequence. Conversely, stover and total dry matter yields were not significantly different between hybrids with the corn followign corn sequence. It therefore appears that the hybrids used responded differently to the rotation effect. Pioneer 3901 was an example of one hybrid which did not appear to be sensitive to the crop sequence while Cargill 834 yielded much better in the corn soybean sequence (similar relative maturities).

Concentrations of many of the plant essential nutrients in the different plant parts were significantly influenced by hybrid. At least a portion of this variation can be explained due to the differences in relative maturity. This cannot be the sole reason associated with the bybrid variability since certain hybrids within the same maturity ranges were different from each other. The practical significance associated with differential plant concentrations (when sufficient quantities are available) remains to be investigated.

Total elemental removal was influenced by hybrid selection, with again difference being observed between the two cropping systems. The nutrients being affected most included N, P, Ca, Mg, Mn, Zn, and Cu. The elements K, Fe, and B were also found to be different between varities, but only when the sequence was corn following soybeans. There are numerous comparisons that can be made between nutrients and corn hybrids. One interesting comparison was between Cargill 834 and Pioneer 3901 (similar maturities). In a corn following soybean sequence both varities produced similar yields. The potassium removal by Cargill 834 was significantly higher than Pioneer 3901. When the same two hybrids were compared in the corn following corn sequence, the potassium removal was very similar. The grain yield of Cargill 834 was however significantly lower than Pioneer 3901. Relationships such as these deserve continued evaluation.

Yield Limiting Factors:

As was mentioned earlier, the yields obtained in 1983 were very disappointing. The yields obtained not only from these experiments but others at the research station rate among the lowest obtained in the last 6-7 years. As is the case in many years, the reduced yields were probably not the result of one thing, but as results from the combination of a number of factors. Many of these factors were external and could not be controlled.

The growing season was characterized by being very cold early. At the critical stage of germination some of the hybrids reflected reduced emergence. Even though all plots were over-seeded and thinned to a desired stand, one hybrid, LH39XA641, was reduced to an extent that the emergence was 25% below the desired population. The stress conditions associated with cold weather were dramatically reversed to create substantial heat stress during vegetive production and pollination. The net result was the creation of a plant that was extremely spindly and weak. Combine this with several severe storms and one of the worst infestations of corn borer in the last 25 years and we have a tremendous lodging problem. The problems of lodging and barren stalks are typically not a problem at this location. The high stress conditions (high plant population and weather) experienced in 1983 produced severe lodging and barren stalks (barreness was as high as 30-40%). Barren stalks of less than 5% are normally observed at this location.

Table 1. Leaf N content, grain yield, dry matter production, grain N content and nitrogen removal by nine corn varieties following corn - Becker MN. 1983.

Treatments	Leaf N	Grain Yield	Dry Matter Production Grain	Stover	Total	N-Conc. Grain	Stover	N-Removal Grain	Stover	Total
	%	Bu/A	T/A			%		lbs/A		
Pioneer 3978	2.78	138.3	3.27	2.19	5.47	1.34	0.70	88.1	30.5	118.7
Pride 1142	2.85	124.9	2.95	2.49	5.45	1.41	0.90	83.7	45.3	129.0
A654 X CM105	2.79	151.3	3.58	2.15	5.74	1.46	0.72	104.7	31.2	136.0
Funks G4256	2.85	133.2	3.15	2.61	5.77	1.49	1.04	94.5	54.9	149.4
Trojan T950	3.19	138.7	3.28	2.29	5.57	1.51	0.94	99.5	43.3	142.9
LH39 X A641	3.22	148.3	3.51	2.44	5.95	1.50	0.91	105.7	44.7	150.4
Cargill 834	3.01	126.2	2.98	2.47	5.46	1.47	0.89	88.3	44.1	132.4
Pioneer 3901	2.99	145.8	3.45	2.63	6.08	1.48	0.77	102.4	40.6	143.1
Mo17 X A641	3.13	133.8	3.16	2.83	6.00	1.42	0.87	90.4	49.7	140.2
P-Value	98	98	98	89	55	69	99	95	99	84
BLSD (.05)	0.31	17.7	0.42				0.15	18.1	13.2	

Table 2. The elemental concentration of silage stover silage grain and leaf oppsite and below the ear at silking on nine corn varieties following corn.

Treatment	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	Elemental Concentration										
	%				ppm						
Silage Stover											
Pioneer 3978	0.06	1.88	0.31	0.21	166	135	61	68	17	10	11
Pride 1142	0.08	1.80	0.33	0.24	172	141	68	71	21	8	12
A645 X CM105	0.04	2.11	0.31	0.22	194	153	68	79	16	8	12
Funks G4256	0.10	2.13	0.31	0.25	200	176	60	92	30	8	12
Trojan T950	0.09	2.23	0.40	0.25	284	242	76	100	27	8	13
LH39 X A641	0.08	1.95	0.39	0.21	200	174	62	108	26	8	11
Cargill 834	0.07	1.99	0.26	0.18	254	207	70	86	22	6	12
Pioneer 3901	0.06	1.70	0.28	0.22	209	189	59	70	24	10	11
Mo17 X A641	0.08	1.71	0.29	0.23	320	259	65	84	26	8	10
P-Value	99	99	99	97	52	68	49	99	99	99	99
BLSD (.05)	0.03	0.25	0.04	0.05				19	7	1	2
Silage Grain											
Pioneer 3978	0.23	0.36	0.003	0.11	1	16	4	6	25	2	3
Pride 1142	0.23	0.35	0.001	0.12	1	17	10	6	25	2	3
A654 X CM105	0.26	0.35	0.002	0.12	1	15	4	5	23	2	4
Funks G4256	0.26	0.37	0.002	0.12	1	14	3	6	19	1	4
Trojan T950	0.28	0.37	0.003	0.14	1	15	3	8	27	1	3
LH39 X A641	0.23	0.36	0.003	0.13	1	16	4	7	25	2	3
Cargill 834	0.21	0.32	0.003	0.11	1	17	3	8	21	2	3
Pioneer 3901	0.26	0.38	0.003	0.13	1	20	3	7	25	2	4
Mo17 X A641	0.24	0.40	0.004	0.10	1	18	3	6	21	3	4
P-Value	99	95	99	99	42	99	72	99	99	99	99
BLSD (.05)	0.04	0.05	0.001	0.02		2		1	3	1	1
Leaf											
Pioneer 3978	0.26	3.37	0.46	0.24	71	127	54	67	27	12	14
Pride 1142	0.27	3.42	0.45	0.28	70	123	57	62	25	12	16
A654 X CM105	0.24	3.15	0.42	0.25	86	126	59	71	26	12	15
Funks G4256	0.27	3.05	0.38	0.22	67	111	58	69	26	12	13
Trojan T950	0.28	2.96	0.42	0.24	46	103	49	83	30	12	13
LH39 X A641	0.30	2.91	0.55	0.26	44	113	53	90	37	12	12
Cargill 834	0.26	2.76	0.40	0.22	54	113	50	81	33	12	13
Pioneer 3901	0.28	2.40	0.40	0.32	51	109	50	93	27	12	11
Mo17 X A641	0.28	2.82	0.38	0.24	52	106	46	89	35	12	10
P-Value	99	99	99	99	99	99	97	87	99	76	99
BLSD (.05)	0.02	0.12	0.05	0.03	16	11	9		5		3

Table 3. The total elemental removal of silage stover and silage grain at physiological maturity on nine corn varieties following corn.

Treatment	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	Total Elemental Removal										
	Silage Stover										
	lbs/A										
Pioneer 3978	2.8	83.6	13.7	9.3	0.7	0.27	0.26	0.30	0.07	0.04	0.04
Pride 1142	4.1	89.8	16.3	12.0	0.8	0.28	0.33	0.35	0.10	0.03	0.06
A654 X CM105	2.0	91.4	13.3	9.6	0.8	0.30	0.29	0.34	0.07	0.03	0.05
Funks G4256	5.6	112.1	16.2	13.1	1.0	0.35	0.31	0.48	0.16	0.04	0.06
Trojan T950	4.4	102.7	18.2	11.3	1.2	0.48	0.34	0.46	0.12	0.03	0.05
LH39 X A641	4.2	96.0	19.1	10.2	1.0	0.34	0.30	0.53	0.12	0.03	0.05
Cargill 834	3.8	96.4	12.9	8.7	1.2	0.41	0.34	0.42	0.11	0.03	0.06
Pioneer 3901	3.5	90.3	14.5	11.5	1.1	0.37	0.31	0.36	0.12	0.05	0.06
Mo17 X A641	4.6	97.5	16.4	13.1	1.6	0.51	0.35	0.47	0.15	0.04	0.05
P-Value	99	70	99	99	77	68	51	99	99	99	64
BLSD (.05)	1.8		2.8	2.3				0.13	0.04	0.01	
	Silage Grain										
Pioneer 3978	15.6	23.7	0.2	7.4	0.003	0.10	0.03	0.04	0.16	0.01	0.02
Pride 1142	13.9	20.9	0.1	7.1	0.003	0.10	0.06	0.04	0.15	0.02	0.01
A654 X CM105	18.9	25.7	0.2	8.3	0.004	0.11	0.02	0.04	0.16	0.01	0.03
Funks G4256	16.5	23.0	0.1	7.6	0.002	0.10	0.02	0.04	0.12	0.01	0.02
Trojan T950	18.5	24.3	0.2	9.4	0.003	0.10	0.02	0.05	0.18	0.01	0.02
LH39 X A641	16.7	25.0	0.3	8.9	0.003	0.11	0.03	0.05	0.18	0.01	0.02
Cargill 834	12.6	19.3	0.2	6.7	0.002	0.10	0.02	0.05	0.13	0.01	0.02
Pioneer 3901	18.6	26.6	0.3	9.2	0.003	0.13	0.02	0.05	0.17	0.02	0.03
Mo17 X A641	15.3	25.3	0.3	6.9	0.002	0.11	0.02	0.04	0.13	0.01	0.03
P-Value	99	99	99	99	64	99	63	99	99	99	99
BLSD (.05)	2.9	4.0	0.1	1.4		0.02		0.01	0.02	0.01	0.01
	Total										
Pioneer 3978	18.4	107.3	14.0	16.7	0.7	0.38	0.29	0.34	0.24	0.06	0.07
Pride 1142	17.9	110.8	16.5	19.2	0.8	0.38	0.40	0.39	0.26	0.06	0.08
A654 X CM105	20.9	117.1	13.5	18.0	0.8	0.41	0.32	0.38	0.24	0.05	0.08
Funks G4256	22.1	135.2	16.3	20.7	1.1	0.44	0.34	0.51	0.28	0.05	0.09
Trojan T950	22.9	127.1	18.4	20.7	1.3	0.59	0.37	0.51	0.30	0.05	0.08
LH39 X A641	21.0	121.1	19.4	19.1	1.0	0.46	0.34	0.58	0.31	0.05	0.07
Cargill 834	16.4	115.7	13.2	15.4	1.2	0.52	0.36	0.48	0.24	0.04	0.08
Pioneer 3901	22.1	116.9	14.8	20.7	1.1	0.52	0.33	0.41	0.30	0.07	0.08
Mo17 X A641	19.9	122.8	16.7	20.0	1.7	0.63	0.38	0.51	0.29	0.06	0.08
P-Value	99	60	99	99	77	77	56	99	97	99	75
BLSD (.05)	4		2.8	3.1				0.13	0.06	0.01	

Table 4. Leaf N content, grain yield, dry matter production, grain N content and nitrogen removal by nine corn varieties following soybeans - Becker MN. 1983.

Treatments	Leaf N	Grain Yield	Dry Matter Production Grain	Stover	Total	N-Conc. Grain	N-Removal Stover	Grain	Stover	Total
	%	Bu/A	T/A			%		lbs/A		
Pioneer 3978	2.70	147.7	3.49	2.27	5.77	1.27	0.70	89.3	33.2	136.1
Pride 1141	2.53	133.2	3.15	2.68	5.84	1.33	0.96	84.3	51.7	136.1
A654 X CM105	2.68	149.0	3.52	2.12	5.65	1.44	0.67	102.2	28.4	130.6
Funks G4256	2.82	143.9	3.40	2.98	6.39	1.48	1.00	101.1	59.9	161.0
Trojan T950	3.15	152.1	3.60	2.62	6.22	1.43	0.97	103.3	51.1	154.4
LH39 X A641	2.91	157.1	3.72	2.34	6.06	1.39	0.99	103.4	46.3	149.7
Cargill 834	2.87	150.3	3.56	3.32	6.88	1.46	0.86	104.5	57.4	161.9
Pioneer 3901	2.91	146.8	3.47	2.93	6.40	1.40	0.81	97.5	47.8	145.3
Mo17 X A641	2.83	143.9	3.40	2.70	6.11	1.35	0.83	92.6	45.4	138.1
P-Value	98	80	80	99	99	97	99	89	99	99
BLSD (.05)	0.32			0.42	0.64	0.14	0.16		10.6	17.5

Table 5. The elemental conceration of silage stover, silage grain and leaf oppsite and below the ear at silking on nine corn varieties following soybeans.

Treatment	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	Elemental Concentration										
	%				ppm						
Silage Stover											
Pioneer 3978	0.06	1.78	0.32	0.02	305	222	64	83	16	7	12
Pride 1142	0.09	1.54	0.32	0.23	162	145	65	76	19	6	12
A654 X CM105	0.05	1.84	0.31	0.22	185	144	63	78	17	8	13
Funks G4256	0.09	1.89	0.31	0.25	212	182	59	83	20	7	12
Trojan T950	0.08	2.21	0.37	0.22	252	216	68	121	20	6	13
LH39 XA641	0.08	1.96	0.36	0.20	244	196	66	104	23	6	12
Cargill 834	0.06	1.84	0.29	0.18	225	189	61	79	16	5	12
Pioneer 3901	0.07	1.51	0.32	0.25	225	187	60	80	21	91	11
Mo17 X A641	0.07	1.73	0.27	0.21	313	242	63	73	18	5	13
P-Value	98	99	99	96	86	94	5	99	84	99	57
BLSD (.05)	0.03	0.20	0.05	0.05				26		1	
Silage Grain											
Pioneer 3978	0.20	0.33	0.003	0.10	2	14	8	5	22	2	2
Pride 1142	0.23	0.34	0.002	0.12	1	17	8	6	24	2	3
A654 X CM105	0.25	0.34	0.003	0.11	1	14	10	5	21	1	4
Funks G4256	0.27	0.36	0.003	0.12	1	14	9	6	19	1	3
Trojan T950	0.26	0.36	0.003	0.13	1	16	6	8	25	1	3
LH39 X A641	0.24	0.37	0.003	0.13	1	18	5	7	25	1	2
Cargill 834	0.22	0.35	0.003	0.12	1	18	9	8	20	2	3
Pioneer 3901	0.24	0.34	0.003	0.13	1	19	5	6	22	2	3
Mo17 X A641	0.25	0.40	0.004	0.12	1	19	5	6	20	2	3
P-Value	82	93	99	98	55	99	39	99	99	99	99
BLSD (.05)			0.001	0.02		3		1	3	1	1
Leaf											
Pioneer 3978	0.25	3.45	0.40	0.21	75	149	54	59	24	9	12
Pride 1142	0.26	3.28	0.43	0.27	76	119	58	58	22	8	11
A654 X CM105	0.23	3.10	0.42	0.25	81	130	63	50	21	9	13
Funks G4256	0.28	3.07	0.36	0.25	63	107	54	73	25	8	12
Trojan T950	0.28	3.14	0.40	0.23	57	111	53	82	27	8	11
LH39 X A641	0.28	2.98	0.51	0.27	59	114	55	77	32	8	11
Cargill 834	0.25	2.83	0.38	0.22	52	111	43	71	26	7	10
Pioneer 3901	0.29	2.63	0.38	0.30	54	114	51	88	26	9	10
Mo17 X A641	0.28	2.83	0.39	0.24	56	106	50	80	29	7	8
P-Value	99	99	99	99	99	99	99	95	99	99	88
BLSD (.05)	0.02	0.22	0.04	0.03	11	15	12	24	5	5	

Table 6. Total elemental removal of silage stover and silage grain at physiological maturity on nine corn varieties following soybeans.

Treatment	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	Total Elemental Removal										
	Silage Stover										
	lbs/A										
Pioneer 3978	2.8	82.3	14.5	9.5	1.4	0.44	0.29	0.38	0.07	0.03	0.05
Pride 1142	5.0	83.2	17.1	12.5	0.8	0.29	0.34	0.40	0.10	0.03	0.06
A654 X CM105	2.1	78.6	13.3	9.3	0.7	0.28	0.26	0.33	0.07	0.03	0.05
Funks G4256	5.5	113.2	18.8	15.2	1.2	0.36	0.35	0.49	0.12	0.04	0.07
Trojan T950	4.7	116.7	19.5	11.4	1.3	0.43	0.35	0.63	0.10	0.03	0.07
LH39 X A641	3.9	92.0	17.2	9.6	1.1	0.39	0.30	0.49	0.11	0.03	0.05
Cargill 834	4.1	123.0	19.3	12.4	1.5	0.37	0.40	0.52	0.10	0.03	0.08
Pioneer 3901	4.4	88.6	18.5	14.7	1.3	0.37	0.35	0.47	0.12	0.05	0.06
Mo17 X A641	4.0	93.5	14.7	11.5	1.7	0.48	0.35	0.40	0.10	0.03	0.07
P-Value	99	99	99	99	87	94	74	99	91	99	98
BLSD (.05)	1.7	20.7	3.4	2.3				0.15		0.01	0.02
	Silage Grain										
Pioneer 3978	14.6	23.6	0.2	7.1	0.012	0.10	0.06	0.07	0.15	0.01	0.02
Pride 1142	15.1	21.8	0.1	7.6	0.001	0.11	0.06	0.04	0.15	0.01	0.02
A654 X CM105	18.2	24.3	0.2	8.0	0.001	0.10	0.07	0.04	0.15	0.01	0.03
Funks G4256	18.4	24.2	0.2	8.4	0.001	0.10	0.06	0.04	0.13	0.01	0.02
Trojan T950	18.8	25.9	0.2	9.7	0.001	0.12	0.04	0.05	0.18	0.01	0.02
LH39 X A641	18.5	27.4	0.2	9.9	0.001	0.13	0.04	0.05	0.18	0.01	0.02
Cargill 834	16.3	25.3	0.3	8.6	0.001	0.13	0.06	0.06	0.14	0.01	0.02
Pioneer 3901	17.2	24.1	0.2	8.8	0.001	0.13	0.04	0.04	0.15	0.02	0.02
Mo17 X A641	17.6	27.8	0.3	7.9	0.001	0.13	0.04	0.04	0.13	0.01	0.02
P-Value	88	90	99	99	61	99	43	99	99	99	99
BLSD (.05)		5.1	0.1	1.7		0.02		0.01	0.02	0.01	0.01
	Total										
Pioneer 3978	17.6	106.0	14.7	16.6	1.4	0.54	0.35	0.41	0.23	0.05	0.07
Pride 1142	20.1	105.1	17.2	20.1	0.8	0.40	0.40	0.44	0.25	0.04	0.08
A654 X CM105	20.3	102.8	13.5	17.3	0.8	0.38	0.33	0.37	0.22	0.04	0.08
Funks G4256	24.0	137.4	19.0	23.6	1.3	0.46	0.41	0.54	0.25	0.05	0.09
Trojan T950	23.5	142.6	19.7	21.1	1.3	0.55	0.40	0.69	0.29	0.04	0.09
LH39 X A641	22.5	119.5	17.5	19.5	1.1	0.52	0.34	0.54	0.29	0.04	0.07
Cargill 834	20.5	148.3	19.6	21.0	1.5	0.50	0.47	0.58	0.25	0.05	0.10
Pioneer 3901	21.6	112.8	18.7	23.5	1.3	0.51	0.39	0.51	0.27	0.07	0.09
Mo17 X A641	21.6	121.4	15.0	19.4	1.7	0.61	0.38	0.44	0.24	0.04	0.09
P-Value	95	99	99	99	87	98	69	99	99	99	99
BLSD (.05)	4.4	18.4	3.4	2.4		0.14		0.15	0.05	0.01	0.02

SOIL TEST LAB COMPARISON ON IRRIGATED POTATOES - BECKER, 1983

W. E. Fenster, W. E. Jokela and M. O'Leary

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

Experimental Procedures

This experiment was established in 1980 on a Hubbard loamy sand at the Sand Plains Irrigation Farm at Becker, MN. Each year samples were dried, thoroughly mixed, and divided into five subsamples which were sent to five soil testing labs, including the University of Minnesota. In 1983 fertilizer recommendations were requested for Russet Burbank potatoes grown under irrigation. Fertilizer as recommended by each of the five labs was applied. The sixth treatment was a no-fertilizer check. Experimental design is randomized complete block with four replications.

Results and Discussion

Soil test results and fertilizer recommendations are shown in Table 1 and 2. Recommended N rates were quite similar, but there were differences in amounts of P and K and in which secondary and micronutrients were recommended. The university of Minnesota recommendations for P_2O_5 and K_2O were considerably higher than other labs and somewhat higher for sulfur.

Tuber yield and an economic comparison are shown in Table 3. Potato yields varied from 407 to 499 CWT with lab C being significantly higher than other labs except lab D.

It is difficult to explain why lower recommendations of lab C gave significantly higher yields. It appears that lab E (U of M) recommendations for P and K are higher than necessary.

Table 1. Soil test results[1/] for 1983 after 3 years of fertilization and cropping. Becker, MN. 1982 fall sampling.

	A	B	C	D	E(U of M)	Check[2/]
pH	6.8	6.5	6.4	6.5	6.8	6.6
Buffer Index	--	7.0	--	7.1	--	--
P	29	28	28	24	18	18
K	104	121	105	70	60	111
Ca	786	880	960	1000	--	--
Mg	138	188	160	150	154	122
S	5	6	9	9	2	4
Fe	19.7	18	16	8	--	--
Mn	5.5	5	5.2	2	--	--
Zn	2.4	1.8	2.1	1.7	2.0	1.8
Cu	.8	.6	.5	.4	--	
B	.5	.9	.6	.8	--	
NO_3-N (0-6")	3	--	3.2	--	--	
O.M. %	1.4	1.8	--	1.7	2.4	1.9
CEC (Mg/100g)	5.3	6.8	--	6.5	--	--

1/ ppm unless otherwise noted

2/ soil test U of M lab

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

Table 2. Fertilizer recommendations from five soil testing labs for potatoes. Becker, MN 1983.

Lab	N[1/]	P_2O_5	K_2O	S	Mg	B	Zn	Mn	Cu
	nutrients in lb/A								
A	185	110	195	25	3	1.2	--	--	--
B	150	75	190	16	--	1	2.5	3	1
C	163	0	135	20	--	1	--	--	--
D	159	49	224	20	--	--	--	--	--
E (U of M)	170	150	400	30	--	--	--	--	--

[1/] N added as follows:
20% preplant, 40% at 12" height, 40% at hilling

Table 3. Potato yield and economic return over fertilizer costs for 6 fertilizer programs, Becker 1983.

Lab	Yield CWT	Gross[1/] Tuber Value per acre	Fertilizer Cost[2/] per acre	$ Benefit above check[3/]
A	438	$ 2,628	101.10	$ 930.90
B	407	2,442	90.55	755.45
C	499	2,994	61.82	1,336.18
D	465	2,790	80.29	1,113.71
E	438	2,628	139.30	892.18
Check	266	1,596	-0-	
Significance	**			
BLSD (.05)	52			
C.V.	8.9			

[1/] Potatoes valued at $6/cwt

[2/] Fertilizer costs per lb.
N = $.24 (urea), P_2O_5 = $.23, K_2O = .12, S = $.20, Zn = $.90, Mn = $1.25, Mg = $.70, B = $2.50, and Cu = $2.80.

[3/] Crop value minus fertilizer cost minus value of check.

MICRONUTRIENT FERTILIZATION OF POTATOES AND CORN UNDER IRRIGATION

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

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

Experimental Procedures

Seven treatments, including a control, four micronutrient treatments, and two macronutrient treatments were established in a randomized complete block design with four replications. Rates and types of fertilizer included: 5 lbs. of copper/a as $CuSO_4 5H_2O$, 2 lbs. of boron/a as Solubor, 25 lbs. of sulfur/a as $CaSO_4$, 75 lbs. of magnesium, as $MgCl_2$, 10 lbs. of zinc/a as $ZnCl_2$ and 3 lbs. of manganese/a as $MnCl_2$. Application of materials were made to the same plots as in the past 5 years. The corn and potato areas were rotated in 1983 so the corn was planted into the 1982 potato area (eight replications) and the potatoes were planted into the corn areas (four replications of each variety).

Fertilizer treatments were broadcast, incorporated by plowing on April 18, and the potatoes planted on April 21. Norlands were planted in 9 inch spacing utilizing 36 inch rows, while Russet Burbanks were planted in 12 inch spacing with the same row width. A starter was used at the rate of 1000 lbs./a of 8-10-30 and the insecticide Temik 15G was banded at 14 lbs./a at planting time. A tank mix of Linoran 2# ai/a and Lasso 2# ai/a, along with a tank of Eptan 4.25# ai/a was used for control. Nitrogen was sidedressed on May 25 (185 lbs./a 34-0-0) and on June 13 (250 lbs./a 34-0-0), along with hilling at the last sidedressing. Samples of the youngest mature potato leaves were obtained 81 days after planting for nutrient concentration. The Norlands were harvested on September 8 and the Russet Burbank on September 20. Irrigation water was applied during the period of June 13 through August 24 with a total addition of 10.88 inches. Precipitation during the growing season was 18.4 inches for the Norlands and 19.7 inches for the Russet Burbanks. Utilizing the 1982 potato experiment, eight replications of the aforementioned treatments were planted to corn. The experimental area had been fertilized with 800 lbs./a 8-10-30 prior to planting on April 29. A commercial corn variety (Pioneer 3901) was planted in 30 inch rows at a population of 30,700 seeds/a. Starter fertilizer at the rate of 165 lbs./a of 8-10-30 was banded at planting. For weed control Lasso (1.6 lbs. ai/a) was used as a preemergence application and 2,4-D (1 lb. ai/a) was applied on June 6 for weed control. The insecticides Lorsban 15G (8 lbs. ai/a) was handled at planting. Nitrogen applications were made on May 25 (220 lbs./a 34-0-0) and June 22 (260 lbs./a 34-0-0).

Leaf samples from opposite and below the ear at mid-silking were taken on July 21, dried ground and analyzed for elemental concentrations. Total dry matter production and final yield was determined on September 19 by hand harvesting 100 ft.^{2} of plot area. Ears were separated from the stalks, separate field weights and sub-samples removed for moisture determineation and elemental concentrations. Grain yeilds were adjusted to 15.5% moisture. The irrigation program was started on June 13 and continued through August 24 with a total of 10.88 inches of water being applied through irrigation. An additional 24.0 inches of water was obtained during the growing season through rainfall.

General Results

The results from 1983, along with the six-year average yields are presented in Tables 1-4. Norland tuber yields in 1983 were similar to the six-year average while Russet Burbank yields were slightly above the six-year average. Corn grain yields in 1983 were substantially lower than the long-term average yields. There was no yield advantage in 1983 to the application of any of the six elements added. The six-year averages suggest some interesting differences especially with potatoes. With the Norland variety significant (.05) yield increases were obtained with both boron and zinc application. A substantial yield increase was also obtained with Norland when magnesium was applied. By contrast, the six-year average yields for the Russet Burbank potatoes reflected no response to any applied treatment. Positive trends were observed with zinc and boron and a negative trend for manganese, but these trends were not significant (.10). Corn grain yields, when evaluated over a

six-year period, reflected differences only at the 90% probability level. Magnesium and zinc applications produced the higher yields while the manganese treatment had the lowest yield.

Nutrient concentrations in the leaf and total nutrient uptake tended to follow those nutrients which suggested a yield response. Increased utilization of zinc, boron, and magnesium were the most predominant. Copper application frequently resulted in increased tissue concentrations and uptake. Reduced concentrations and uptake of calcium in corn stover were associated with mangesium application. This did not appear to have a detrimental influence on grain yield.

Table 1. Influence of micronutrient fertilization (also Mg and S) on tuber yield and nutrient concentration on the youngest mature leaves 81 days following planting for Norland and Russet Burbank potatoe.

Treatment	Rate/A #/A	Tuber Yield cwt/a	6yr. Ave. cwt/a	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
				Norland Potatoes Leaf Concentration											
				%					ppm						
Control	-	382	399	4.74	0.38	5.38	1.44	0.45	192	161	67	318	19	14	59
Cu	5	398	402	4.92	0.36	5.12	1.49	0.44	124	148	63	319	18	18	58
B	2	437	422	4.92	0.35	5.33	1.29	0.39	155	161	71	378	18	14	71
S	25	398	404	5.09	0.35	5.10	1.39	0.42	127	160	67	340	18	14	58
Mg	75	404	415	4.76	0.36	5.35	1.45	0.55	247	182	55	308	19	11	59
Zn	10	426	423	4.91	0.35	5.21	1.39	0.43	190	158	30	368	26	13	62
MN	3	414	414	4.79	0.35	5.04	1.53	0.49	162	173	60	312	17	12	63
P-Value		92	99	76	61	41	26	88	50	42	93	27	99	91	82
BLSD (.05)			17										2		
				Russet Burbank Potatoes											
Control	-	458	441	5.04	0.33	4.49	0.88	0.50	294	166	47	269	16	12	44
Cu	5	485	447	4.85	0.34	4.41	0.89	0.50	226	160	37	225	16	17	42
B	2	503	459	4.90	0.33	4.33	0.80	0.49	294	169	67	244	16	12	48
S	25	501	447	5.08	0.33	4.38	0.87	0.49	360	175	70	240	17	11	46
Mg	75	473	442	5.01	0.32	4.45	0.82	0.57	361	180	53	204	17	10	40
Zn	10	464	457	4.97	0.33	4.36	0.86	0.48	187	158	42	258	20	11	44
Mn	3	442	429	5.05	0.34	4.27	0.93	0.53	259	174	70	237	16	12	45
P-Value		75	89	77	3	33	31	95	19	22	97	52	99	96	36
BLSD(.05)											26		1	4	

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

Treatment	Rate/a #/A	Grain Yield Bu/A	6 yr. Ave. Bu/A	Dry Matter Production Stover	Grain	Total
				T/A		
Control	-	151.7	181.8	2.66	3.59	6.26
Cu	5	162.1	184.9	2.78	3.83	6.62
B	2	154.9	183.7	2.66	3.63	6.33
S	25	155.9	184.2	2.59	3.68	6.28
Mg	75	152.8	185.5	2.62	3.61	6.24
Zn	10	155.6	186.3	2.67	3.68	6.35
Mn	3	155.3	180.4	2.55	3.67	6.22
P-Value		50	90	28	50	42
BLSD (.05)						

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

Treatment	Rate/A	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
		Elemental Concentration											
		Silage Stover											
	#/A	%					ppm						
Control	-	0.65	0.14	1.87	0.28	0.13	204	171	49	64	12	8	8
Cu	5	0.67	0.11	1.86	0.29	0.14	225	207	47	61	12	10	8
B	2	0.68	0.13	1.95	0.27	0.13	217	187	50	63	12	9	9
S	25	0.65	0.14	1.91	0.29	0.13	214	180	49	63	12	9	8
Mg	75	0.63	0.11	2.09	0.25	0.14	212	177	49	60	12	9	8
Zn	10	0.65	0.11	1.84	0.31	0.14	237	191	51	61	29	8	8
MN	3	0.62	0.12	1.89	0.27	0.12	227	191	49	62	11	9	8
P-Value		20	99	79	99	31	20	37	8	1	99	98	99
BLSD (.05)			0.02		0.03						4	1	1
		Silage Grain											
Control	--	1.26	0.33	0.46	0.003	0.13	1	16	1	7	23	2	3
Cu	5	1.31	0.32	0.46	0.003	0.12	1	16	1	6	22	2	3
B	2	1.31	0.33	0.47	0.003	0.13	1	17	1	7	23	2	3
S	25	1.31	0.33	0.46	0.003	0.13	1	17	1	6	25	2	2
Mg	75	1.30	0.33	0.46	0.003	0.14	1	18	1	7	23	2	3
Zn	10	1.31	0.32	0.45	0.003	0.13	1	17	1	6	27	2	3
Mn	3	1.35	0.33	0.48	0.003	0.13	1	16	1	6	22	2	3
P-Value		39	79	68	84	93	56	20	45	57	84	69	99
BLSD(.05)													1
		Leaf											
Control	--	2.72	0.33	2.68	0.43	0.21	34	106	67	97	18	9	6
Cu	5	2.79	0.32	2.69	0.45	0.22	35	106	66	92	19	11	6
B	2	2.77	0.32	2.71	0.44	0.21	37	107	67	92	19	9	7
S	25	2.85	0.33	2.74	0.46	0.20	38	109	68	94	18	9	6
Mg	75	2.93	0.32	2.80	0.44	0.24	38	111	70	92	20	9	6
Zn	10	2.68	0.31	2.68	0.44	0.21	36	105	67	84	31	8	6
Mn	3	2.82	0.32	2.68	0.45	0.21	37	107	68	93	19	9	7
P-Value		98	79	36	5	91	26	81	36	50	99	99	96
BLSD(.05)		0.16									3	1	1

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

Treatment	Rate/A	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
		Total Elemental Removal											
		Silage Stover											
	#/A	lbs/A											
Control	-	35.5	7.5	100.7	14.9	7.2	1.1	0.34	0.26	0.33	0.06	0.04	0.04
Cu	5	37.1	6.3	103.6	16.6	7.8	1.3	0.41	0.26	0.34	0.06	0.05	0.04
B	2	36.4	7.2	104.4	14.9	7.0	1.1	0.37	0.26	0.33	0.06	0.05	0.05
S	25	33.5	7.0	99.6	15.1	6.7	1.1	0.35	0.25	0.32	0.06	0.04	0.04
Mg	75	32.9	5.8	109.5	13.4	7.2	1.1	0.35	0.25	0.31	0.06	0.04	0.04
Zn	10	34.8	6.0	99.7	16.6	7.4	1.3	0.38	0.27	0.33	0.16	0.04	0.04
Mn	3	31.7	6.3	96.2	13.8	6.4	1.1	0.38	0.24	0.31	0.06	0.04	0.04
P-Value		45	92	22	96	61	25	37	6	10	99	89	99
BLSD(.05)					2.6						0.03		0.01
		Silage Grain											
Control	-	90.9	23.7	33.6	0.22	9.3	0.003	0.12	0.01	0.05	0.16	0.02	0.02
Cu	5	100.9	24.7	35.0	0.22	9.6	0.004	0.12	0.01	0.05	0.16	0.02	0.02
B	2	96.2	24.5	34.6	0.21	9.5	0.003	0.12	0.01	0.05	0.16	0.02	0.02
S	25	96.6	24.5	34.2	0.22	9.5	0.003	0.13	0.01	0.05	0.18	0.02	0.02
Mg	75	94.0	24.4	33.4	0.21	9.7	0.004	0.13	0.01	0.05	0.16	0.02	0.02
Zn	10	96.7	23.6	33.1	0.24	9.5	0.000	0.12	0.01	0.05	0.19	0.02	0.02
Mn	3	99.0	24.3	35.0	0.20	9.4	0.003	0.12	0.01	0.05	0.16	0.02	0.02
P-Value		53	16	47	69	5	62	41	43	5	86	83	97
BLSD(.05)													
		Total											
Control	-	126.5	31.3	134.4	15.1	16.5	1.1	0.46	0.27	0.39	0.23	0.06	0.06
Cu	5	138.1	31.1	138.7	16.9	17.4	1.3	0.53	0.27	0.39	0.23	0.07	0.06
B	2	132.7	31.7	139.1	15.1	16.4	1.1	0.50	0.28	0.39	0.23	0.07	0.07
S	25	130.2	31.6	133.8	15.4	16.3	1.1	0.48	0.26	0.37	0.24	0.06	0.06
Mg	75	126.9	30.2	142.9	13.6	17.0	1.1	0.48	0.26	0.36	0.23	0.06	0.06
Zn	10	131.5	29.7	132.9	16.8	16.9	1.3	0.51	0.29	0.38	0.35	0.06	0.06
Mn	3	131.1	30.7	131.2	14.0	15.9	1.2	0.50	0.25	0.36	0.22	0.06	0.06
P-Value		34	61	14	96	37	25	38	6	10	99	90	99
BLSD(.05)					2.6						0.04		0.01

EVALUATION OF FORMOLENE FOLIAR FEED N SOURCE ON POTATOES AT BECKER, 1983

W. E. Fenster, M. O'Leary and G. Buzicky

The objective of using a liquid nitrogen product is to add substantial amounts to the potato foliage when the nutrient demand is the greatest. The Formolene fertilizer (30-0-2) efficiency was compared to normal amounts of soil applied ammonium nitrate (34-0-0) on irrigated sandy textured soils. Fifty pounds per acre of N were applied during tuberization to the control plots to offset the possibility of blight spreading from the control area to the adjacent plots. All plots were replicated four times. Applications at planting time (4/22) across all plots except control based on U of M soil tests were as follows:

P_2O_5 - 150#A
K_2O - 400#A
S - 15#A
N - 20# + 60# at emergence

The U of M recommendation indicated in Table 1 had 60 pounds of N applied at tuberization. On another set of plots there was an additional 40 pounds of N applied for the plots labeled U of M Rec. + 40#.

Thus in addition to basic soil treatments for all plots (except control) the comparisons of two nitrogen sources and two rates of N were:

60# N ammonium nitrate (U of M rec.)
60# N as Formolene
100# N as Formolene
100# N as ammonium nitrate (U of M rec. + 40#)

The Formolene treatment schedule was as follows:

60# N rate of Formolene -

10# N	10 to 12 inch height	June 15
30# N	at tuberization	June 21
20# N	at canapy closure	June 30

100# N rate of Formolene -

20# N	10 to 12 inch height	June 15
30# N	at tuberization	June 21
20# N	at flowering	June 27
30# N	at canapy closure	June 30

Tuber yields in CWT per acre and percent of sample in several weight categories are shown in Table 1.

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

Table 1. Yields and size differences of potatoes comparing Formolene and ammonium nitrate fertilizers.

Treatment	Tuber Yield CWT/A	% of sample by weight (oz.) 0-3	3-6	6-9	9-12	12-16
Control	334	18	40	34	8	0
U. of M Rec.	460	9	37	34	10	10
Formolene (60#)	427	9	29	36	19	6
Formolene (100#)	458	10	30	34	20	7
U. of M. Rec. + 40# N	427	9	30	37	16	8
Significance	**					
BLSD (.05)	50					
C.V.	7.8					

Table 2. Nitrate - N (NO_3 + NO_2) in leaf plus petiole at 3 growth stages of potatoes. Becker, 1983.

1st stage 6/27 initial flowering

Treatment	Replicates I	II	III	IV	$\bar{X}$
Control	1682	423	975	491	893
U. of M. Rec.	833	726	923	578	765
Formolene (60#)	990	1009	624	1240	966
Formolene (100#)	1492	2090	1085	1172	1460
Significance					ns
BLSD (.05)					--
C.V.					40.4

2nd stage 7/11 full flower

Treatment	Replicates I	II	III	IV	$\bar{X}$
Control	1452	1822	1926	1784	1746
U. of M. Rec.	2038	1979	1848	1227	1773
Formolene (60#)	2552	1432	1440	1383	1702
Formolene (100#)	2707	2862	1753	2040	2341
Significance					ns
BLSD (.05)					--
C.V.					21.7

3rd stage 7/26 late flowering

Treatment	Replicates I	II	III	IV	$\bar{X}$
Control	413	456	302	230	350
U. of M. Rec.	339	247	379	154	280
Formolene (60#)	482	164	340	178	291
Formolene (100#)	520	1116	511	1000	787
Significance					**
BLSD (.05)					350
C.V.					49.3

Results

There was a highly significant response from foliar applied Formolene and from the ammonium nitrate soil applied over the control plot, even though some nitrogen was added to the control area. There were no significant differences in yields among nitrogen comparisons.

There was a shift to larger tuber sizes due to Formolene leaf treatments with both the 60 and 100 pounds of N as Formolene and the 100 pounds per acre ammonium nitrate treatment, (table 1). Although there was no apparent effect on tuber yield the plant tests (leaf & petiole) showed trends to higher nitrate N in the plant from the Formolene product at all three sampling dates but significant at the 5% level only on the third stage of sampling, (table 2).

1983 WEATHER

R. K. Severson

Mild temperatures during the first three months of 1983 made winter in the Red River Valley very enjoyable this year. January, February, and March average temperatures were all well above normal being +9.5°, +10.2°, and +4.7°, respectively. The area snow depth reached a maximum of 6 inches on February 20 and the depth of ground frost reached a maximum of 34 inches on February 15. With temperatures in the mid-30's during the last week of March, the snow pack was completely melted by the first week of April. The ground frost also began melting during the first week of April and the frost was out by April 29.

April and May temperatures were below normal with the average temperature for May being 4.5° cooler than normal. Precipitation for April was also 1.35 inches below normal making the early spring season less desirable for the warm season crops. June realized 1.62 inches above normal precipitation and average temperatures. A stormy period during June 12 and 13 dumped 3.09 inches of rain leaving water standing in some fields which was devastating to crops like sugarbeet. Another storm system came through June 21 and 22 dumping nearly an inch of precipitation along with strong winds and a couple of tornados producing property damage just to the east of Crookston.

July, August and September were all above normal in regard to average temperature with monthly departures from normal of +3.4°, +5.3°, and +5.3°F, respectively. July was relatively hot and dry recording 1.83 inches of precipitation which was 1.26 inches below normal. August and September were both above normal for precipitation with August at 1.67 inches and September at 0.27 inches above normal. Yet another strong storm system moved through the area on August 25 and 26 dumping 2.10 inches of precipitation together with strong winds which caused severe damage to corn and sunflower fields through lodging of the crops. October and November were above normal in regard to precipitation. October was below normal and November above normal in regard to average temperature. December marked the coldest December in the history of the Crookston weather station with an average monthly temperature of -1.8° which was 13.3° below normal. Three new low maximum daily temperature records were set during the month of December. December 12, 23, and 24 records were -12, -15, and -18°F, respectively. During the period of time from December 16 through December 25, the temperature was below zero.

The mean temperature for the year was 1.1° above normal with 4 all-time high temperature records surpassed. They occurred on 2/14, 8/8, 9/3, and 10/28 with respective temperatures of 46°, 104°, 98°, and 74°F. The last spring frost was recorded May 25 (31°) which initiated a 120-day growing season ending September 22 (31°) when the first fall frost occurred.

The precipitation for 1983 totaled 23.24 inches of which 20.88 inches were recorded as rain and 2.36 inches were contained in 35.3 inches of snow. Three record daily amounts of precipitation were also recorded in 1983 on 1/6, 6/13, and 9/15 with .25, 2.34, and 1.27 inches of precipitation recorded, respectively.

Table 1. Weather summary for 1983 with averages for precipitation and mean temperature (1890-1979).

Month	Precipitation					Mean Temperature	
	Snow	Precip.	Rain	Total	1890-1979	1983	1890-1979
	Inches					°F	
January	6.0	.36	.01	.37	.56	13.2	3.7
February	6.9	.52	.04	.56	.59	18.3	8.1
March	6.7	.64	1.40	2.04	.84	27.6	22.9
April	0.5	T	.22	.22	1.57	39.9	41.4
May	1.0	.03	2.59	2.62	2.59	50.1	54.6
June	--	--	5.18	5.18	3.56	64.3	64.4
July	--	--	1.83	1.83	3.09	73.0	69.6
August	--	--	4.57	4.57	2.90	72.7	67.4
September	--	--	2.43	2.43	2.16	56.8	51.5
October	--	--	2.13	2.13	1.43	42.6	45.3
November	8.0	.43	.48	.91	.78	29.8	26.7
December	6.2	.38	--	.38	.60	-1.8	11.5
TOTAL	35.3	2.36	20.88	23.24	20.67	40.54	39.4

STARTER FERTILIZER STUDY--SPRING WHEAT

G. E. Varvel and H. L. Meredith

Objective of Study: To compare commercially available fertilizer materials with experimental urea phosphates prepared by TVA as starter fertilizers on a highly calcareous soil.

Location: University of Minnesota, Northwest Experiment Station, Crookston, MN.

Carriers: 1) urea phosphate (17-44-0), 2) diammonium phosphate (18-46-0), 3) urea phosphate (17-44-0) + UAN solution (28-0-0) to give (13-28-0), and ammoniated phosphoric acid (10-34-0) + UAN solution (28-0-0) to also give (13-28-0).

P Rate: 50 and 100 lb P_2O_5/A.

Methods: All treatments were applied with the seed. The test variety was Marshall and all treatments (seed + fertilizer) were applied on May 4, 1983. Emergence (stand counts) were taken on June 2, 1983. Whole plant samples were taken at jointing (June 24, 1983) and maturity (August 2, 1983) for total N and ICP analyses. Whole plant samples taken at maturity (soft dough) were used to calculate N, P, and K uptake. Grain was harvested on August 12, 1983 to determine yields and subsamples were taken for test weight and protein analyses. Soil test data for the study were: pH-8.2, NO_3-N (0-2')-60 lb/A, NO_3-N (0-6')-124 lb/A, $NaHCO_3$ P (0-6")-23, and exchangeable K (0-6")-320 lb/A. The experiment was done on a Wheatville loam soil.

Table 1. The effect of starter fertilizer on elemental analyses of whole plant samples of spring wheat taken at jointing.

Treatment		Elemental Analyses								
Carrier	P_2O_5 Rate	N	P	K	Ca	Mg	Mn	Zn	Cu	B
	lb/A	%					ppm			
Check	0	2.95	0.30	2.97	0.29	0.24	52	17	7	4
17-44-0	50	3.42	0.34	3.10	0.32	0.28	59	19	8	4
	100	3.42	0.36	3.47	0.33	0.30	59	20	13	5
18-46-0	50	3.11	0.33	3.15	0.32	0.27	53	17	8	5
	100	3.04	0.34	3.46	0.33	0.27	54	19	11	5
13-28-0	50	2.77	0.31	3.10	0.27	0.23	50	17	10	4
	100	3.11	0.33	3.22	0.30	0.26	52	18	11	5
13-28-0	50	3.17	0.33	3.04	0.30	0.27	55	18	9	4
	100	3.20	0.36	3.11	0.35	0.29	55	19	8	5
Significance		N.S.	**	*	*	**	N.S.	N.S	N.S.	N.S.
B.L.S.D. (.05)			0.03	0.39	0.05	0.03				
C.V. (%)		10.6	6.3	7.1	9.0	8.1	10.7	9.3	29.3	8.3
Main Effects										
Carrier										
17-44-0		3.42	0.35	3.28	0.33	0.29	59	19	10	5
18-46-0		3.08	0.33	3.30	0.33	0.27	53	18	9	5
13-28-0		2.94	0.32	3.16	0.28	0.24	51	17	11	5
13-28-0		3.18	0.35	3.07	0.33	0.28	55	18	8	5
Significance		*	*	N.S.	**	**	N.S.	*	N.S.	N.S
P_2O_5 Rate										
lb/A										
50		3.12	0.33	3.10	0.30	0.26	54	18	9	4
100		3.19	0.35	3.31	0.33	0.28	55	19	11	5
Significance		N.S.	*	*	**	N.S.	N.S.	*	N.S.	*

Results: Elemental analyses of plant samples taken at jointing and maturity are shown in Tables 1 and 2, respectively. Significant differences in P, K, Ca, and Mg content at jointing (Table 1) were obtained when all of the treatments, including a check, were analyzed. Significant differences in N, P, Ca, Mg and Zn content were obtained between carriers and in P, K, Ca, Zn, and B content between the two rates of applied P at jointing (Table 1). No significant differences at maturity were obtained (Table 2).

Stand counts, grain yield, protein, test weight, forage yield, N, P, and K uptake at maturity are shown in Table 3. No significant differences in any of the measured variables except emergence were obtained. Emergence was significantly affected by both carrier and rate of applied P.

Discussion: Soil test levels of P and K were sufficient for maximum crop production at this location. Nitrate-N levels in the 0-2' level were low enough that a response to N would have been expected, but variability in the results negated it. Significant differences in stand were obtained, but as in previous years they did not cause or correlate with any reduction in yield. These results support those obtained in the previous two years and indicate that urea phosphates can be safely used as starter fertilizers on spring wheat at the levels tested in these studies.

Table 2. The effect of starter fertilizer on elemental analyses of whole plant samples of spring wheat taken at maturity (soft dough).

Treatment		Elemental Analyses								
Carrier	P_2O_5 Rate	N	P	K	Ca	Mg	Mn	Zn	Cu	B
	lb/A	%					ppm			
Check	0	1.61	0.30	1.07	0.11	0.17	29	25	15	2
17-44-0	50	1.66	0.27	1.07	0.12	0.17	32	23	18	2
	100	1.50	0.27	1.03	0.10	0.17	30	23	16	2
18-46-0	50	1.56	0.28	1.00	0.11	0.17	33	24	18	2
	100	1.43	0.27	1.00	0.10	0.17	30	24	16	2
13-28-0	50	1.45	0.29	0.96	0.10	0.17	33	26	20	2
	100	1.40	0.28	1.05	0.11	0.18	31	23	18	2
13-28-0	50	1.55	0.28	0.98	0.11	0.17	31	24	17	2
	100	1.53	0.29	1.05	0.12	0.17	33	25	17	2
Significance		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	.S.
C.V. (%)		10.2	7.2	11.4	13.6	7.6	9.1	9.7	12.4	18.2
Main Effects										
Carrier										
17-44-0		1.58	0.27	1.05	0.11	0.17	31	23	17	2
18-46-0		1.49	0.28	1.00	0.10	0.17	31	24	17	2
13-28-0		1.42	0.28	1.00	0.11	0.17	32	25	19	2
13-28-0		1.54	0.29	1.01	0.11	0.17	32	24	17	2
Significance		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
P_2O_5 Rate										
lb/A										
50		1.55	0.28	1.00	0.11	0.17	32	24	18	2
100		1.47	0.28	1.03	0.10	0.17	31	24	17	2
Significance		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 3. The effect of starter fertilizer on emergence (stand count), grain yield, protein, test weight, forage yield, N, P, and K uptake of spring wheat.

Treatment			Grain			Forage			
	P_2O_5	Stand			Test	D.M.	Uptake		
Carrier	Rate	Count	Yield	Protein	Weight	Yield	N	P	K
	lb/A	Plants/A	bu/A	%	lb/Bu	- - - - - - lb/A - - - - - - -			
Check	0	750,105	35.7	14.5	58.5	5018	82.3	14.9	54.3
17-44-0	50	881,655	49.8	15.1	58.8	7619	126.5	20.1	81.8
	100	778,850	47.2	15.0	58.9	7016	106.3	18.8	72.6
18-46-0	50	885,140	42.5	14.6	59.2	6646	104.0	18.6	67.8
	100	820,670	44.3	14.2	59.0	6441	92.0	17.5	63.6
13-28-0	50	1,014,080	38.9	14.0	58.9	5515	80.5	15.8	53.3
	100	966,160	42.2	14.0	58.2	6673	94.4	18.3	70.4
13-28-0	50	1,046,310	47.9	15.1	58.5	7425	114.9	20.7	73.0
	100	969,645	45.7	14.5	58.8	6803	104.2	19.7	71.6
Significance		**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)		110,280							
C.V. (%)		8.6	18.2	5.7	1.2	18.8	24.9	15.1	25.6
Main Effects									
Carrier									
17-44-0		830,255	48.5	15.1	58.8	7318	116.4	19.5	77.2
18-46-0		852,905	43.4	14.4	59.1	6543	98.0	18.0	65.7
13-28-0		990,120	40.5	14.0	58.6	6094	87.4	17.0	61.9
13-28-0		1,007,980	46.8	14.8	58.6	7114	109.6	20.2	72.3
Significance		**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
P_2O_5 Rate									
lb/A									
50		956,795	44.8	14.7	58.8	6801	106.5	18.8	69.0
100		883,830	44.8	14.4	58.7	6733	99.2	18.6	69.5
Significance		**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

BROADCAST FERTILIZER STUDY - SPRING WHEAT

G. E. Varvel and H. L. Meredith

Objective: To evaluate experimental N carriers with varying urea content on a highly calcareous soil.

Location: University of Minnesota, Northwest Experiment Station, Crookston, MN.

Carriers: 1) Cogranulated urea-urea phosphate (38-12-0), 2) urea-ammonium phosphate (28-28-0), 3) urea phosphate (17-44-0), and 4) urea phosphate (17-44-0) + UAN (28-0-0) mixed to give (15-28-0).

N Rates: 30 and 60 lb N/A.

Methods: The treatments were applied and incorporated immediately on May 4, 1983 on a Wheatville loam soil. Phosphorus rates were equalized between all treatments with superphosphate (0-44-0). Marshall wheat was planted on the same day the treatments were applied. Emergence was evaluated on June 2, 1983 by taking stand counts. Whole plant samples were taken at jointing (June 24, 1983) and at maturity (August 2, 1983) for total N and ICP analyses. Grain was harvested on August 12, 1983 and subsamples were taken for protein and test weight determinations. Soil test data for the study were: pH-8.2, NO_3-N (0-2')-91 lb/A, $NaHCO_3P$ (0-6")-23 lb/A, and exchangeable K (0-6")-320 lb/A.

Results: Elemental analyses of plant samples taken at the jointing and soft dough (maturity) stages are shown in Tables 1 and 2, respectively. No significant differences were obtained between carriers at either sampling stage. All of the significant differences in elemental analyses shown in Tables 1 and 2 were due to increasing N rate.

Table 1. The effect of broadcast fertilizer materials on elemental analyses of whole plant samples of spring wheat taken at jointing.

Treatment		Elemental Analyses								
Carrier	N Rate	N	P	K	Ca	Mg	Mn	Zn	Cu	B
	lb/A	%					ppm			
Check	0	3.45	0.36	3.48	0.33	0.28	63	20	11	5
38-12-0	30	3.83	0.39	3.50	0.41	0.31	68	21	8	5
	60	3.92	0.42	3.52	0.44	0.35	76	25	10	5
28-28-0	30	3.69	0.37	3.60	0.36	0.31	64	21	10	5
	60	3.96	0.40	3.44	0.41	0.34	75	24	10	5
17-44-0	30	3.68	0.39	3.44	0.36	0.30	68	20	7	5
	60	3.85	0.42	3.46	0.43	0.33	75	23	9	5
15-28-0	30	3.66	0.40	3.36	0.40	0.32	68	23	13	5
	60	3.87	0.42	3.50	0.40	0.33	72	23	8	5
Significance		**	N.S.	N.S.	**	**	**	**	N.S.	N.S.
B.L.S.D. (.05)		0.30			0.06	0.03	8	3		
C.V. (%)		5.4	8.4	8.2	10.4	7.1	8.0	9.5	43.6	7.9
Main Effects										
Carrier										
38-12-0		3.87	0.40	3.51	0.43	0.33	72	23	9	5
28-28-0		3.83	0.39	3.52	0.39	0.32	70	23	10	5
17-44-0		3.76	0.40	3.45	0.40	0.32	71	21	8	5
15-28-0		3.77	0.41	3.43	0.40	0.33	70	23	10	5
Significance		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
N Rate lb/A										
30		3.71	0.39	3.48	0.38	0.31	67	21	9	5
60		3.90	0.41	3.48	0.42	0.34	74	23	9	5
Significance		**	*	N.S.	**	**	**	**	N.S.	N.S.

Table 2. The effect of broadcast fertilizer materials on elemental analyses of whole plant samples of spring wheat taken at maturity (soft dough).

Treatment		Elemental Analyses								
Carrier	N Rate	N	P	K	Ca	Mg	Mn	Zn	Cu	B
	lb/A	%					ppm			
Check	0	1.70	0.30	1.24	0.12	0.18	35	24	16	2
38-12-0	30	1.52	0.29	1.14	0.12	0.18	33	27	19	2
	60	1.72	0.27	1.30	0.13	0.19	35	23	20	2
28-28-0	30	1.66	0.29	1.18	0.11	0.18	33	24	16	2
	60	1.70	0.26	1.35	0.14	0.20	36	24	23	3
17-44-0	30	1.74	0.30	1.27	0.12	0.19	36	24	20	2
	60	1.51	0.27	1.21	0.14	0.19	37	24	23	3
15-28-0	30	1.61	0.28	1.17	0.12	0.18	32	23	19	2
	60	1.65	0.28	1.23	0.13	0.19	34	24	19	2
Significance		**	**	N.S.	N.S.	*	N.S.	N.S.	*	*
B.L.S.D. (.05)		0.11	0.02			0.02			5	1
C.V. (%)		5.0	4.9	10.8	15.1	6.4	9.4	9.6	17.0	21.5
Main Effects										
Carrier										
38-12-0		1.62	0.28	1.22	0.13	0.18	34	25	20	2
28-28-0		1.68	0.28	1.27	0.13	0.19	35	24	20	2
17-44-0		1.63	0.29	1.24	0.13	0.19	37	24	22	3
15-28-0		1.63	0.28	1.20	0.12	0.18	33	24	19	2
Significance		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
N Rate lb/A										
30		1.63	0.29	1.19	0.12	0.18	33	25	19	2
60		1.65	0.27	1.27	0.14	0.19	36	24	21	2
Significance		N.S.	**	*	**	**	N.S.	N.S.	*	N.S.

Stand count (emergence), grain yield, protein, test weight, grain N removal, forage yield, N, P, and K uptake results are shown in Table 3. Significant differences in grain yield, protein, and grain N removal were obtained between carriers. Significant differences in test weight, forage yield, N, and K uptake were obtained due to N rate.

Discussion: A significant response in grain yield was obtained when all treatments were compared to the check (Table 3). This response was expected as soil NO_3-N levels were sufficiently low, but the difference in grain yield between carriers was not expected. Forage yields (dry matter) and other measurements taken do not help explain the difference as they are essentially the same for all of the carriers. Comparison and analyses of the results from the first two years of the study with this year's results should provide additional information from which they can be evaluated.

Table 3. The effect of broadcast fertilizer materials on emergence, grain yield, protein, test weight, grain N removal, forage yield, N, P, and K uptake of spring wheat.

Treatment		Stand	Grain				Forage			
							D.M.	Uptake		
Carrier	N Rate	Count	Yield	Protein	Test Weight	N Removal	Yield	N	P	K
	lb/A	Plants/A	Bu/A	%	lb/Bu	lb/A	lb/A	- - - lb/A - - -		
Check	0	1,032,895	44.8	14.5	58.0	67.8	6508	111.0	18.9	81.8
38-12-0	30	1,000,140	53.7	14.2	58.3	79.6	7504	114.9	21.7	85.2
	60	1,033,590	54.7	15.3	58.0	88.1	8010	138.1	21.8	104.3
28-28-0	30	1,007,110	48.9	15.2	58.4	78.4	7375	122.2	21.5	87.2
	60	1,052,410	48.7	14.9	57.3	76.3	7820	133.0	20.6	105.9
17-44-0	30	1,028,020	47.7	14.9	57.8	74.5	7092	123.2	21.1	88.6
	60	1,058,680	51.2	14.5	58.0	78.2	7892	119.3	21.6	96.1
15-28-0	30	1,057,985	52.5	14.2	58.4	77.8	7547	121.2	21.5	87.9
	60	1,039,865	51.2	13.6	57.8	73.0	7762	128.0	22.0	95.1
Significance		N.S.	**	N.S.	N.S.	**	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)			4.7			9.8				
C.V. (%)		6.9	6.9	5.6	1.1	8.9	10.6	11.8	11.2	16.6
Main Effects										
Carrier										
38-12-0		1,016,865	54.2	14.7	58.2	83.9	7757	126.5	21.7	94.8
28-28-0		1,029,760	48.8	15.1	57.8	77.3	7597	127.6	21.1	96.5
17-44-0		1,043,350	49.5	14.7	57.9	76.4	7492	121.3	21.3	92.3
15-28-0		1,048,925	51.9	13.9	58.1	75.4	7655	124.6	21.7	91.5
Significance		N.S.	**	*	N.S.	*	N.S.	N.S.	N.S.	N.S.
N Rate lb/A										
30		1,023,310	50.7	14.6	58.2	77.6	7380	120.4	21.4	87.2
60		1,046,135	51.5	14.6	57.8	78.9	7871	129.6	21.5	100.3
Significance		N.S.	N.S.	N.S.	*	N.S.	*	*	N.S.	**

HIGH PHOSPHORUS AND POTASSIUM RATES ON CONTINUOUS SPRING WHEAT

G. E. Varvel and R. K. Severson

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. The experiment was located on a Wheatville loam soil.

Experimental procedure:
Ten treatments consisting of P and K combinations have been used. Treatment combinations and applications made to date are shown in Table 1. Treatments applied in the fall of 1983 were broadcast and plowed down. Nitrogen, as urea, was spring applied at 70 lb N/A and incorporated with a field cultivator on April 27, 1983. Marshall wheat was planted on April 27, 1983 and harvested for grain yields on August 8, 1983. Whole plant samples were taken at jointing (June 24, 1983) and soft dough (August 1, 1983) for elemental analyses. Samples taken at soft dough (maturity) were used to determine forage yields and N, P, and K uptake. Soil samples were taken after crop removal to measure the residual effects of the treatments.

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

Treatment No.	Application Date			
	Spring 1980	Fall 1980	Fall 1981	Fall 1982
	P_2O_5 (lb/A) + K_2O (lb/A)			
1	0 + 0	0 + 0	0 + 0	0 + 0
2	0 + 100	0 + 100	0 + 100	0 + 100
3	50 + 100	50 + 100	50 + 100	50 + 100
4	100 + 100	100 + 100	100 + 100	100 + 100
5	150 + 100	0 + 100	0 + 100	150 + 100
6	100 + 0	100 + 0	100 + 0	100 + 0
7	100 + 50	100 + 50	100 + 50	100 + 50
8	100 + 150	100 + 0	100 + 0	100 + 150
9	150 + 100	0 + 0	0 + 0	0 + 0
10	100 + 150	0 + 0	0 + 0	0 + 0

Results:
Elemental analyses of the whole plant samples taken at jointing and soft dough are shown in Tables 2 and 3 respectively. Significant differences in N, P, K, Mg, Zn, and B at jointing (Table 2) and in N and P at maturity (Table 3) were obtained between treatments.

Grain yield, protein, test weight, forage yield, N, P, and K uptake values shown in Table 4 indicate that only protein and P uptake were affected by the treatments.

Soil test results from the fall of 1983 sampling date are shown in Table 5. Samples were analyzed by both the University of Minnesota and North Dakota State University soil testing laboratories. Significant differences in residual P and K levels were obtained by both labs.

Discussion:
The importance of plant sampling being done early is shown in Tables 2 and 3. Plant samples taken at jointing (Table 2) or earlier do a good job of reflecting plant nutrient status while those taken at soft dough (Table 3) are generally too late to indicate anything about plant nutrient status during the growing season. These results agree with those from previous years and also with recommendations in the literature. The results in Table 2 indicate that the P and K being applied are being taken up by the plant but the lack of yield response (Table 4) indicates that neither P or K were limiting in 1983.

Soil test results in the fall of 1983, after 4 years of fertilization and cropping, indicate that soil test levels are being built up (Table 5). This build up has occurred in all cases where fertilizer has been applied, but no reduction in soil test levels has occurred where no fertilizer has been applied.

Table 2. Effect of P and K rate combinations on the elemental analyses of whole plant samples of spring wheat taken at jointing.

Treatment[1/] No.	Elemental Analyses N	P	K	Ca	Mg	Mn	Zn	Cu	B
	%					ppm			
1	3.53	0.32	3.53	0.33	0.30	56	25	9	5
2	3.50	0.32	3.85	0.32	0.25	56	25	9	5
3	3.09	0.40	3.93	0.29	0.25	55	19	4	4
4	3.09	0.42	3.85	0.27	0.25	57	19	7	4
5	3.30	0.41	3.96	0.32	0.24	52	19	5	4
6	3.18	0.40	3.26	0.29	0.29	57	18	8	4
7	3.15	0.42	3.70	0.30	0.26	57	20	7	4
8	2.94	0.40	3.56	0.30	0.24	51	18	5	4
9	3.29	0.36	3.30	0.31	0.27	53	22	7	4
10	3.36	0.36	3.60	0.32	0.27	57	22	6	5
Significance	**	**	**	N.S.	**	N.S.	**	N.S.	**
B.L.S.D. (.05)	0.24	0.03	0.28		0.04		4		1
C.V. (%)	5.0	5.8	5.3	12.0	8.7	9.2	12.2	56.7	9.1

1/ Corresponds to treatments shown in Table 1.

Table 3. Effect of P and K rate combinations on the elemental analyses of whole plant samples of spring wheat taken at maturity (soft dough).

Treatment No.	Elemental Analyses N	P	K	Ca	Mg	Mn	Zn	Cu	B
	%					ppm			
1	1.55	0.27	1.23	0.13	0.19	40	30	12	3
2	1.49	0.27	1.39	0.13	0.17	34	32	15	3
3	1.30	0.28	1.29	0.12	0.17	37	22	10	2
4	1.38	0.29	1.21	0.11	0.17	39	26	17	2
5	1.34	0.28	1.31	0.13	0.16	35	26	14	2
6	1.37	0.29	1.15	0.12	0.18	39	23	15	2
7	1.43	0.29	1.23	0.12	0.16	37	22	13	2
8	1.35	0.28	1.22	0.13	0.17	32	22	14	2
9	1.42	0.27	1.18	0.12	0.17	36	22	6	2
10	1.50	0.28	1.32	0.13	0.17	37	22	6	3
Significance	**	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)	0.14	0.02							
C.V. (%)	6.0	4.4	8.5	12.4	7.9	9.5	22.7	72.3	16.1

Table 4. Effect of P and K rate combinations on grain yield, protein, test weight, forage yield, N, P, and K uptake.

Treatment No.	Grain Yield	Grain Protein	Grain Test Weight	Forage D.M. Yield	Forage Uptake N	Forage Uptake P	Forage Uptake K
	Bu/A	%	lb/Bu	lb/A	lb/A	lb/A	lb/A
1	46.1	14.1	59.9	6599	103.0	17.8	82.6
2	47.7	13.9	60.0	6964	103.9	18.5	98.0
3	46.4	12.8	60.2	7177	93.6	19.9	94.0
4	48.6	13.0	59.6	7478	102.9	21.9	91.1
5	48.4	13.0	60.0	7562	102.0	21.1	100.1
6	46.6	12.9	60.0	7247	99.9	21.1	83.8
7	48.3	13.0	59.9	7172	102.7	21.0	88.2
8	51.4	12.8	60.2	7803	105.5	21.7	95.9
9	45.5	13.2	59.4	7328	104.7	19.9	86.7
10	50.3	13.5	59.9	7320	110.2	20.2	98.3
Significance	N.S.	**	N.S.	N.S.	N.S.	*	N.S.
B.L.S.D. (.05)		0.8				2.9	
C.V. (%)	7.3	3.6	0.8	8.5	11.0	8.2	13.1

Table 5. Effect of P and K rate combinations on residual P and K soil test levels after four years of application as determined by two soil testing laboratories.

Treatment No.	North Dakota State Univ. $NaHCO_3$ P 0-6"	North Dakota State Univ. $NaHCO_3$ P 6-12"	North Dakota State Univ. Exchangeable K 0-6"	North Dakota State Univ. Exchangeable K 6-12"	University of Minnesota Bray P-1 10:1 0-6"	University of Minnesota Bray P-1 10:1 6-12"	University of Minnesota Bray P-1 50:1 0-6"	University of Minnesota Bray P-1 50:1 6-12"	University of Minnesota $NaHCO_3$ P 0-6"	University of Minnesota $NaHCO_3$ P 6-12"	University of Minnesota Exchangeable K 0-6"	University of Minnesota Exchangeable K 6-12"
	lb/A	lb/A	lb/A	lb/A	lb/A	lb/A	lb/A	lb/A	lb/A	lb/A	lb/A	lb/A
1	12	7	284	224	11	4	49	28	10	6	263	227
2	13	8	336	258	24	15	55	36	10	7	321	250
3	30	17	324	264	43	21	96	54	25	14	302	255
4	54	25	393	274	43	17	149	69	44	21	307	263
5	39	22	333	250	52	22	116	61	33	19	319	265
6	48	23	259	216	33	12	109	46	39	20	251	218
7	43	27	288	238	55	28	128	68	36	23	273	250
8	53	32	328	274	70	36	148	76	43	25	309	280
9	20	12	258	203	31	16	78	39	16	9	273	241
10	17	10	274	215	33	20	76	44	14	8	255	231
Significance	**	**	**	**	**	*	**	**	**	**	**	**
B.L.S.D.(.05)	6	5	52	38	25	18	19	15	5	4	30	26
C.V. (%)	14.1	21.9	11.6	10.3	41.9	55.8	14.4	20.7	13.0	20.6	7.3	7.0

SOIL TEST LEVELS AND CROP QUALITY AS AFFECTED BY DIFFERENT FERTILIZER PROGRAMS IN A CONTINUOUS WHEAT CROPPING SYSTEM

G. E. Varvel and R. K. Severson

The objective of this study was to measure the effects of different fertilizer programs, so called maintenance versus build, over a 10-year period on soil test levels and crop quality in a continuous wheat cropping system. Soil test and crop quality measurements are taken to provide information for evaluation and determination of the most effective program. The study was originated in the spring of 1978.

Experimental Procedure: Five treatments with 4 replications were arranged in a randomized complete block design. Each of the 5 fertilizer treatments was based upon soil test data from the plots on which that treatment had been applied to in the previous years. All of the treatments were applied in the fall of 1982 and plowed down. Marshall wheat was planted April 27, 1983 and harvested August 8, 1983. Whole plant samples were taken at jointing (June 24, 1983) and at maturity (August 1, 1983) for elemental analyses. Whole plant samples taken at maturity (soft dough) were used to determine forage yields and to calculate N, P, and K uptake. Soil samples were taken after crop removal to measure the effects of the treatments and to establish the 1984 treatments.

Results: The effects of the treatments on the elemental analyses at jointing and maturity are shown in Tables 1 and 2. Significant differences in N, P, Ca, Mg, and Cu at jointing (Table 1) and Zn and B at maturity (Table 2) were obtained between the treatments. The grain and forage results are shown in Table 3 and all the measured variables were significantly affected by the treatments.

Soil test results from the fall of 1983 are shown in Table 4. The results shown in Table 4 indicate NO_3-N levels at the various depths and total NO_3-N for the 0-2' and 0-5' depths after 6 years of cropping under the various fertilizer programs. Significant differences in NO_3-N in the 0-1', 1-2', 2-3', 0-2', and 0-5' depths were obtained. Table 4 also contains P and K soil test results for samples taken from the 0-6" and 6-12" depths. Significant differences in residual P at both depths and residual K in the 0-6" depth were obtained.

Discussion:
All of the fertilizer programs have increased yields and some soil test levels over those of the check. The differences in yield have largely been due to the applied N, while P and K have increased soil test P and K levels only.

Table 1. The effects of five fertilizer programs on the elemental analyses of whole plant samples taken at jointing of spring wheat.

Treatment			Elemental Analyses								
N	P_2O_5	K_2O	N	P	K	Ca	Mg	Mn	Zn	Cu	B
- - - lb/A - - -			- - - - - - - - - % - - - - - - - - -					- - - - - - ppm - - - - - -			
0	0	0	3.25	0.32	3.54	0.31	0.29	64	33	9	5
90	30	40	2.93	0.35	3.57	0.28	0.26	58	28	8	5
90	30	55	2.70	0.34	3.68	0.26	0.25	57	25	8	5
100	30	40	3.53	0.36	3.42	0.35	0.30	63	32	9	5
90	40	40	3.52	0.39	3.70	0.34	0.32	62	30	11	5
Significance			**	**	N.S.	*	**	N.S.	N.S.	**	N.S.
B.L.S.D. (.05)			0.30	0.02		0.08	0.03			1	
C.V. (%)			6.3	4.6	5.6	14.6	7.2	5.7	11.8	10.1	8.3

Table 2. The effects of five fertilizer programs on the elemental analyses of whole plant samples taken at maturity (soft dough) of spring wheat.

Treatment			Elemental Analyses								
N	P_2O_5	K_2O	N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A			%					ppm			
0	0	0	1.55	0.28	1.12	0.10	0.16	37	37	16	2
90	30	40	1.61	0.28	1.20	0.10	0.17	36	30	16	2
90	30	55	1.51	0.28	1.21	0.10	0.17	36	29	17	2
100	30	40	1.70	0.27	1.24	0.13	0.18	37	32	16	4
90	40	40	1.67	0.25	1.24	0.13	0.18	34	30	19	3
Significance			N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	**	N.S.	*
B.L.S.D. (.05)									4		1
C.V. (%)			6.6	8.5	9.3	20.2	9.0	6.7	7.9	16.3	28.8

Table 3. The effects of five fertilizer programs on grain yield, test weight, protein, grain N removal, forage yield, N, P, and K uptake of spring wheat.

Treatment			Grain				Forage			
								Uptake		
N	P_2O_5	K_2O	Yield	Test Weight	Protein	N Removal	D.M. Yield	N	P	K
lb/A			Bu/A	lb/Bu	%	lb/A	lb/A			
0	0	0	36.9	59.1	13.9	54.4	5564	86.2	15.2	62.1
90	30	40	46.6	59.6	14.5	71.5	6582	105.8	18.4	78.7
90	30	55	46.1	59.9	14.8	72.2	6333	96.1	17.7	77.3
100	30	40	51.9	57.4	15.5	84.8	7076	120.3	18.9	88.0
90	40	40	47.6	56.9	15.6	78.3	7418	123.8	18.5	91.1
Significance			*	**	**	*	*	**	**	*
B.L.S.D. (.05)			10.5	7.1	0.9	18.3	1150	23.4	2.1	20.8
C.V. (%)			13.4	1.7	4.0	15.3	10.6	13.6	7.3	15.4

Table 4. The effects of five fertilizer programs on residual NO_3-N, P, and K soil test levels after six years in a continuous wheat cropping system.

Treatment			Soil Test Levels										
			NO_3-N							$NaHCO_3$ P		Exchangeable K	
N	P_2O_5	K_2O	0-1'	1-2'	2-3'	3-4'	4-5'	0-2'	0-5'	0-6"	6-12"	0-6"	6-12"
lb/A			lb/depth					lb/A		lb/A			
0	0	0	19	14	17	18	18	33	84	11	7	270	206
90	30	40	17	12	15	22	19	29	84	24	15	260	211
90	30	55	18	10	16	23	20	28	87	25	15	320	244
100	30	40	38	30	41	28	23	68	159	22	15	245	213
90	40	40	39	27	31	25	19	66	141	32	19	243	200
Significance			*	*	*	N.S.	N.S.	*	*	**	**	**	N.S.
B.L.S.D. (.05)			17	14	18			30	58	3	5	47	
C.V. (%)			40.1	46.2	45.9	42.7	37.4	41.7	31.6	9.1	21.5	10.7	10.5

COMPARISON OF TWELVE HARD RED SPRING WHEAT VARIETIES TO NITROGEN FERTILIZATION - CROOKSTON 1983

S. Comfort, G. Malzer, R. Busch, and G. Varvel

Introduction

Maximizing the benefits of nitrogen fertilization depends largely on the responsiveness of the individual plant. Spring wheat genotypes, as with many other crops, differ considerably in growth response to increases in nitrogen fertilizer. The reason why some wheat varieties respond more to nitrogen fertilization than others in not well understood, but it has been suggested that it may be related to favorable plant characteristics both above and below the ground. The general objective of this study was to evaluate twelve spring wheat varieties under three different nitrogen rates. More specifically the study intended to determine which varieties continued to show an increase in growth to added nitrogen and also which varieties performed better within an individual nitrogen rate. It was hoped that knowledge of varietal performances over a range of growing seasons would 1) aid in more efficient use of nitrogen fertilizer for a specific variety and 2) aid in determining which varieties' morphological and physiological characteristics should be more critically examined.

Experimental Procedures

Twelve varieties of hard red spring wheat were compared at 0, 67, and 137 Kg/ha at the Northwest Experimental Station at Crookston, Minn. Nitrogen was applied as a spring application of ammonium nitrate broadcast and incorporated. The field experiment was arranged as split plot design with nitrogen rates as the whole plot treatments and varieties as the subplot treatments. Varieties were planted in an area 5' x 20' utilizing a cone seeder. Each treatment was replicated four times.

Total plant dry matter production was determined at approximately the "soft dough" stage of growth and samples were collected for nitrogen content and calculation of nitrogen uptake. Yield grain was harvested with a 3 row grain binder from a 14 ft.^{2} area. The above ground growth (grain and straw) was removed from the experimental plot and placed in a forced air dryer. After drying, the samples were thrashed and the grain reweighed for yield determination. Straw weight was determined by difference. Samples of both straw and grain were collected and analyzed for nitrogen content and determination of nitrogen removal.

General Results

As was to be expected, all varieties did not respond in a similar manner to increasing rates of nitrogen fertilization. Consequently, a significant nitrogen rate x variety interaction was observed for all response parameters. Significant interaction of main effects necessitates the need to analyze 1) varietal differences within each nitrogen rate and 2) responsiveness of each variety to nitrogen fertilization. With this criteria, varietal comparisons can be made from Table 1. With respect to yield, Butte, Mn73168, and James had the highest yield at the zero N rate, while Butte, Mn7222, and Marshall were among the highest yeilding at the 67 kg N/ha rate of application, with James, Coteau, and Era leading the group when 134 kg N/ha was applied. At the highest N rate Coteau also removed the largest amount of N with the grain.

Table 2 allows for analysis of the ability of each variety to continue to respond to nitrogen fertilizer application. Two kinds of varieties are apparent from this table: 1) those which only significantly responded to the first increment in nitrogen fertilization; and 2) those which continued to respond from the 67 to 134 kg N/ha rate of application. The grain yields of all varieties except Olaf significantly increased with the first increment of fertilization. There was no significant increase in grain yield with any variety going from the 67 to 134 kg N/ha rate of application.

The variety James, however, reflected the largest grain yield increase with the second N increment. The second increment of N fertilization also increased nitrogen removal with the forage for Coteau, Marshall, and Olaf.

Table 1. Comparison of yield, N content, and N removal for forage, straw, and grain at 3 nitrogen rates on 12 varieties of hard red spring wheat. Location: Crookston, MN 1983.

		FORAGE			STRAW			GRAIN		
	N rate	YIELD	N CONT	N REMOV	YIELD	N CONT	N REMOV	YIELD	N CONT	N REMOV
	kg ha^{-1}	Mg ha^{-1}	g kg^{-1}	kg ha^{-1}	Mg ha^{-1}	g kg^{-1}	kg ha^{-1}	Mg ha^{-1}	g kg^{-1}	kg ha^{-1}
Butte	0	7.15	14.2	103.3	3.48	3.68	13.0	2.42	23.8	58.7
Coteau	0	4.80	13.5	65.9	2.72	3.95	10.7	1.96	29.8	59.3
Era	0	5.04	13.3	67.3	2.30	4.38	10.2	2.00	23.8	48.2
Marshall	0	5.14	14.3	75.5	2.35	4.43	10.4	2.07	25.8	53.7
Mn 7125	0	5.38	13.0	70.2	2.25	4.33	9.6	1.77	21.9	38.5
Mn 7222	0	3.95	13.8	54.5	1.86	4.48	8.2	1.90	23.1	43.9
Olaf	0	4.98	15.8	78.5	3.30	6.13	20.7	2.01	27.9	56.5
Thatcher	0	3.56	13.0	46.5	2.09	4.55	9.5	1.28	25.6	32.9
Mn 7357	0	4.20	13.9	58.4	2.23	6.15	13.9	1.81	22.4	40.2
Mn 73167	0	4.69	13.8	64.4	1.67	5.73	9.5	1.63	21.1	36 3
Mn 73168	0	5.58	15.0	84.0	2.65	6.65	17.6	2.37	23.4	55.6
James	0	5.67	15.5	87.3	3.23	3.15	12.8	2.30	27.9	64.2
HSD (.05)*		2.19	2.8	45.0	1.30	1.85	12.0	0.80	3.9	23.7
(.10)		2.02	2.6	41.4	1.19	1.70	11.0	0.74	3.6	21.8
Butte	67	10.15	13.7	139.7	5.06	3.83	19.8	3.77	24.5	92.5
Coteau	67	9.38	14.4	135.7	5.64	3.75	21.3	3.41	30.3	103.5
Era	67	8.66	14.1	121.9	4.21	4.33	18.5	3.40	22.8	77.6
Marshall	67	8.54	14.4	124.2	4.41	4.30	18.9	3.46	24.4	84.7
Mn 7125	67	8.73	12.9	113.2	4.37	5.50	23.8	3.36	23.7	79.6
Mn 7222	67	9.00	14.8	133.0	4.47	5.35	23.7	3.66	23.9	87.0
Olaf	67	8.75	14.5	126.4	4.89	5.05	24.7	2.63	26.4	69.4
Thatcher	67	8.91	13.3	117.9	5.01	4.80	23.9	2.63	25.1	66.1
Mn 7357	67	9.11	14.3	130.6	4.76	5.38	25.5	3.39	22.6	76.7
Mn 73167	67	9.95	13.9	138.6	4.93	5.00	24.6	3.36	22.3	75.1
Mn 73168	67	8.62	13.4	115.4	4.42	5.25	23.0	3.08	22.1	67.9
James	67	8.56	15.3	130.6	5.13	5.28	26.5	3.21	25.4	81.8
HSD (.05)*		2.19	2.8	45.0	1.30	1.85	12.0	0.80	3.9	23.7
(.10)		2.02	2.6	41.4	1.19	1.70	11.0	0.74	3.6	21.8
Butte	134	9.78	16.2	157.8	5.34	5.35	28.3	3.51	27.3	95.6
Coteau	134	10.51	16.0	168.1	6.29	5.60	35.4	3.57	31.0	110.6
Era	134	9.08	15.9	144.4	4.78	6.03	29.0	3.52	26.0	91.5
Marshall	134	10.21	16.2	164.2	4.98	6.35	31.6	3.43	28.4	97.1
Mn 7125	134	8.92	14.8	132.2	4.65	7.30	34.0	3.32	24.6	81.6
Mn 7222	134	8.56	14.9	127.6	4.10	6.83	28.3	2.90	27.7	80.0
Olaf	134	10.47	16.3	171.0	5.73	7.00	40.2	2.94	28.9	85.3
Thatcher	134	9.43	14.8	139.2	5.48	6.28	34.5	2.76	27.4	75.7
Mn 7357	134	8.53	16.7	142.9	5.17	7.20	37.1	2.99	28.7	84.2
Mn 73167	134	10.20	15.9	162.5	5.31	7.75	41.2	3.49	27.0	93.6
Mn 73168	134	9.33	15.8	146.7	5.29	8.03	42.7	3.06	27.3	82.2
James	134	9.97	14.9	148.8	5.46	6.10	33.2	3.72	26.9	99.9
HSD (.05)*		2.19	2.8	45.0	1.30	1.85	12.0	0.80	3.9	23.7
(.10)		2.02	2.6	41.4	1.19	1.70	11.0	0.74	3.6	21.8

*HSD values for comparison of variety means within one nitrogen rate.

Table 2. Comparison of means for nitrogen rates within one variety for forage, straw and grain. Crookston, Mn. 1983.

		------Forage------			-------Straw------			------Grain------		
VARIETY	N RATE	YIELD	N CONT	N REMOV	YIELD	N CONT	N REMOV	YIELD	N CONT	N REMOV
	kg/ha	Mg/ha	g/kg	kg/ha	Mg/ha	g/kg	kg/ha	Mg/ha	g/kg	kg/ha
Butte	0	7.15	14.2	103.3	3.48	3.68	13.0	2.42	23.8	58.7
	67	10.15	13.7	139.7	5.16	3.83	19.8	3.77	24.5	92.5
	134	9.78	16.2	157.8	5.34	5.35	28.3	3.51	27.3	95.6
Coteau	0	4.80	13.5	65.9	2.72	3.95	10.7	1.96	29.8	59.3
	67	9.38	14.4	135.7	5.64	3.75	21.3	3.41	30.3	103.5
	134	10.51	16.0	168.1	6.29	5.60	35.4	3.57	31.0	110.6
Era	0	5.04	13.3	67.3	2.30	4.38	10.2	2.00	23.8	48.2
	67	8.66	14.1	121.9	4.22	4.33	18.5	3.40	22.8	77.6
	134	9.08	15.9	144.4	4.78	6.03	29.0	3.52	26.0	91.5
Marshall	0	5.14	14.3	75.5	2.35	4.43	10.4	2.07	25.8	53.7
	67	8.54	14.4	124.2	4.41	4.30	18.9	3.46	24.4	84.7
	134	10.21	16.2	164.2	4.98	6.35	31.6	3.43	28.4	97.1
Mn 7125	0	5.38	13.0	70.2	2.25	4.33	9.6	1.77	21.9	38.5
	67	8.73	12.9	113.2	4.37	5.50	23.8	3.36	23.7	79.6
	134	8.92	14.8	132.2	4.65	7.30	34.0	3.32	24.6	81.6
Mn 7222	0	3.95	13.8	54.5	1.86	4.48	8.2	1.90	23.1	44.0
	67	9.00	14.8	133.0	4.47	5.35	23.7	3.66	23.9	87.0
	134	8.56	14.9	127.6	4.10	6.83	28.3	2.90	27.7	80.0
Olaf	0	4.98	15.8	78.5	3.30	6.13	20.7	2.01	27.9	56.5
	67	8.75	14.4	126.4	4.89	5.05	24.7	2.63	26.4	69.4
	134	10.47	16.3	171.0	5.73	7.00	40.2	2.94	29.0	85.3
Thatcher	0	3.56	13.0	46.5	2.09	4.55	9.5	1.28	25.6	32.9
	67	8.91	13.2	117.9	5.01	4.80	23.9	2.63	25.1	66.1
	134	9.43	14.8	139.2	5.48	6.28	34.4	2.76	27.4	75.7
Mn 7357	0	4.20	13.9	58.4	2.23	6.15	13.9	1.81	22.4	40.2
	67	9.11	14.3	130.6	4.76	5.38	25.5	3.39	22.6	76.7
	134	8.53	16.7	142.9	5.17	7.20	37.1	3.00	28.7	84.2
Mn 73167	0	4.69	13.8	64.4	1.67	5.73	9.5	1.63	22.1	36.3
	67	9.94	13.9	138.6	4.93	5.00	24.6	3.36	22.3	75.1
	134	10.20	15.9	162.5	5.31	7.75	41.2	3.49	27.0	93.6
Mn 73168	0	5.58	15.0	84.0	2.65	6.65	17.6	2.37	23.4	55.6
	67	8.62	13.4	115.4	4.42	5.25	23.0	3.08	22.1	67.9
	134	9.33	15.8	146.7	5.29	8.03	42.7	3.06	27.3	82.2
James	0	5.67	15.5	87.3	3.23	3.95	12.8	2.30	27.9	64.2
	67	8.56	15.3	130.6	5.13	5.28	26.5	3.22	25.4	81.8
	134	9.97	14.9	148.8	5.46	6.10	33.2	3.72	26.9	99.9
BSD(.05)*		1.55	2.7	31.8	1.05	1.99	11.0	0.68	4.3	18.1

*BSD values for comparison of nitrogen means for one variety

EFFECTS OF HIGH NITROGEN RATES IN STARTER FERTILIZERS ON SPRING WHEAT

G. E. Varvel and R. K. Severson

Many studies have been done at various locations to determine how much N can be applied with the seed of various crops at planting time. This study was initiated in 1982 because results from other trials at Crookston had indicated that fairly high N rates could be applied with the seed of spring wheat without reducing germination or yield.

Experimental Procedure:

Three materials, urea (46-0-0), diammonium phosphate (18-46-0), and urea phosphate (17-44-0) were used in the study. One check treatment, four rates of urea (45, 60, 80 and 100 lb N/A) and one rate each of DAP (55 lb N/A) and urea phosphate (40 lb N/A) were randomized in a complete block design with four replications. Marshall wheat was planted along with the various N treatments on May 4, 1983 and harvested on August 12, 1983. Emergence (stand counts) were taken on June 2, 1983. Soil test results for the study were: pH-8.2, $NaHCO_3$ P-21 lb/A, exchangeable K-320 lb/A, and NO_3-N (0-2')-56 lb/A.

Results:

Stand count (emergence) was significantly reduced when N rates with the seed were 80 lb/A or greater with urea. No reduction in emergence was obtained with either the DAP or urea phosphate at the N rates used in this study. A significant yield increase was obtained when treatments were compared to the check, except when urea was applied at 100 lb N/A. At that point, the stand count had been reduced enough to affect yield. Test weight was significantly reduced with each successive rate of urea, which is consistent with other N rate studies. Test weight was not significantly different from the check for the DAP or urea phosphate treatments. No significant differences in protein or grain N removal were obtained, but trends indicated higher protein and N removal with the N treatments.

Discussion:

Results indicated that higher levels of N fertilizer in starters may be used at planting time on spring wheat on the medium to heavy textured soils of the Red River Valley than had previously been recommended. Emergence was reduced, but not until levels far above current recommendations were reached. These results will permit greater flexibility in N recommendation programs for spring wheat.

Table 1. The effects of starter fertilizers with high N levels on emergence, grain yield, protein, test weight, and grain N removal.

Treatment		Stand	Grain			
Source	N Rate	Count	Yield	Protein	Test Weight	N Removal
	lb/A	Plants/A	Bu/A	%	lb/Bu	lb/A
Check	0	722,225	39.3	16.3	59.0	61.9
Urea	45	737,035	48.9	16.3	59.3	76.6
	60	830,255	49.8	16.6	58.7	79.6
	80	663,855	47.6	16.8	57.7	76.8
	100	553,212	43.3	17.3	56.9	71.8
18-46-0	55	775,370	50.4	16.1	58.9	78.3
17-44-0	40	703,060	48.7	16.1	59.3	75.3
Significance		**	+	N.S.	**	N.S.
B.L.S.D. (.05)		12,430	9.1		1.0	
C.V. (%)		11.1	11.0	3.9	1.2	13.8

EFFECTS OF NITROGEN AS UREA IN STARTER FERTILIZER ON SPRING BARLEY

G. E. Varvel and R. K. Severson

This study was initiated because results from other trials at Crookston had indicated that fairly high N rates could be used in starter fertilizers without reducing germination or yield of spring barley on soils of the Red River Valley.

Experimental Procedure:
Six rates of N (0, 45, 60, 75, 85, 100 lb/A) as urea were randomized in a complete block design with four replications. Robust barley was seeded with the various treatments shown above on May 5, 1983. Emergence (stand counts) were taken on June 2, 1983. Grain was harvested on August 8, 1983 and subsamples were used to determine test weight, protein content, and percentage plump kernels. Soil test results for the study were: pH-8.2, $NaHCO_3$ P-22 lb/A, exchangeable K-275 lb/A, and NO_3-N (0-2')-53 lb/A.

Results:
The effects of the treatments are shown in Table 1. Significant differences in stand count, grain yield, test weight, and N removal were obtained between the treatments. Stand count and test weight were both significantly reduced while grain yield and N removal increased up to their maximum with the 75 lb/A N rate and then decreased with additional N.

Discussion:
The use of urea as a starter fertilizer was not as detrimental as had been expected. Stand count (emergence) was reduced, but it did not become critical until N rates in excess of 75 lb/A were used. This level is far above any that have been recommended in the literature. These findings indicate that urea can be used as a starter fertilizer on spring barley when N rates of 50-60 lb/A or less are needed. These results coincide with those obtained in a starter fertilizer study that has been conducted at Crookston during the last three years on spring wheat. These findings should allow greater flexibility when fertilizer recommendations are being made.

Table 1. The effects of N as urea in starter fertilizer on emergence (stand counts), grain yield, test weight, protein, plump kernels, and N removal of spring barley.

		Grain				
N Rate	Stand Count	Yield	Test Weight	Protein	Plump Kernels	N Removal
lb/A	Plants/A	Bu/A	lb/Bu	%	%	lb/A
0	547,985	32.8	46.4	13.9	88	35.3
45	459,995	52.1	46.6	14.5	86	57.6
60	461,735	47.6	46.1	15.3	88	55.7
75	363,290	52.2	45.5	15.5	87	61.9
85	339,770	41.0	44.6	15.3	86	48.2
100	315,375	32.8	42.3	16.3	87	41.1
Significance	*	**	**	N.S.	N.S.	**
B.L.S.D. (.05)	150,850	9.0	1.2			10.7
C.V. (%)	22.0	14.1	1.8	7.7	3.0	14.4

EFFECTS OF NITROGEN RATE AND PLACEMENT ON THREE MALTING BARLEY VARIETIES

G.E. Varvel and R.K. Severson

The importance of malting barley in northwestern Minnesota has generated the need for additional information on N fertilization with the release of new higher yielding varieties. The higher yield potential of these varieties is due in part to greater straw strength and disease resistance which may allow higher levels of N fertilization. This study was established in 1981 to evaluate two varieties, Morex and Glenn, under various N management programs. Robust, a new variety released in the spring of 1983, has been included in this year's study.

Experimental Procedure:
The treatments consisted of N from UAN solution (28-0-0) at rates of 0, 50, 100, and 150 lb/A both surface applied (broadcast) and injected (6 inches deep, 12 inches apart) on three malting barley varieties in a factorial arrangement. A randomized complete block design with four replications was used. Soil test results for the experiment were: NO_3-N (0-2')-60 lb/A, $NaHCO_3$ P-20 lb/A, and exchangeable K-420 lb/A.

The fertilizer treatments were applied and the varieties planted on May 2, 1983. Whole plant samples were taken at jointing (June 20, 1983) and soft dough (July 25, 1983) for N analyses. The samples taken at soft dough (maturity) were used to calculate forage yield and N uptake. Grain was harvested August 1, 1983 for yield and quality determinations (protein, bushel weight, percent plump kernels). Harvest index (HI) was calculated as the ratio of grain yield to forage yield and nitrogen harvest index (NHI) was calculated as the ratio of total grain N content to N content of the forage.

Table 1. The effects of variety, N rate, and N placement on early plant N, forage yield, forage N content, N uptake, grain yield, test weight, protein content, plump kernels, N removal, HI and NHI of malting barley.

		Forage			Grain						
Variety	N[1/]	D.M. Yield	N[2/]	N Uptake	Yield	Test Weight	Protein[3/]	Plump Kernels	N Removal	HI	NHI
	%	lb/A	%	lb/A	Bu/A	lb/Bu	%	%	lb/A		
Morex	3.38	6057	1.33	80.9	50.3	44.3	12.1	77	47.0	0.41	0.60
Glenn	3.18	6458	1.33	86.6	53.1	44.1	11.8	81	48.4	0.41	0.59
Robust	3.31	6630	1.34	89.5	55.2	47.0	12.6	89	53.9	0.40	0.62
Significance	**	**	N.S.	*	**	**	**	**	**	N.S.	N.S.
B.L.S.D. (.05)	0.11	348	--	6.5	2.5	0.3	0.3	3	2.6	--	--
N-Rate lb/A											
0	2.62	4456	1.32	59.4	38.7	45.4	11.5	89	34.3	0.43	0.61
50	3.15	6475	1.29	84.3	53.8	45.3	11.9	82	49.4	0.40	0.61
100	3.53	7154	1.32	94.8	58.5	45.0	12.2	83	55.1	0.40	0.59
150	3.86	7441	1.40	104.2	60.5	44.7	13.0	77	60.3	0.39	0.59
Significance	**	**	*	**	**	**	**	**	**	*	N.S.
B.L.S.D. (.05)	0.11	361	0.07	6.5	2.6	0.4	0.4	4	2.9	0.03	--
N Placement											
Surface	3.23	6415	1.33	86.4	53.8	45.2	12.1	83	50.6	0.41	0.61
Injected	3.35	6349	1.33	85.0	52.0	45.0	12.2	82	49.0	0.40	0.60
Significance	**	N.S.	N.S.	N.S.	+	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

1/ Kjeldahl N (early plant)

2/ Kjeldahl N

3/ Kjeldahl N x 6.25

Results:
The main effects of variety, N rate, and fertilizer placement are shown in Table 1 for all of the measured variables. All possible interactions were analyzed and those that were significant will be discussed below. Significant differences between varieties were obtained on all the measured variables except forage N, HI, and NHI. Nitrogen application caused significant differences in all of the mesaured variables except for NHI. Nitrogen placement significantly affected only N content in the plant at jointing.

Discussion:
Results obtained in 1983 provide additional information on N fertilization of malting barley. The application of additional N significantly increased early plant N, forage yield, N uptake, grain yield, protein content, and N removal and significantly decreased test weight on all three varieties. A significant N rate by variety interaction was obtained with respect to the percent plump kernels because the addition of N significantly decreased plump kernels with Morex and Glenn but had no effect on the percent plump kernels of Robust.

The differences between the varieties were significant with respect to many of the measured variables as can be seen in Table 1. Robust had the highest forage yield, N uptake, grain yield, protein content, percent plump kernels, and N removal of the three varieties. These results indicate that even though the varieties are all responding similarly to applied N, inherent characteristics in the varieties cause them to respond at different levels. These differences have been seen consistently over the duration of this study and will provide a greater flexibility when it comes to choosing the right variety for various situations which exist.

COMPARISON OF NITROGEN SOURCES ON SPRING WHEAT AND BARLEY

G.E. Varvel and R.K. Severson

Nitrogen fertilization is a large investment for small grain farmers in northwestern Minnesota. Information on the source and amount of N to use is available, but improving the efficiency of the applied N has become more important. These studies were designed to evaluate the N sources available using two application methods on spring wheat and barley.

Experimental Procedure:
The treatments used are shown in Tables 1 and 2. Four nitrogen sources, anhydrous ammonia (82-0-0), urea (46-0-0), ammonium nitrate (34-0-0), and UAN solution (28-0-0) were used. Urea, ammonium nitrate, and UAN solution were surface applied (broadcast) and injected (6 inches deep, 12 inches apart) at two N rates (50 and 100 lb/A) so that application methods could be analyzed. Anhydrous ammonia was injected only at the same N rates as above which then allows analyses of all the injected treatments so that the sources could be compared. Two check plots with 0 N were also included. All fertilizer treatments were made on April 29, 1983 for both the spring wheat and barley studies. Marshall wheat and Robust barley were seeded on April 30, 1983 on their respective studies. Whole plant samples taken at soft dough (July 25, 1983) from the barley study and at jointing (June 25, 1983) and soft dough (August 2, 1983) from the wheat study were analyzed for total N content. Samples taken at soft dough were used to calculate N uptake. Grain yields were taken on August 2, 1983 from the barley study and on August 8, 1983 from the wheat study. Test weight and protein analyses were run on the grain samples. Soil test results for the barley study were: NO_3-N (0-2')-50 lb/A, $NaHCO_3$-P (0-6")-23 lb/A, and exchangeable K (0-6")-330 lb/A. Soil test results for the wheat study were: NO_3-N (0-2')-45 lb/A, $NaHCO_3$-P (0-6")-18 lb/A, and exchangeable K (0-6")-410 lb/A.

Table 1. The effect of nitrogen source, rate, and application method on barley yield and quality.

Treatment			Forage			Grain				
Source	N Rate	Method[1/]	D.M. Yield	N	N Uptake	Yield	Test Weight	Protein	N Removal	Plump Kernels
	lb/A		lb/A	%	lb/A	Bu/A	lb/Bu	%	lb/A	%
Check	0	B	4190	1.37	59.2	33.2	47.7	12.1	31.1	91
	0	I	3632	1.38	50.8	29.1	47.0	11.3	25.4	88
Anhy. Amm.	50	I	7126	1.32	95.0	63.2	46.6	11.8	57.2	85
82-0-0	100	I	7839	1.46	114.6	68.8	46.5	12.7	67.3	87
Urea	50	B	7428	1.21	90.2	62.1	47.6	11.6	55.9	90
46-0-0	100	B	7676	1.41	109.6	72.5	47.0	13.2	73.1	87
	50	I	7437	1.31	97.2	62.9	46.9	11.6	56.4	89
	100	I	8288	1.42	117.1	64.9	46.3	12.9	64.2	83
UAN	50	B	4374	1.26	55.9	40.4	47.2	11.1	34.5	90
28-0-0	100	B	5757	1.13	66.1	51.1	46.2	11.2	44.0	89
	50	I	6190	1.23	79.0	55.8	46.9	11.4	49.3	92
	100	I	7115	1.17	83.6	56.9	46.9	11.5	50.4	92
Ammonium	50	B	7220	1.26	91.5	64.1	46.9	11.9	58.8	87
Nitrate	100	B	8497	1.49	126.2	70.1	46.8	13.4	72.2	84
34-0-0	50	I	7751	1.23	95.6	58.0	47.4	11.3	50.7	91
	100	I	8530	1.44	122.8	69.0	46.3	12.7	67.3	86
Significance			**	**	**	**	*	**	**	N.S.
B.L.S.D. (.05)			1061	0.15	18.2	8.8	1.1	0.9	10.8	
C.V. (%)			11.9	7.8	15.2	11.6	1.3	5.5	15.2	5.6

1/ B - Broadcast, I - Injected.

Results:
The effects of the treatments are shown in Tables 1 and 2 for the barley and wheat studies, respectively. Results from the UAN treatments created problems because it appears that the material obtained had been diluted at some point before we received it. This can be seen when the results in Tables 1 and 2 are examined. Results from another study in which the same UAN material was used indicate the same problem.

Despite this problem, several things are still apparent from the results in both tables. The addition of N significantly increased all of the measured variables on both wheat and barley except for test weight, which was significantly reduced. Carrier differences were harder to assess because of the problem with UAN. The only apparent difference between carriers and methods of application was obtained in the N content in the wheat plant at jointing (Table 2). These results indicate that even though we are able to get more N in the plant early by injecting it, these differences are lost later in the growing season.

Table 2. The effect of nitrogen source, rate, and application method on wheat yield and quality.

Treatment				Forage			Grain			
Source	N Rate	Method[1/]	N[2/]	D.M. Yield	N	N Uptake	Yield	Test Weight	Protein	N Removal
	lb/A		%	lb/A	%	lb/A	Bu/A	lb/Bu	%	lb/A
Check	0	B	2.38	3307	1.34	43.6	19.9	60.0	13.9	28.9
	0	I	2.52	3181	1.37	44.2	20.4	60.1	13.2	28.3
Anhy. Amm.	50	I	3.19	6882	1.42	97.9	44.5	60.7	12.9	60.4
82-0-0	100	I	3.63	6790	1.49	102.7	49.9	60.4	13.6	71.2
Urea	50	B	2.98	6133	1.36	83.6	40.5	60.4	12.7	54.2
46-0-0	100	B	3.63	8222	1.55	127.9	54.3	59.8	13.8	78.8
	50	I	3.24	6662	1.36	91.2	43.4	60.9	13.0	59.2
	100	I	3.79	8189	1.53	125.5	53.3	60.4	13.8	77.2
UAN	50	B	2.41	4567	1.32	61.1	26.4	60.6	12.5	34.7
28-0-0	100	B	2.67	5179	1.43	74.3	33.1	60.7	12.4	43.4
	50	I	2.96	6021	1.37	84.2	36.2	60.7	12.7	48.5
	100	I	3.34	6552	1.33	88.1	45.8	60.7	13.0	62.7
Ammonium	50	B	3.27	6781	1.37	93.1	43.0	60.6	12.7	57.4
Nitrate	100	B	3.85	8045	1.58	127.3	54.9	59.9	14.5	83.6
34-0-0	50	I	3.27	6529	1.38	90.0	42.3	60.4	12.9	57.5
	100	I	3.84	7653	1.57	121.0	55.1	59.9	14.3	82.6
Significance			**	**	+	**	**	**	**	**
B.L.S.D. (.05)			0.21	822	0.27	16.8	4.4	0.7	0.8	7.1
C.V. (%)			5.1	10.1	9.6	14.2	8.3	0.7	4.1	9.6

1/ B - Broadcast, I - Injected.

2/ Kjeldahl N (early plant)