SOIL SERIES

A REPORT ON FIELD RESEARCH IN SOIL SCIENCE

The 1980 edition of the "Bluebook" is a compilation of data collected and analyzed throughout Minnesota. Information was contributed by personnel of the Department of Soil Science including Extension Soil Specialists, Scientists at the branch stations of Crookston, Grand Rapids, Lamberton, Morris, Rosemount and Waseca; the "Sand Plain" experimental sites; and Soils and Crop area agents. Associated personnel from the Soil Conservation Service, the Soil and Water Research group of the SEA-USDA, the Tennessee Valley Authority, the Department of Natural Resources and the Departments of Agriculture also contributed information.

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

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

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Spring 1980 Minnesota Soil Moisture Situation

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

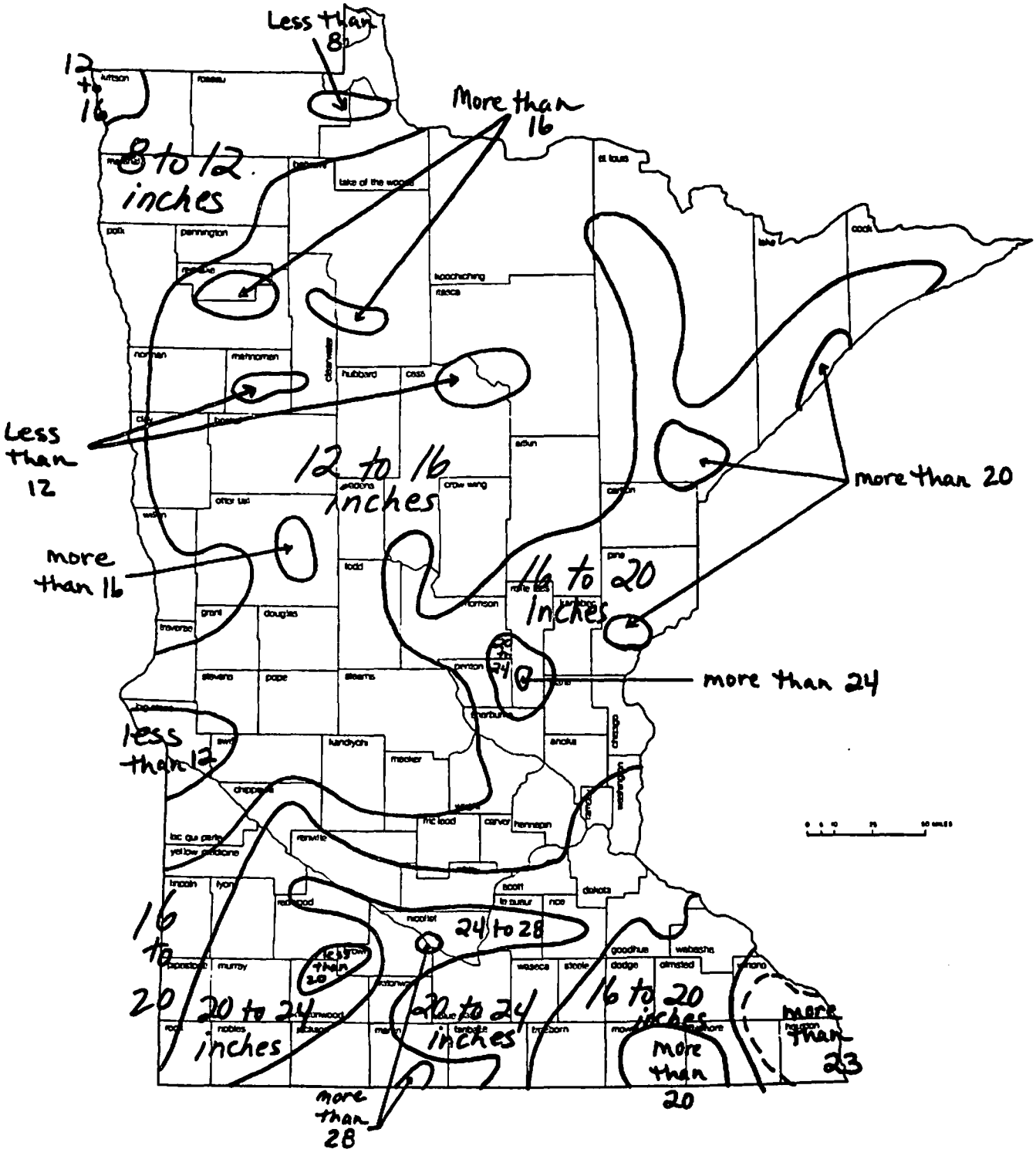
Table 1 shows the available water, field capacity, percent of capacity, and the total season precipitation at each site. The season precipitation is the amount of rainfall received between the spring and fall sample dates. The data were recorded, in most cases, at the site where the samples were taken.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

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

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

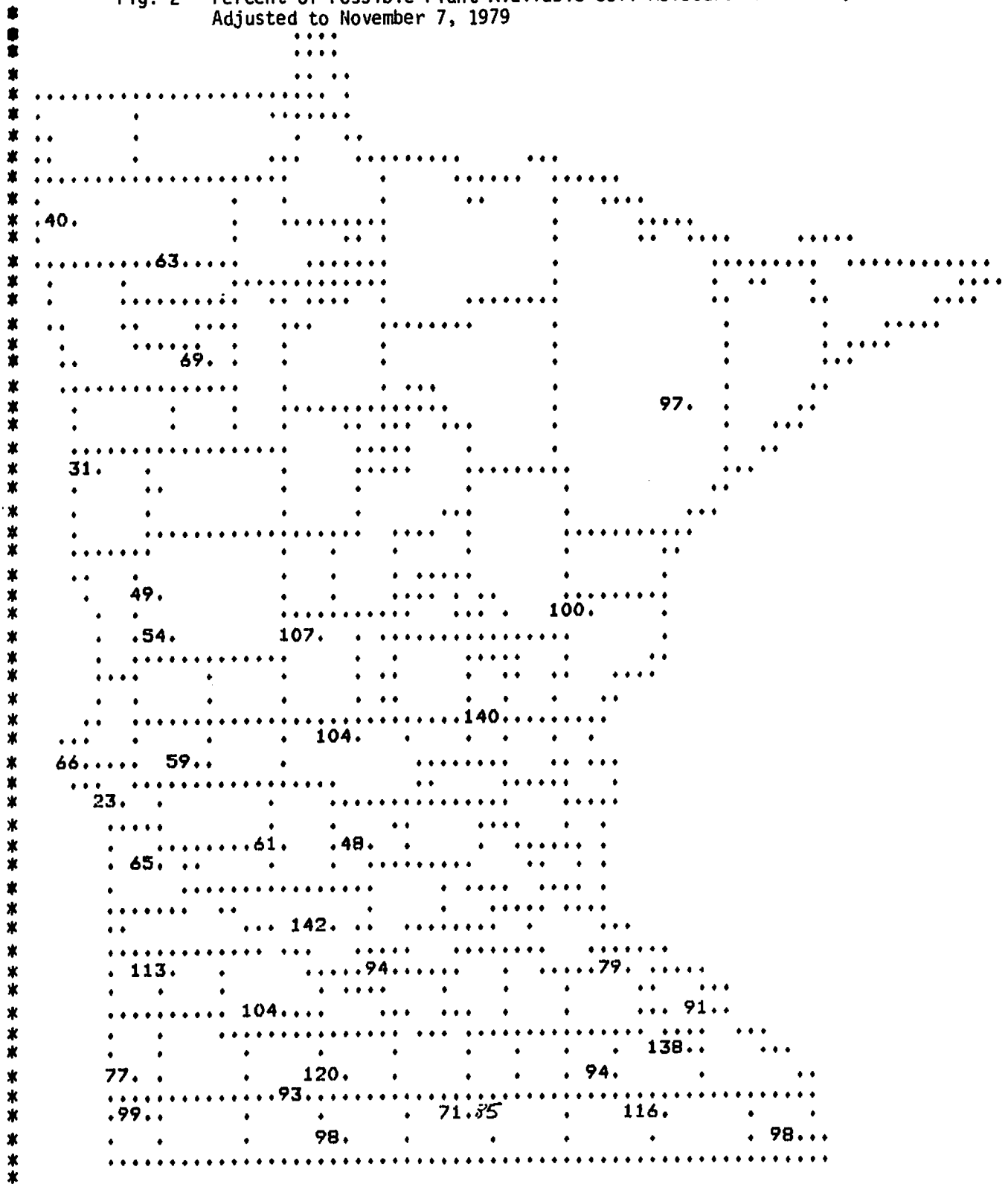
These data show that for the 26 sites sampled that had corn grown on them, an average of 21.3 inches of water was used to satisfy all demands. With most of the sites having 8 to 10 inches or more of available water when sampled last fall, this shows that only 10-22 inches of rainfall which enters the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

Fig. 1 PRECIPITATION FOR MAY-SEPTEMBER, 1979



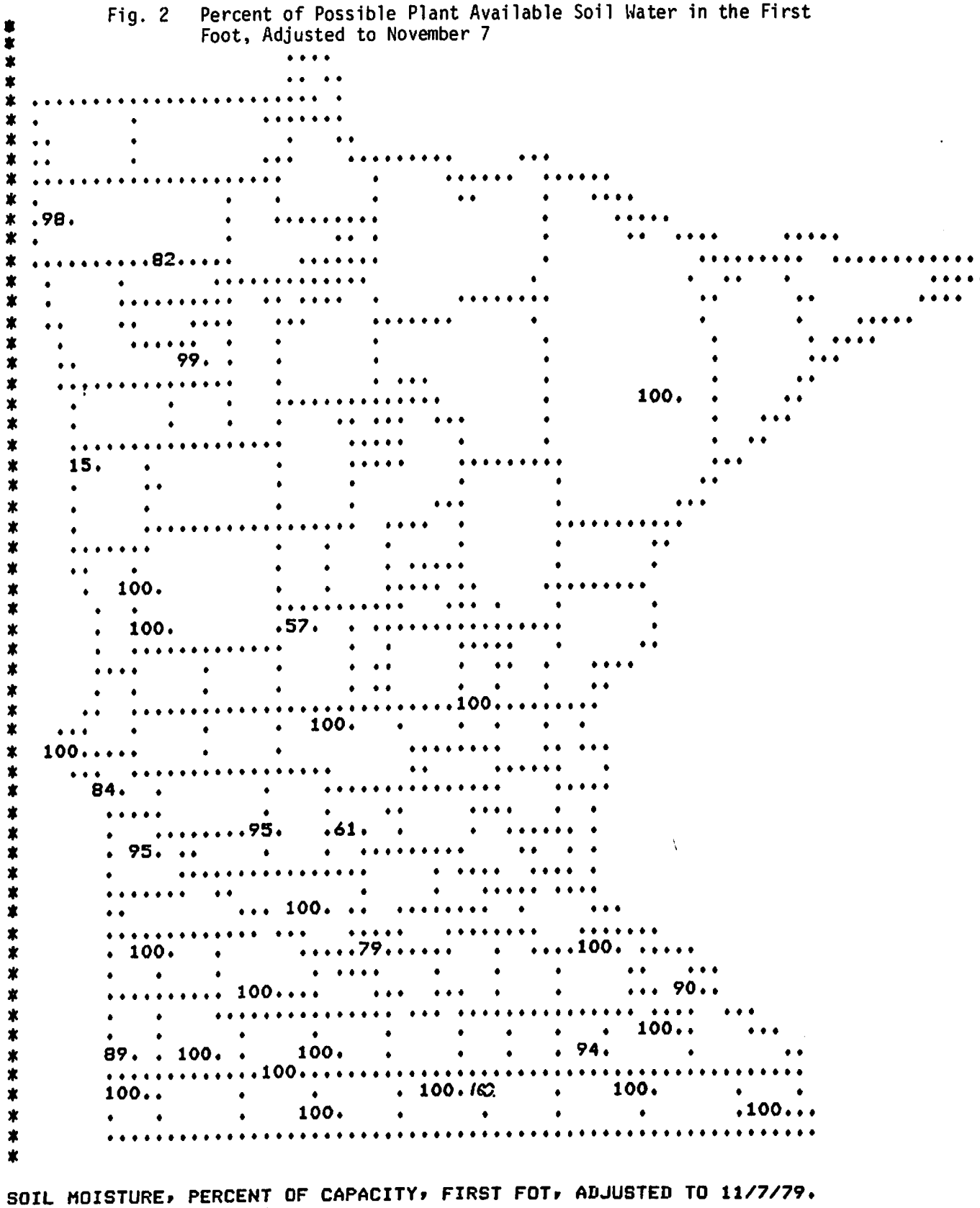
Data prepared from National Weather Service and DNR-Forestry observations.

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



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

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



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

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

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

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

Fall 1979 Soil Moisture Results

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

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

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

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

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

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

Soil Moisture Profiles at Lamberton and Morris

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

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

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

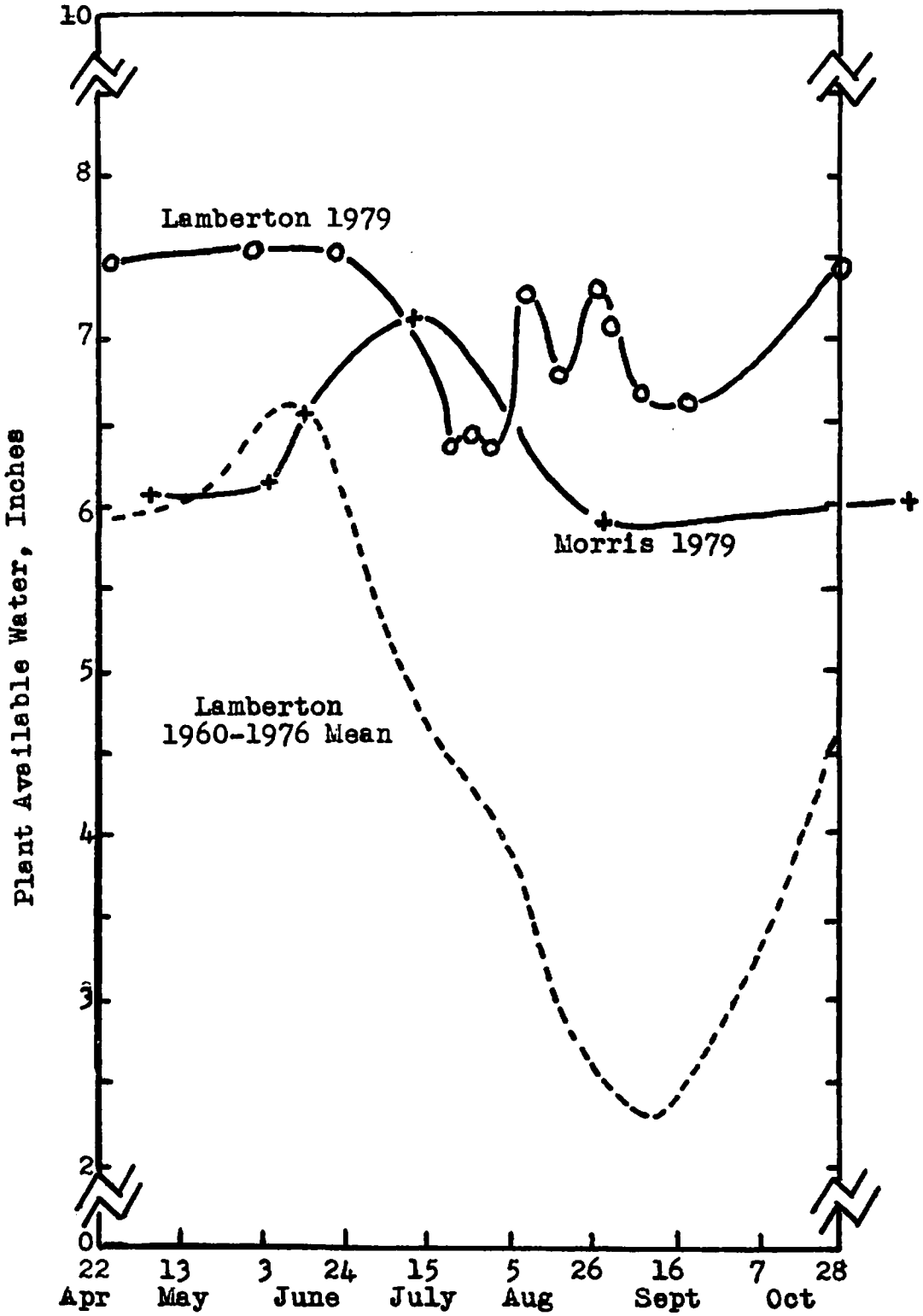


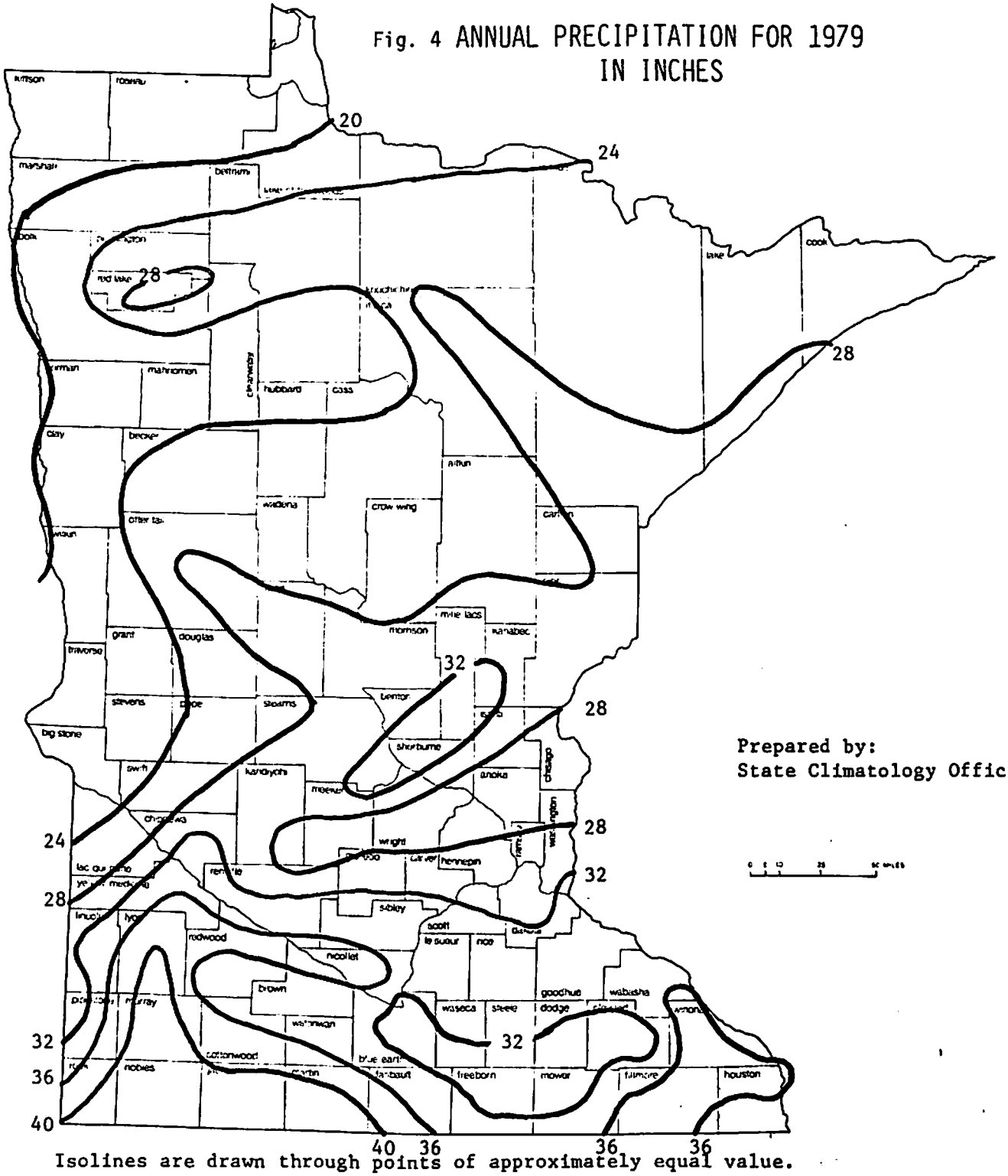
Fig. 3 Soil moisture at Lamberton and Morris in 1979 compared to the long-term Lamberton mean.

The 1979 Precipitation

by Earl L. Kuehnast and Donald G. Baker

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

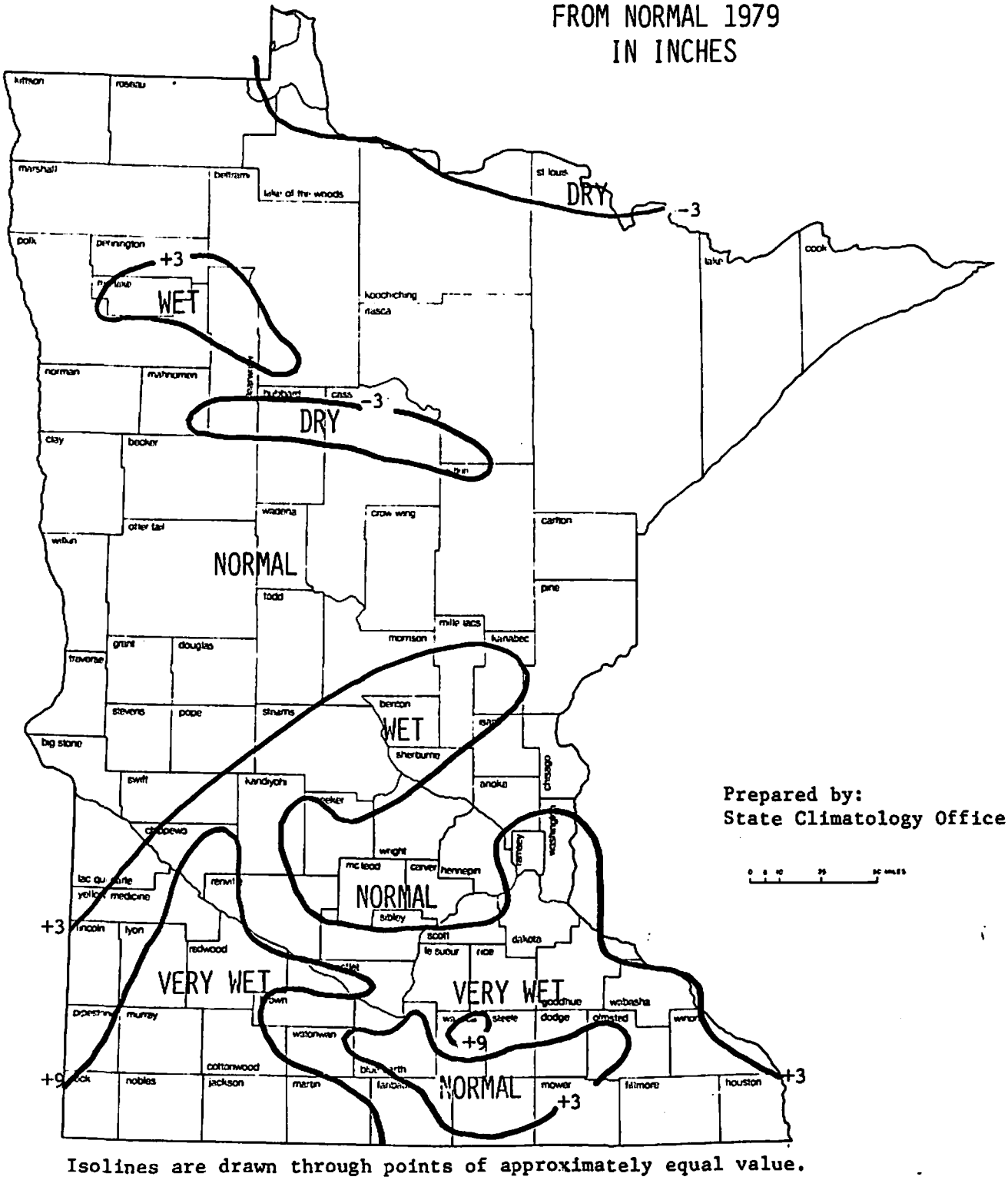
Fig. 4 ANNUAL PRECIPITATION FOR 1979
IN INCHES



Prepared by:
State Climatology Office

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

Fig. 5 ANNUAL PRECIPITATION DEPARTURE FROM NORMAL 1979 IN INCHES



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

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

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

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

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

Crop Phenological Data

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

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

Agroclimatic Data

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

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

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

1. Cumulative precipitation.

2. Estimates of consumptive use.

3. Spring and fall frost probabilities.

4. Ratio of potential evapotranspiration to pan evaporation.

5. Estimates of insect phenological stages.

6. Weekly precipitation probabilities.

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

TABLE 1

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

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

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

TABLE 2

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

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

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

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

FIGURE 1

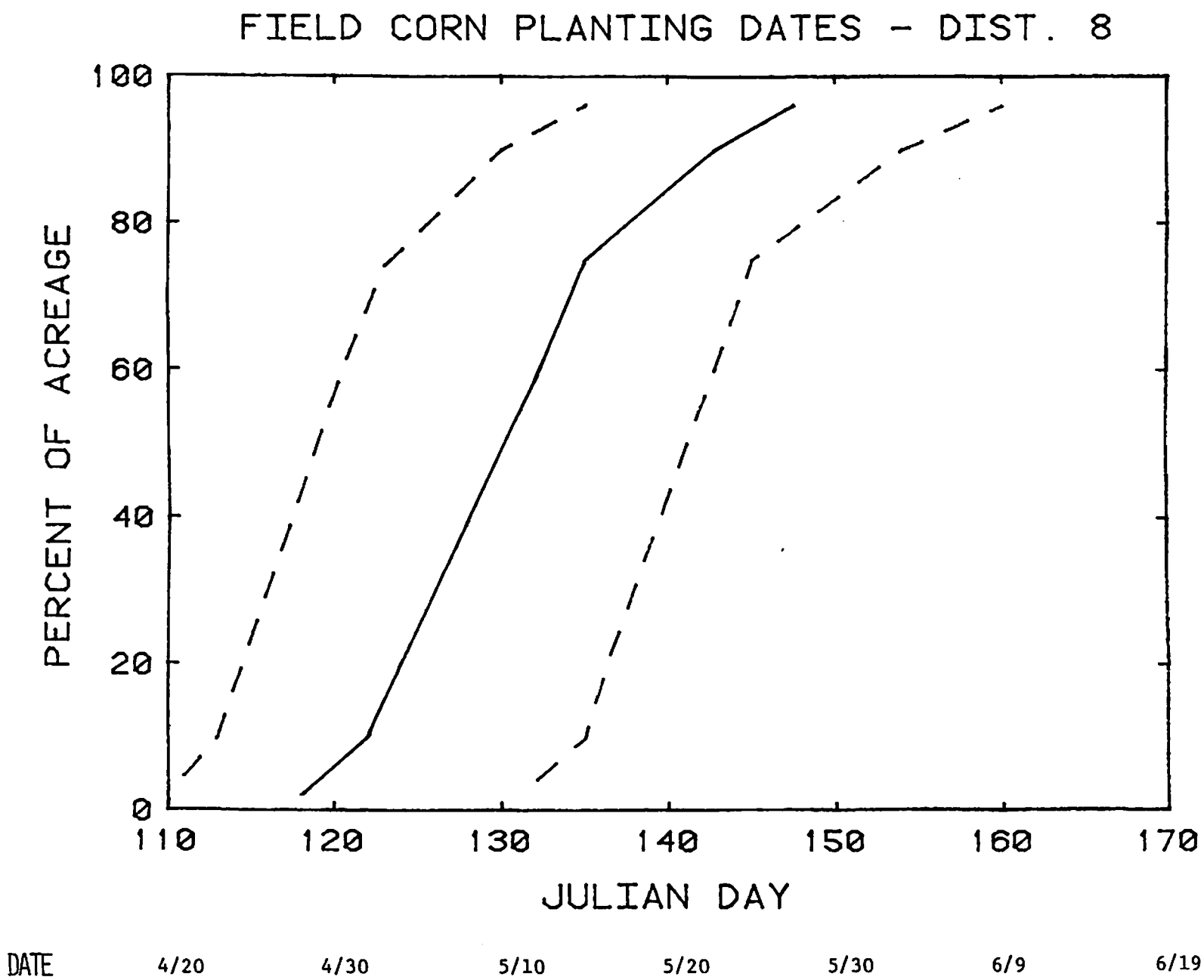

FIELD CORN PLANTING DATES - DIST. 8
PERCENT OF ACREAGE
100
80
60
40
20
0
110
120
130
140
150
160
170
JULIAN DAY
DATE
4/20
4/30
5/10
5/20
5/30
6/9
6/19

FIGURE 2

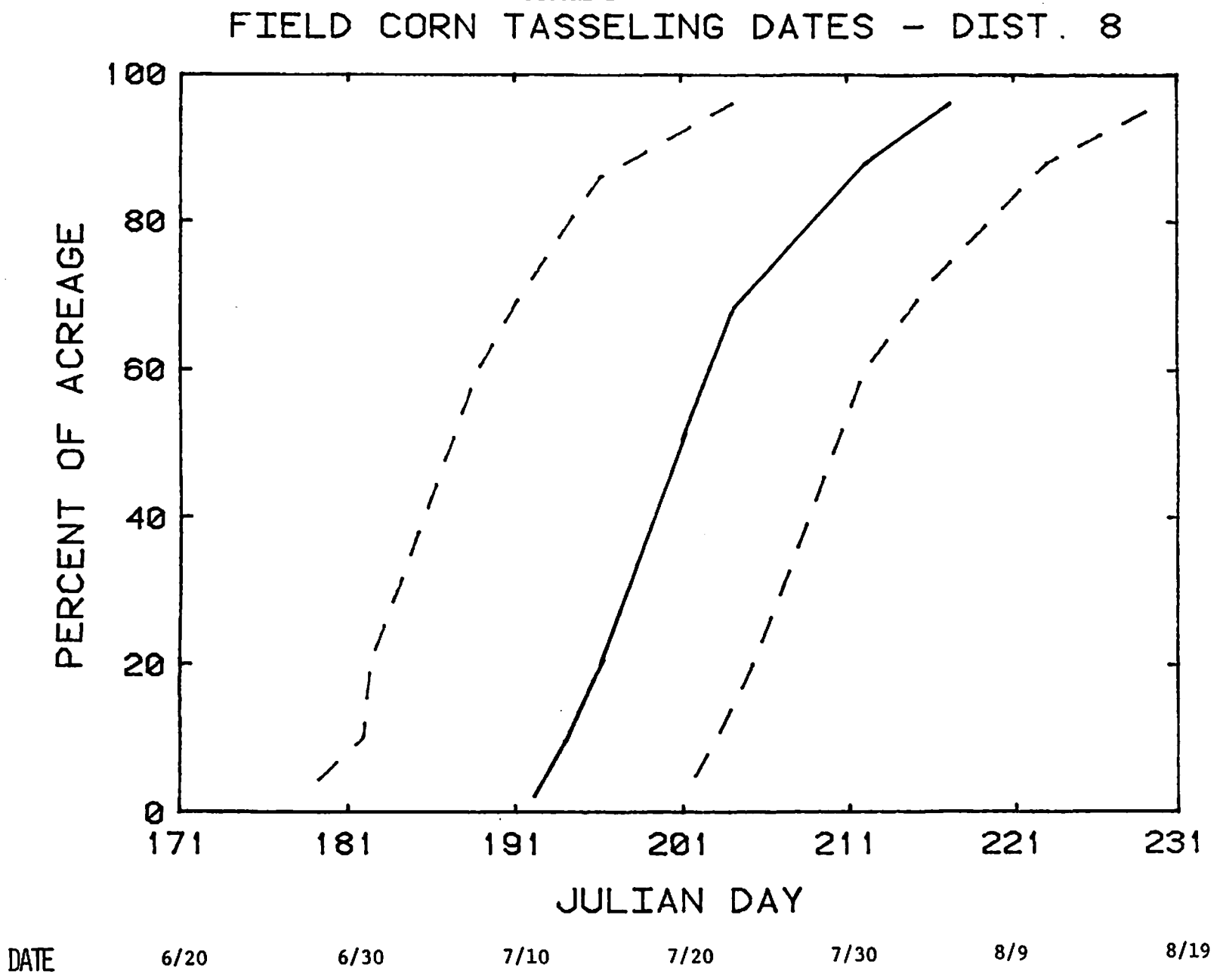

FIELD CORN TASSELING DATES - DIST. 8
PERCENT OF ACREAGE
100
80
60
40
20
0
171
181
191
201
211
221
231
JULIAN DAY
DATE
6/20
6/30
7/10
7/20
7/30
8/9
8/19

FIGURE 3

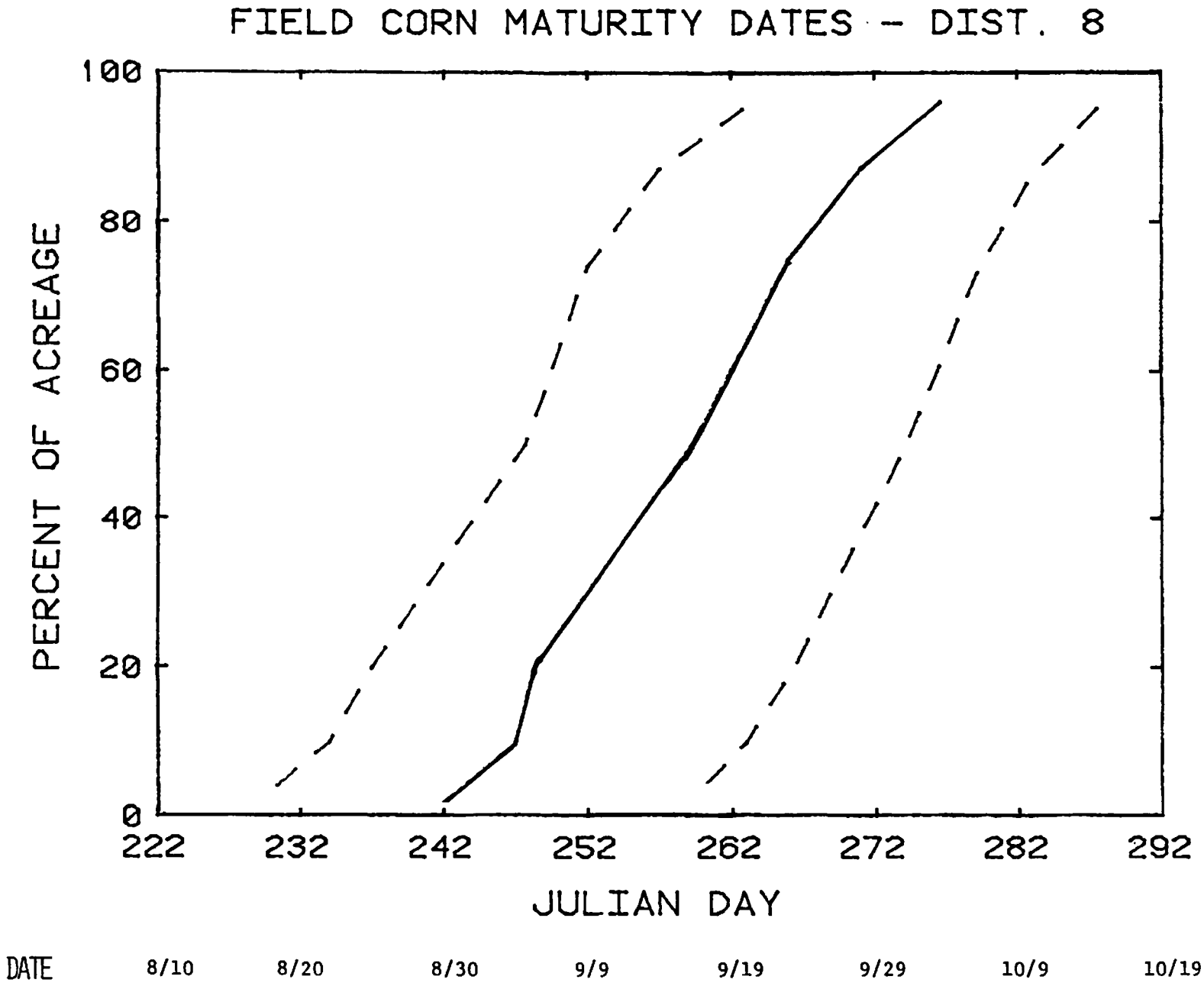
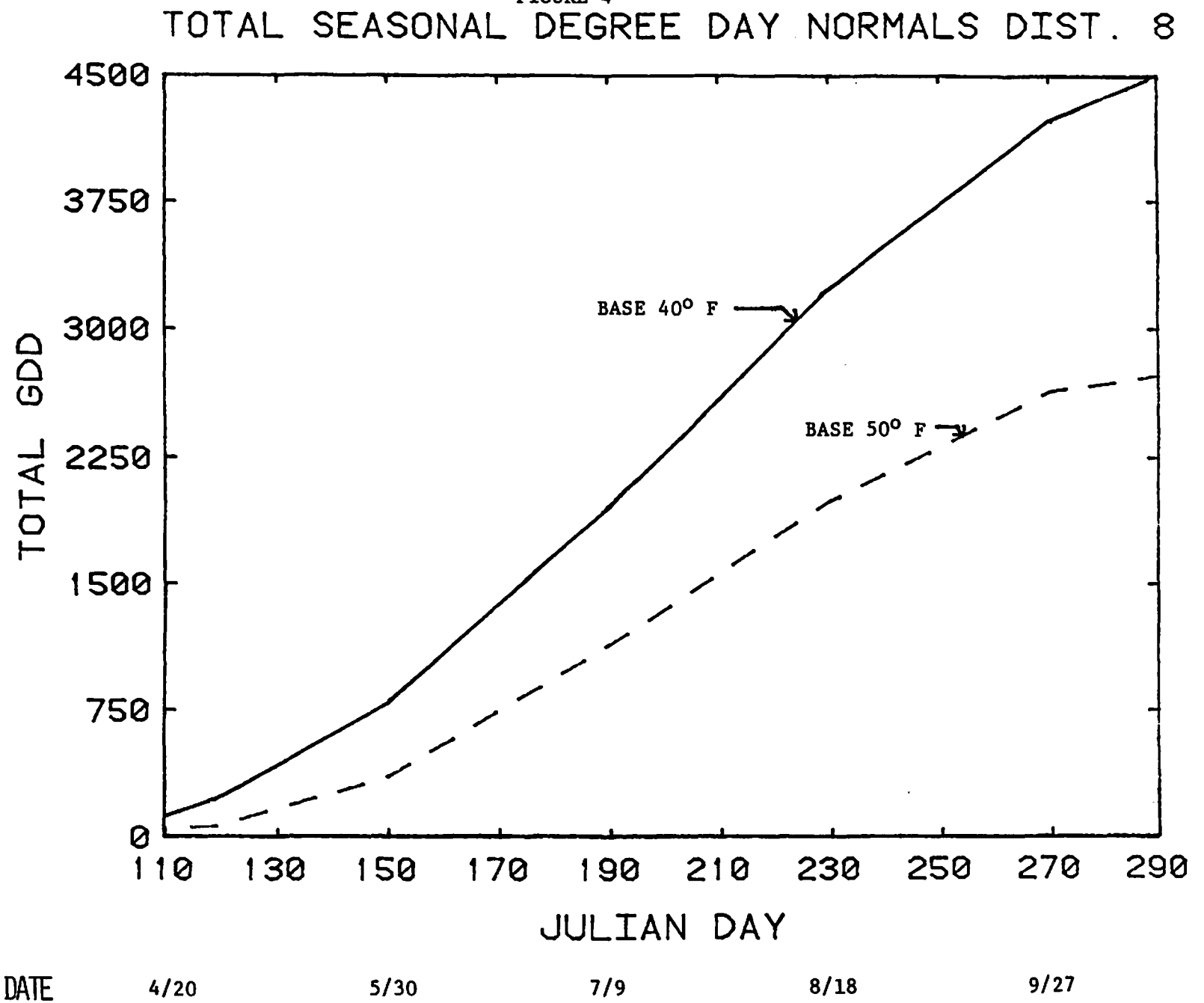

FIELD CORN MATURITY DATES - DIST. 8
PERCENT OF ACREAGE
100
80
60
40
20
0
222
232
242
252
262
272
282
292
JULIAN DAY
DATE
8/10
8/20
8/30
9/9
9/19
9/29
10/9
10/19

FIGURE 4


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

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

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

Lowering pH with Nitrogen

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

Plot work at the Becker Irrigation Farm was initiated in 1976 with three forms of nitrogen; ammonium nitrate, urea, and ammonium sulfate. The latter is expected to reduce pH faster than the other two. Soil pH readings are determined in the fall annually. Two varieties, Norland and Russet Burbank, are used. The Norland variety received 200 pounds of N per acre since it is relatively early maturing and 300 pounds per acre were used on the Russets.

The calcium carbonate equivalent of the irrigation water averages 42 pounds per acre inch. The irrigation water supplied 721 pounds per acre of very fine lime in 1976, 483 pounds in 1977, 386 pounds in 1978, and 252 in 1979.

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

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

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

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

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

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

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

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

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

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

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

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

MICRONUTRIENT TESTS ON ALFALFA

Becker, MN 1979

C.J. Overdahl and Jerome Lensing

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

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

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

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

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

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

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

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

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

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

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

MICRONUTRIENT FERTILIZATION OF POTATOES AND CORN UNDER IRRIGATION

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

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

EXPERIMENTAL PROCEDURES

Seven treatments, including a control, four micronutrient treatments, and two macro nutrient treatments were established in a randomized complete block design with either four or eight replications. Rates and types of fertilizer applied included: 5 lbs. of copper/A as $Cu(NO_3)_2$, 2 lbs. of Boron/A as Solubor, 25 lbs. of Sulfur/A as $CaSO_4$, 75 lbs. of Magnesium/A as $MgCl_2$, 10 lbs. of Zinc/A as $ZnCl_2$ and 3 lbs. of Manganese/A as $MnCl_2$. All treatments were applied as preplant broadcast and incorporated treatments. Application of material was made to exactly the same plot area as was applied in 1978. The corn and potato areas were rotated in 1979 so corn was planted into the 1978 potato area (eight replications) and potatoes were planted into the corn areas, (four replications of each variety).

The entire experimental area was spring plowed and the experimental potato area sprayed with 3½ lbs./A of Eptam (46 gal./A) incorporated for weed control. Fertilizer treatments were applied, incorporated by discing and the potatoes planted on April 27 and 28th. Norlands were planted in nine inch spacings utilizing 36 inch rows, while Russet Burbanks were planted in 12" spacings with the same row width. At the time of planting, starter was used at the rate of 1200 lbs./A of 8-10-30 and an insecticide, Temik 15G banded at 14 lbs./A. Lorox herbicide was applied on May 17th at 2 lbs./A (46 gal/A spray) for additional weed control. Sidedressing treatments of nitrogen were made on June 4 (230 #/A of 34-0-0) and on June 19th (200 lbs./A of 34-0-0), along with hilling at the last sidedressing. Samples of the youngest mature potato leaves were obtained 79 days after planting for nutrient composition. Several hail storms during the 1979 growing season damaged both varieties. To minimize disease problems, a system of spraying with either Sevin and Bravo or Thiodan and Bravo was started on July 3 and continued through August 3 at approximately 7-11 day intervals. The Norland potatoes were harvested on September 5 and and the Russet Burbanks on October 19th. Irrigation water was applied during the period of June 15 through August 20th with a total addition of 6.55 inches. Precipitation during the period of May-August was 22.02 inches and May-September was 23.01 inches.

Utilizing the 1978 potato experimental area, eight replications of the aforementioned treatments were planted to corn. The experimental area had been fertilized with 500 lbs./A of 8-10-30 prior to planting on May 7th. A commercial corn variety (Pioneer 3901) was planted in 30" rows at a population of 30,700 seeds/A. Starter fertilizer at the rate of 165 lbs./A of 8-10-30 was utilized at planting time followed by a spray application of Lasso (2 lbs. ai/A). Sidedressing applications of nitrogen were made on June 5 (230 lbs./A of 34-0-0) and July 5 (300 lbs./A of 34-0-0) for a total addition of 233 lbs. of N/A for the season. In addition to the 23.0 inches of precipitation received during the growing season an additional 6.55 inches was added through irrigation during the period of June 15th through August 20th.

GENERAL RESULTS

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

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

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

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

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

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

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

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

Experimental Procedures

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

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

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

General Results

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

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

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

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

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

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

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

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

Nitrogen management on the coarse textured irrigated soils of Minnesota is a prime decision that all corn growers must make in their production system. Nitrogen management includes many aspects of nitrogen fertilization such as rates, forms, methods, times, equipment, and additives. Nitrogen fertilizer application is an essential component for top yields on these coarse textured soils, and many times the producer does not have the flexibility in nitrogen management that a producer on a finer textured soil might have. A large portion of the flexibility in nitrogen management is lost due to the potential loss of nitrate nitrogen by leaching prior to plant demand. To minimize these losses, nitrogen applications are often made in split applications through the irrigation system or as late sidedressing treatments. These management alternatives often add to the cost of production and require a reasonable amount of timeliness to avoid yield reductions. Commercial availability of chemical additives known as nitrification inhibitors also offer some potential in minimizing nitrogen losses and may add flexibility into the overall nitrogen management program. A new trial was established in 1979 to evaluate the significance of nitrogen rates, timing of nitrogen application and the use of nitrification inhibitors.

Experimental Procedures

An experiment consisting of 33 treatments with four replications was arranged in a randomized complete block design and established at the Sand Plains Research Farm near Becker, MN. A Factorial treatment arrangement consisting of three rates of nitrogen (75, 150, and 225 #N/A), three nitrification inhibitor treatments (none, N-Serve-Dow Chemical Co., and Dwell(Terrazole - Olin Corporation) and three times of nitrogen application (preplant, 8 leaf and 12-leaf) were utilized. Also included in the experimental treatments were a control, application of the three nitrogen rates without inhibitors as split applications during the growing season, along with nitrogen application rates of 75 and 150 #N/A applied as single treatments at tasseling. All nitrogen treatments were applied as urea and all nitrification inhibitor treatments were applied at rates of 0.5 #ai/A as coatings onto the urea. All inhibitor treatments were incorporated either by discing in the preplant applications or by utilizing the irrigation water with the later applications. Nitrogen application were made at preplanting (May 1), at the 8-leaf stage of corn growth (June 15), at the 12-leaf growth stage (July 19), and at tasseling (July 31). Split nitrogen application treatments were applied 1/6 at preplant, 1/6 at the 8-leaf stage, 3/6 at the 12-leaf stage, and 1/6 at tasseling. The soil type was a Hubbard coarse sand with approximately 2½% organic matter.

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

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

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

General Results

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

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

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

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

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

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

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

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

Crookston - 1979 Weather Summary

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

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

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

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

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

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

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

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

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

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

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

G.E. Varvel and R.K. Severson

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

Experimental Procedure:

Four nitrogen carriers, 2 rates and 2 application dates were compared. Three of the carriers, urea, UAN solution and ammonium nitrate, were also applied with and without incorporation. To facilitate comparisons, Table 1 includes those treatments where they were incorporated and Table 2 includes those treatments where they were not incorporated, both Tables include the anhydrous ammonia treatments. Application dates were October 19, 1978 and May 14, 1979. Era was planted May 16 and harvested August 27. Whole plant samples taken August 6 at soft dough were used to determine forage yield and nitrogen uptake.

Soil test results from samples taken prior to initiation of the study were: pH - 8.1, NO_3-N (0-2') - 50 lb/A, extractable P (Bray P1-10:1) - 41 lb/A and exchangeable K - 200 lb/A.

A randomized complete block design with 4 replications was used.

Results:

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

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

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

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

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

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

G.E. Varvel and R.K. Severson

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

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

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

A randomized complete block design was used.

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

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

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

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

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

SPRING WHEAT FERTILIZATION - 1979*

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

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

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

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

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

A randomized complete block design was used for all studies.

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

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

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

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

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

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

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

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

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

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

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

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

Crookston, MN. - 1979

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

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

EXPERIMENTAL PROCEDURES

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

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

GENERAL RESULTS

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

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

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

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

General Results

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

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

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

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

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

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

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

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

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

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

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

SOIL TEST LEVELS AS AFFECTED BY DIFFERENT FERTILIZER PROGRAMS IN A CONTINUOUS WHEAT CROPPING SYSTEM*

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

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

Experimental Procedure:

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

Results:

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

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

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

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

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

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

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

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

G.E. Varvel and R.K. Severson

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

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

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

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

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

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

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

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

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

PHOSPHORUS AND POTASSIUM FERTILIZER RATE STUDIES ON MALTING BARLEY - 1979

G.E. Varvel and R.K. Severson

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

Experimental Procedure:

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

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

A randomized complete block design was used for both experiments.

Results:

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

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

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

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

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

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

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

+ Denotes significance at the 10% level.

EFFECTS OF MICRONUTRIENTS ON SPRING WHEAT GROWN ON ORGANIC SOILS 1979

G.E. Varvel and R.K. Severson

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

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

A randomized complete block design was used in both studies.

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

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

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

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

+ Denotes significance at the 10% level.

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

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

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

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

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

RESIDUAL EFFECTS OF COPPER APPLIED ON ORGANIC SOILS
1979

G.E. Varvel and R.K. Severson

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

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

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

A randomized complete block design was used.

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

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

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

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

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

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

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

Experimental Procedure:

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

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

A randomized complete block design was used.

Results:

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

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

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

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

G.E. Varvel and R.K. Severson

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

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

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

TWENTY YEARS OF FIELD EXPERIMENTATION WITH NITROGEN SOURCE, PLACEMENT, AND TIME OF APPLICATION TO A WEBSTER LOAM NEAR LAMBERTON.

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

(Annual reports of this experiment have been reported in Soil Series 74 through 105 and some of this information will not be included here).

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

Spring N treatments are broadcast before seedbed preparation late in April or in early May. The corn is drilled in 30" rows to produce approximately 20,000 plants/A, using a banded starter fertilizer of 8-24-12 at the rate of 180 lbs. over the entire experimental area, thus supplying an additional 14 lbs. N/acre to all plots. Herbicides and insecticides are also annually applied. Nitrogen sidedressing treatments are broadcast in June. Nitrogen concentrations present in the sixth or "index" leaf at silking were determined and are reported along with individual plot yields and nitrogen utilization in table 1.

The yields obtained in 1979 were below average when considering the long term previous average for this experiment. Treatment averages in 1979 appeared to follow the trends which had been established with the long term average yields.

NINETEEN YEAR AVERAGE

The average grain yields for the nineteen years of this experiment are shown in table 2. When only 40 lbs. of N/A was fall applied, urea was slightly better than ammonium nitrate with very little difference due to incorporation.

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

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

GENERAL CONCLUSIONS

1. Urea is as effective as ammonium nitrate for the production of corn on these medium textured non-calcareous soils.

2. Late fall surface applied N is at least equal to that plowed down, but where N fertilization rates are relatively low, spring or side-dressing N treatments appear more effective.

3. Where corn is grown annually on these soils good yields can be maintained with annual applications of 100 lbs. N/A providing adequate amounts of P and K are also supplied. At this rate of application most of the N will be removed in the grain leaving relatively small amounts to be lost to the environment.

Table 1. Average N in sixth corn leaf and grain yield @ 15.5% moisture, from a Webster loam fertilized annually with NH_4NO_3 or urea (4 replications).

N applied annually in lbs/A[1]	% N 6th Leaf	Bu/A @ 15.5% Moisture I	II	III	IV	Ave.	Yield Grain N Content	N Removal
							%	#/A
Check	1.66	37.0	41.6	42.9	28.9	37.6	1.04	18.6
40-NH_4NO_3-fpd[2]	1.80	44.9	91.7	40.7	75.3	63.1	1.07	32.5
40-urea-fpd	1.92	80.9	90.6	60.4	74.8	76.7	1.05	38.5
40-NH_4NO_3-fpd[3]	1.74	64.1	76.0	45.1	73.1	64.6	1.07	32.8
40-urea-fps	1.82	56.7	62.8	79.9	121.5	80.2	1.13	43.1
80-NH_4NO_3-fpd	2.28	56.0	138.6	76.8	107.7	94.8	1.25	57.4
80-urea-fpd	2.16	58.3	124.2	60.0	102.3	86.2	1.18	48.8
160-NH_4NO_3fpd	2.65	110.6	120.1	81.0	122.9	108.7	1.34	68.4
160-urea-fpd	2.69	120.6	156.5	91.3	140.9	127.3	1.36	82.4
40-NH_4NO_3-std[4]	1.81	64.5	116.8	59.6	105.4	86.6	1.12	45.9
40-urea-std	1.61	64.8	83.2	58.2	91.6	74.5	1.10	38.7
80-NH_4NO_3-std	2.32	72.5	114.0	103.7	59.1	87.3	1.18	49.3
80-urea-std	2.16	101.1	110.1	84.1	106.0	100.3	1.26	59.6
40-NH_4NO_3-sd[5]	2.56	108.9	86.8	82.5	118.6	99.2	1.22	57.1
40-urea-sd	2.07	87.7	54.1	97.8	137.1	94.2	1.17	52.5
80-NH_4NO_3-sd	2.58	131.0	61.8	93.8	138.7	106.3	1.29	65.0
80-urea-sd	2.64	116.8	128.9	111.3	115.5	118.1	1.30	72.9
160-NH_4NO_3-sd	2.93	145.3	142.0	150.8	153.8	148.0	1.47	103.1
Significance	**					**	**	**
C.V. (%)	8.7					22.8	7.0	26.2
BLSD(0.05)	0.25					30.8	0.11	19.3

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

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

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

Table 2. Yields of ear corn during 19 years on a tiled Webster loam near Lamberton with annual applications of NH_4NO_3 or urea nitrogen at different rates, times, and placement. (Average of 4 replications)

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

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

[2] fpd -- fall plow down [3] fps -- fall plow surface [4] std -- spring topdress [5] sd -- sidedress

Table 2. (continued). Yields of ear corn during 19 years on a tilled Webster loam near Lamberton with annual applications of NH_4NO_3 or urea nitrogen at different rates, times, and placement. (Average of 4 replications).

N applied annually in lbs/A	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	19 Year Average
					Ear corn yield in bushels per acre						
Check	85.7	40.8	75.6	69.2	53.4	58.3	No	141.2	64.6	37.6	68.0
40 NH_4NO_3-fpd[2]	96.3	88.7	113.6	92.0	80.5	88.6		145.1	98.1	63.1	86.4
40 Urea-fpd	120.4	100.7	113.9	101.5	96.9	96.6	Yields	165.2	110.2	76.7	94.5
40 NH_4NO_3-fps	122.5	81.5	109.9	93.0	88.3	78.2		149.4	101.3	64.6	90.0
40 Urea-fps	121.2	82.4	106.7	97.8	85.0	78.9	Taken	156.8	101.4	80.2	93.7
80 NH_4NO_3-fpd	134.7	108.0	143.1	121.7	103.6	89.2		156.9	128.4	94.8	107.6
80 Urea-fpd	141.4	107.8	140.1	117.9	107.2	96.9		146.0	123.6	86.2	106.1
160 NH_4-NO_3-fpd	141.7	120.2	147.6	121.0	113.1	90.4		149.8	129.3	108.7	111.6
160 Urea-fpd	140.4	110.6	151.7	114.9	105.1	82.4		163.0	124.4	127.3	113.9
40 NH_4NO_3-std	125.6	84.0	117.0	104.0	82.8	88.0		160.0	97.4	86.6	97.8
40 Urea-std	118.9	94.6	116.5	97.1	94.5	89.0		165.2	103.9	74.5	97.0
80 NH_4NO_3-std	140.4	122.7	142.7	118.0	92.9	97.6		162.9	117.1	87.3	109.5
80 Urea-std	146.2	116.0	142.1	117.6	108.5	93.6		162.2	127.4	100.3	111.9
40 NH_4NO_3-sd[5]	127.1	104.5	136.0	99.1	82.7	91.8		153.8	106.8	99.2	99.9
40 Urea-sd	117.7	100.5	133.9	103.9	80.4	92.6		165.4	104.8	94.2	98.4
80 NH_4NO_3-sd	127.7	97.6	124.7	109.4	87.6	95.3		163.2	110.6	106.3	103.3
80 Urea-sd	140.5	124.4	149.8	124.0	95.6	90.1		162.8	126.7	118.1	113.2
160 NH_4NO_3-sd	136.9	104.2	150.0	117.1	105.5	91.3		160.3	126.0	148.0	113.4
Ave. annual corn yield in bu/A	127.0	99.4	128.6	106.6	92.4	88.3		157.2	111.2	91.9	100.9
Significance										**	**
C.V. (%)										22.8	9.4
BLSD(.05)										30.8	5.5

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

[2] fpd -- fall plow down [3]fps -- fall plow surface [4]std -- spring topdress [5]sd -- sidedress

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

WEST CENTRAL EXPERIMENT STATION - MORRIS

WEATHER SUMMARY - 1979

Month	Period	Precipitation 1979	Precipitation 92-yr. av.	Precipitation Dev. from av.	Air Temperature 1979	Air Temperature 92-yr. av.	Air Temperature Dev. from av.	Soil (10 cm) Temperature 1979	Soil (10 cm) Temperature 10-yr. av.
January	1-31	1.36	.67	+ .69	-3.7	8.2	-11.9	12.5	20.7
February	1-28	1.28	.66	+ .62	-0.8	12.8	-13.6	15.9	23.9
March	1-31	2.10	1.08	+1.02	20.7	26.7	-6.0	24.7	29.2
April	1-10	.04	.57	- .53	26.2	38.0	-11.8	29.0	
	11-20	1.02	.75	+ .27	41.2	44.5	-3.3	34.6	
	21-30	.47	.99	- .52	44.6	48.2	-3.6	41.8	
Total or av.		1.53	2.31	- .78	37.4	43.6	-6.2	35.1	41.4
May	1-10	.87	.78	+ .09	42.8	52.0	-9.2	43.4	
	11-20	.64	1.13	- .49	51.2	55.8	-4.6	50.7	
	21-31	1.01	1.08	+ .07	53.3	60.0	-6.7	59.9	
Total or av.		2.52	2.99	- .47	50.7	56.1	-5.4	51.6	57.1
June	1-10	.50	1.28	- .78	61.2	63.2	-2.0	61.2	
	11-20	4.09	1.36	+2.73	66.2	66.5	-0.3	67.8	
	21-30	1.71	1.23	+ .48	64.0	68.3	-4.3	68.8	
Total or av.		6.30	3.87	+2.43	63.8	66.0	-2.2	67.6	69.3
July	1-10	.01	1.50	-1.49	70.7	70.0	+0.7	76.8	
	11-20	.35	1.18	- .83	68.2	71.4	-3.2	78.0	
	21-31	2.35	.89	+1.46	69.0	71.6	-2.6	76.4	
Total or av.		2.71	3.57	- .86	69.4	71.0	-1.6	77.2	76.7
August	1-10	.57	1.06	- .49	69.7	70.4	-0.7	77.4	
	11-20	.02	1.04	-1.02	61.6	69.2	-7.6	70.7	
	21-31	.56	.85	- .29	63.3	66.9	-3.6	70.0	
Total or av.		1.15	2.95	-1.80	64.8	68.8	-4.0	72.6	73.9
September	1-30	.22	2.21	-1.99	59.7	59.1	+0.6	67.4	61.5
October	1-31	4.26	1.61	+2.65	44.1	47.4	-3.3	47.2	47.8
November	1-30	.60	.96	- .36	28.7	29.8	-1.1	31.5	33.6
December	1-31	.26	.68	- .42	22.5	15.5	+7.0	23.8	23.4
April-August Growing Season		14.21	15.69	-1.48	57.3	61.2	-3.9	60.9	63.8
January-December Annual		24.29	23.56	+ .73	38.3	42.1	-3.8	44.1	46.7

CONTINUOUS CORN SILAGE

West Central Experiment Station - Morris

S. D. Evans

I. Experimental Description

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

II. 1979 Operations

In 1979 the variety was Trojan TXS99. Counter was applied at 1 lb/acre (active ingredient) at planting on May 21. Lasso @ 2 lbs/acre plus Bladex @ 2.2 lbs/acre were applied broadcast on May 23. Silage yields were taken on September 26 and grain yields on October 25.

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

Treatment	1979 yield	1966-79 yield
Silage, low fertility	6.72	5.56
Silage, high fertility	7.11	5.97
Grain, low fertility	6.84	5.76
Grain, high fertility	6.98	5.50

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

	1979 yield	1966-79 yield
Grain, low fertility	98.66	90.22
Grain, high fertility	97.80	92.75

V. Check Yields

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

	1979 yield	1966-79 yield
Grain (0 + 0 + 0)	20.47 Bu/A	51.37 Bu/A
Silage (0 + 0 + 0)	3.04 Tons/A	3.76 Tons/A

VI. Discussion

A. In 1979 there were no significant differences in silage yields but the high fertility plots yielded slightly more than the low fertility plots.

B. The 14-year average yields show very little difference between silage and grain plots, but there is still a slight advantage for the higher fertility level.

EFFECT OF FERTILIZER ON CORN GRAIN YIELD AND N CONTENT OF THE EAR LEAVES

West Central Experiment Station - Morris

S. D. Evans, A. C. Caldwell, and Greg Buzicky

Plot areas were established in the fall of 1972 on a Doland silt loam at the West Central Experiment Station to study the effect of fertilizer treatments on corn yield and nutrient content and on chemical elements added to soils. Reported below are some of the observations during the seven years of the experiment.

A 95-day hybrid was planted each year at about 22,000 seeds/A during the first three weeks in May. Corn rootworm and weed control chemicals were used. A starter fertilizer (6-24-24) was applied along the row at 143 lbs/A at planting time. Nitrogen in addition to the starter was applied broadcast as urea, at the times indicated in Table 1. An organic source of N was applied as soybean oil meal, which supplied some P and K as well. The 80-lb rate of meal supplied 8 and 25 lbs/A of P and K, respectively; the 120-lb rate of meal, 12 and 38 lbs/A of P and K, respectively. All materials were incorporated soon after application. The treatments were replicated 4 times.

Grain yield was determined on mature corn. Sixth corn leaf samples were collected for analysis at silking.

Corn Grain Yield

Yields for each of the seven years and the average are given in Table 1. The only significant yield differences occurred in 1974 and 1979. In no case was more than 80 lbs N/A needed for maximum yield. In fact, in some years lesser amounts of N were adequate--1976 - 40 lbs/A, 1977 - starter only, and 1978 - 40 lbs/A. The seven-year average shows maximum yield at 80 lbs N/A.

In most years there was little difference between fall and spring applications of N. In 1975 and 1978 some fall treatments yielded slightly more than corresponding spring treatments. The seven-year average shows no difference between fall and spring applications.

Treatments receiving the organic N source, soybean oil meal, were not significantly different from the corresponding urea treatments 4 and 5. However, there was some year-to-year variation. In 1973 the 80-lb organic treatment was lower yielding than the 80-lb urea treatment, possibly due to inadequate mineralization. In 1975 the 120-lb organic treatment yielded more than the 120-lb urea treatment and in 1979 the 80-lb organic treatment yielded more than the 80-lb urea treatment. The seven-year average again shows no differtnce between organic and urea N sources.

The extra 30 lbs P/A (treatment 12) did not yield significantly better than treatment 4, but in 1976 the yield difference was 11.3 bu/A. There was no significant effect on the seven-year average.

Results of the first seven years of this trial show that (1) 80 lbs N/A were needed for maximum yield, (2) there was no difference between fall and spring urea applications, (3) there was no difference between urea and soybean oil meal as N sources, and (4) the amount of P supplied in the starter was adequate.

N Content of Sixth Leaf

All the values for ear leaf N are given in Table 2. Significant differences occurred in all years except 1977. There was considerable year-to-year variation in N contents within a specific treatment. For example, the 80-lb spring applied urea (treatment 4) varied from a low of 2.53% in 1973 to a high of 3.37% in 1974. In all years there was an increase in the leaf N content as urea rates increased to the 120-lb rate, even though yields reached a maximum at the 80-lb rate. In 1973, 1975, 1976, and 1979 treatments 1 and 2 (starter only) had values in the deficient range (<2.45% N). The 40-lb urea treatment had N contents in the deficient range in 1973 and 1979, in the low range (2.46-2.75%) in 1975 and 1976, and in the sufficient range (2.76-3.50%) in 1974, 1977, and 1978. In all years except 1974 and 1976, leaf N levels were a good indicator of the adequacy of N for maximum yields. In 1974 all N levels were high even though it took 80 lbs N/A for maximum yields. In 1976 yields were very low due to the extreme drouth and maximum yield was at the 40-lb N/A rate.

Soil NO_3-N Content

A summary of the fall soil NO_3-N levels are given in Table 3. In general the NO_3-N levels are related to the N applied. With 80, 120, and 160 lbs N/A there was a large increase in soil NO_3-N in 1973 and 1974. In the fall of 1975 levels in all treatments dropped drastically. This was probably due to the high yield in 1975 (Table 1) and the high precipitation from June thru August (Table 4). Samples were taken to a depth of 8 feet in 1974 and 1975 and a comparison of these values shows that considerable NO_3-N moved below the 8-foot depth. With the poor crop in 1976, levels again increased and the evidence of this increase was still present in the samples taken in the fall of 1978.

Table 1. Effect of fertilizer treatments on corn grain yield.

No.	Fertilizer Treatments	In addition to starter N[2] (lbs/A)	In addition to starter P (lbs/A)	Grain Yield 1973 (bu/A)	1974	1975	1976	1977	1978	1979	7-year average
1	Starter[1]	0	0	112.5	77.3	99.4	19.9	101.8	117.9	79.6	86.9
2	"	0	0	116.3	70.7	104.5	20.1	100.6	117.4	75.0	86.4
3	"	40	0	122.1	81.7	104.7	24.2	101.4	128.2	107.9	95.7
4	"	80	0	129.8	94.0	110.9	24.4	103.3	129.3	112.2	100.4
5	"	120	0	128.2	91.2	112.5	21.2	102.5	126.7	111.0	99.1
6	"	120 (SD)	0	126.5	90.4	119.8	19.6	103.1	126.4	116.3	100.3
7	"	160 (SD)	0	128.9	91.9	110.7	25.6	99.3	125.7	105.8	98.3
8	"	80 (F)	0	118.2	92.8	119.0	23.2	99.6	135.7	115.7	100.6
9	"	120 (F)	0	128.9	90.2	125.7	21.2	103.4	128.6	115.8	102.0
10	"	80 (ORG)	8	122.2	87.8	114.7	25.4	99.4	129.0	121.9	100.0
11	"	120 (ORG)	12	127.7	96.9	119.2	22.0	101.0	130.7	113.1	101.5
12	"	80	30	123.6	91.8	108.9	24.7	104.2	127.8	123.5	100.5
Significance				NS	**	NS	NS	NS	NS	**	**
BLSD(.05)				-	16.9	-	-	-	-	12.0	12.0

[1] Starter (6-24-24) was applied along the row at planting time at 143 lbs/A.

[2] Nitrogen sources were urea except for treatments 10 and 11 which were soybean oil meal. All treatments were spring applied except 8 and 9 which were applied in the fall. Two treatments received split applications of nitrogen: Treatment 6 received 80 lbs at planting and 40 lbs sidedressed and treatment 7 received 80 lbs at planting and 80 lbs sidedressed.

Table 2. Effect of fertilizer treatments on the nitrogen content of the sixth leaf at silking.

Fertilizer treatments				N content of sixth leaves							
		In addition to starter									
No.		N[2]	P	1973	1974	1975	1976	1977	1978	1979	7-year average
		lbs/A		%							
1	Starter[1]	0	0	2.20	2.96	2.26	2.25	3.11	2.64	1.85	2.47
2	"	0	0	2.18	3.04	2.27	2.09	3.00	2.65	1.71	2.42
3	"	40	0	2.40	3.26	2.59	2.57	3.07	3.00	1.98	2.70
4	"	80	0	2.53	3.37	2.85	2.62	3.13	3.13	2.86	2.93
5	"	120	0	2.74	3.50	2.90	2.79	3.16	3.24	2.99	3.05
6	"	120 (SD)	0	2.55	3.46	2.88	2.53	3.12	3.24	2.96	2.96
7	"	160 (SD)	0	2.62	3.45	2.85	2.67	3.04	3.22	2.68	2.93
8	"	80 (F)	0	2.50	3.32	2.82	2.64	3.14	3.12	2.86	2.91
9	"	120 (F)	0	2.48	3.46	2.80	2.62	3.23	3.11	2.88	2.94
10	"	80 (ORG)	8	2.52	3.42	2.84	2.54	3.23	3.16	3.00	2.96
11	"	120 (ORG)	12	2.61	3.42	2.93	2.67	2.98	3.20	2.62	2.92
12	"	80	30	2.49	3.36	2.60	2.64	3.09	3.13	2.40	2.92
Significance				**	**	**	**	NS	**	**	
BLSD(.05)				.22	.19	.23	.16	-	.13	.59	

[1] Starter (6-24-24) was applied along the row at planting time at 143 lbs/A.

[2] Nitrogen sources were urea except for treatments 10 and 11 which were soybean oil meal. All treatments were spring applied except 8 and 9 which were applied in the fall. Two treatments received split applications of nitrogen: Treatment 6 received 80 lbs at planting and 40 lbs sidedressed and treatment 7 received 80 lbs at planting and 80 lbs sidedressed.

Table 3. Effect of fertilizer treatments on fall soil NO_3-N content.

Sample Depth - ft -	Trt. No.	Annual Bcst. N Rate lbs/A	Year 1972	1973	1974	1975	1976	1977	1978
			- lbs NO_3-N/A -						
0-2	1	0	39	48	47	10	54	35	28
0-3	1	0	54	64	63	10	68	63	39
0-4	1	0	65	87	85	15	82	88	57
0-2	3	40	27	-	40	7	79	41	33
0-3	3	40	46	-	64	11	105	100	89
0-4	3	40	80	-	103	18	134	132	140
0-2	4	80	23	64	100	30	115	86	40
0-3	4	80	40	91	128	48	143	186	174
0-4	4	80	65	125	159	57	168	218	245
0-2	5	120	39	112	178	40	187	234	87
0-3	5	120	63	152	220	70	233	470	311
0-4	5	120	89	185	256	81	270	528	458
0-2	7	160	37	-	174	80	258	149	100
0-3	7	160	59	-	211	122	314	299	370
0-4	7	160	87	-	244	141	347	365	596

Table 4. Total monthly precipitation at the West Central Experiment Station, April-November.

Month	Year 1972	1973	1974	1975	1976	1977	1978	1979	92-Year Average
	- inches -								
April	2.61	1.09	1.37	2.76	.47	1.90	2.80	1.53	2.31
May	4.40	3.80	2.59	1.53	.39	5.48	2.48	2.52	2.99
June	2.20	.98	2.40	6.84	1.63	2.72	5.52	6.30	3.87
July	6.28	5.55	3.88	2.03	1.07	3.52	2.08	2.71	3.57
August	1.72	1.76	4.79	4.39	1.76	3.20	2.63	1.15	2.95
September	.38	2.26	.72	1.61	.57	3.50	3.03	.22	2.21
October	1.81	1.79	.68	1.59	.08	3.25	.08	4.26	1.61
November	1.43	.95	1.17	1.77	.14	3.13	1.25	.60	.96
Total	20.83	18.18	17.60	22.43	6.11	26.70	19.87	19.29	20.47

FOLIAR FERTILIZATION OF CORN

G.L. Malzer and S. Evans

Considerable interest was aroused several years ago with foliar fertilization of crops, when Dr. John Hanway of Iowa State University obtained large yield responses with soybeans. This has not only stimulated additional work with soybeans, but has also created interest with other crops. It was the objective of this trial to determine if foliar applications of nutrients to corn could be beneficial in increasing yields and/or nitrogen utilization (Protein content).

Experimental Procedures

Six treatments were replicated six times, arranged in a randomized complete block design and established at the West Central Experiment Station at Morris. The treatments consisted of a control, two rates of "Folian" (5 and 10 gal.) at two different stages of growth (Tassel and 16 days later) along with an additional treatment of NZN applied before tasseling at the rate of 1 qt/acre. The experimental areas had been previously fertilized according to soil test recommendations.

General Results

No significant positive yield responses were obtained to foliar applications of either "Folian" or "NZN". Slight depressions in yield were obtained with the high rate of "folian" applied near tasseling. The foliar treatment appeared to have little or no impact upon protein in the grain or nitrogen utilization.

Table 1. Yield, nitrogen content of grain, and nitrogen removal by corn grain as influenced by rate and time of foliar fertilization to corn. - Morris, 1979.

Treatments		Corn Grain		
Solution	Time	Yield	N Content	N Removal
		bu/A	%	#/A
Control		99.7	1.47	69.2
Folian - 5 gal/A	Tassel	95.5	1.45	65.4
Folian - 10 gal/A	Tassel	91.1	1.46	63.1
Folian - 5 gal/A	16 days post tassel	93.5	1.49	65.8
Folian - 10 gal/A	16 days post tassel	97.7	1.52	70.5
NZN - 1 qt/A	Before tassel	99.1	1.46	68.6
Significance		+	NS	NS
BLSD(.05)		7.7	-	-

MANURE RATE STUDY

West Central Experiment Station - Morris

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

Solid and liquid beef manures were applied at three rates and the effects were compared against check plots. Treatments and results from previous years are given in Soil Series 91, 95, 97, 99, 103 and 105.

I. Manure Application and Analysis

Manure was applied for the sixth time in the fall of 1978. Samples were taken at the time of application and were analyzed by the Animal Waste Laboratory in the Department of Agricultural Engineering. The amounts are given in Table 1. The chemical analysis of each manure is given in Table 2. Using these figures, the amount of each nutrient applied to each manure treatment is given in Table 3.

II. Planting Information

The plots were planted to Dekalb XL12 on May 17, 1979. Lorsban @ 8.8 lbs/acre (1 lb/acre active ingredient) was applied in the row to the entire area at planting. Starter fertilizer consisting of 154 lbs/acre of 10-26-26 was applied to the fertilized treatment. Nitrogen in the form of urea had been applied on October 18, 1978, prior to plowing to provide 110 lbs/acre of N. Lasso (2 lbs/acre) and Bladex (2.2 lbs/acre) were applied broadcast on May 18, 1979.

III. Soil Sampling and Analysis

A. 1978 Measurements

The results of some of the analyses of the soil samples collected to a depth of 10 feet are given in Table 4.

1. NO_3-N - In general there was a decrease of NO_3-N at most depths compared to one year earlier. There was again an increase in both NO_3-N level and depth of NO_3-N penetration as manure rates increased. Downward movement of NO_3-N was minimal, but was apparent in most manure treatments.

2. Chloride - There was some downward movement of chloride.

3. Electrical conductivity - There was some increase in the 3rd and 4th foot, but the increases did not occur in all treatments.

4. Available P - All manure treatments except LB1 had significantly higher P levels than the fertilized treatment.

5. Extractable K - All manure treatments had increased the soil K levels.

B. 1979 Measurements

NO_3-N was the only variable measured in 1979. The values shown in Table 5 indicate small but inconsistent changes in the manure treatments.

IV. Plant Tissue Analysis

A. 1978 Harvest Samples (Table 6)

Stover from all manure treated plots had significantly higher P and K levels and lower Mg levels than FE. The N level of the SB3 treatment was significantly higher than the FE treatment. The Ca levels were decreased slightly by the manure treatments. The N level in the grain on the manure treatments was not significantly different than on the fertilized treatment.

B. 1979 Samples

1. Corn leaves at silking (Table 7)

All manure treatments except LB1 had significantly higher levels of P and K than the fertilized treatment. Nitrogen levels were adequate and increased with higher rates of manure. The levels of Ca and Mg in general decreased with increasing manure. Zinc levels in the SB1, LB1, LB2 and LB3 treatments were significantly lower than in the fertilized treatment.

2. Samples were taken at harvest, but analyses is not complete.

V. Field and Plant Measurements - 1979 (Table 8)

A. Early plant height - All manure treatments were significantly taller than the fertilized check.

B. Early plant dry weight - All manure treatments except LB1 had larger plants than the fertilized treatment.

C. Ear moisture - All manure treatments were significantly drier than FE.

D. Grain yield - All manure treatments yielded more than the fertilized treatment, but only SB1 and LB2 were significantly higher yielding.

E. Silage yield - There were no significant differences in silage yield between the fertilized treatment and the manure treatments.

VI. Summary

Solid beef manure or liquid beef manure have been applied annually in the fall (except 1977) at 3 rates to continuous corn. There have been significant increases and decreases in many of the essential elements in the ear leaf tissue, corn stover, and corn grain. The manure applications in general have given corn grain and silage yields equivalent to where recommended rates of fertilizer were applied annually. After 6 years (fall 1978) there was considerable movement of NO_3^- and Cl^- below the rooting depth of corn.

To date this research indicates that an annual application of solid beef manure at 9.0 tons/acre/year (dry weight) or liquid beef manure at 1.6 tons/acre/year (dry weight) was more than adequate to produce corn grain yields equivalent to those where recommended rates of inorganic fertilizer were applied. Application of higher rates of each manure did not result in higher yields, but did result in higher than normal P and K levels in the ear leaves and substantial NO_3-N buildup and leaching below the rooting depth of corn. Therefore, the maximum recommended rates of application of these two manures to continuous corn under conditions in western Minnesota would appear to be at the lowest levels used in this experiment. In fact, the solid beef manure could probably be applied at a rate somewhat less than 9.0 tons/acre/year.

Table 1. Actual amounts of manure applied in the fall of 1978.

Treatment	Dry Weight	Wet Weight
	- tons/acre -	
SB1	12.737	33.333
SB2	25.473	66.667
SB3	38.210	100.000
LB1	1.721	18.844
LB2	3.441	37.687
LB3	5.162	56.531

Table 2. Average* analysis of manure samples applied in the fall of 1978.

Measurement	Unit†	Type of Manure SB	LB
pH	-	7.1	5.9
Total solids	%	39.29	9.131
Total Kjeldahl N	%	2.894	5.384
NH_4^+-N	%	1.154	2.922
Organic N	%	1.740	2.462
Emission Spectrograph			
P	%	.79	1.27
K	%	1.94	2.06
Ca	%	1.37	1.76
Mg	%	.56	1.22
Na	%	.12	.29
Fe	ppm	2097	1032
Al	ppm	1381	271
Mn	ppm	249	356
Zn	ppm	148	284
Cu	ppm	10	15
B	ppm	15	25

* Values based on 2 samples of SB and 3 samples of LB manure.

† Dry weight basis.

Table 3. Nutrients applied in 1978 for the 1979 crop year.

Element	Treatment SB1	SB2	SB3	LB1	LB2	LB3
	- lbs/acre -					
Total Kjeldahl N	737	1474	2212	185	371	556
NH_4-N	294	588	882	101	201	302
Org-N	443	886	1330	85	169	254
P	201	402	604	44	87	131
K	494	988	1070	71	142	213
Ca	349	698	1047	61	121	182
Mg	143	285	428	42	84	126
Na	31	61	92	10	20	30
Fe	53	107	160	3.6	7.1	10.7
Al	35	70	106	0.9	1.9	2.8
Mn	6.3	12.7	19.0	1.2	2.5	3.7
Zn	3.8	7.5	11.3	1.0	2.0	2.9
Cu	0.2	0.5	0.8	0.05	0.10	0.15
B	0.4	0.8	1.1	0.09	0.17	0.26

Table 4. Effect of two types of beef manure and commercial fertilizer on the NO_3-N, Cl, P, and K levels and electrical conductivity of a Tara soil profile - fall 1978.

Depth	Treatment							
	CK	FE	SB1	SB2	SB3	LB1	LB2	LB3
- ft -				NO_3-N, ppm				
0-1	5.1	9.3	15.5	32.9	58.5	9.2	13.6	17.5
1-2	2.1	50.1	57.5	153.4	121.3	24.9	116.0	126.8
2-3	3.0	80.3	102.4	202.5	208.2	91.6	104.6	205.8
3-4	6.1	49.9	33.7	140.4	166.8	33.8	64.3	114.2
4-5	6.9	20.4	13.8	26.9	101.4	13.6	45.9	36.1
5-6	6.0	10.6	7.3	10.1	63.2	8.4	23.2	19.4
6-7	5.7	8.2	6.7	21.5	37.5	7.5	11.2	12.8
7-8	5.3	7.7	6.4	9.0	22.1	5.5	6.9	7.3
8-9	4.5	7.1	6.1	7.7	13.9	4.5	5.8	6.7
9-10	4.0	5.9	4.0	6.4	8.6	4.0	5.6	5.1
				Chloride, ppm				
0-1	16.5	7.2	15.0	24.6	33.4	21.9	8.4	37.9
1-2	5.6	15.9	46.2	79.1	40.6	16.0	56.4	36.5
2-3	13.9	29.0	143.0	228.7	138.1	78.2	51.8	107.5
3-4	11.1	21.2	62.0	212.0	142.5	35.1	51.2	124.5
4-5	8.8	12.5	20.5	60.0	78.5	17.3	37.8	58.3
5-6	9.9	7.5	14.1	17.0	59.8	10.1	21.6	28.5
6-7	6.5	16.6	13.6	33.5	37.1	8.7	13.9	22.3
7-8	7.6	6.3	11.4	8.4	27.2	7.1	8.8	15.1
8-9	7.9	4.3	8.9	6.5	14.3	8.8	8.1	10.3
9-10	11.8	4.5	9.8	6.4	7.6	4.7	6.4	7.0
				E. C., mmhos/cm				
0-1	.164	.245	.269	.352	.520	.229	.257	.219
1-2	.237	.411	.497	.512	.721	.326	.647	.676
2-3	.328	.506	.730	1.157	1.089	.632	.608	.970
3-4	.234	.385	.387	.862	.935	.332	.438	.624
4-5	.217	.267	.261	.331	.659	.236	.373	.317
5-6	.214	.239	.223	.269	.475	.239	.290	.247
6-7	.203	.241	.226	.297	.362	.229	.260	.223
7-8	.223	.219	.241	.252	.275	.222	.229	.219
8-9	.230	.214	.242	.276	.265	.221	.238	.216
9-10	.269	.139	.243	.266	.224	.197	.262	.210
				Available P, ppm				
0-1	7.1	10.4	55.4	73.9	59.9	12.0	45.6	72.4
				Extractable K, ppm				
0-1	139	133	295	486	994	161	227	259

Table 5. Effect of two types of beef cattle manure and commercial fertilizer on the NO_3-N level of a Tara soil profile - fall 1979.

Depth	Treatment							
	CK	FE	SB1	SB2	SB3	LB1	LB2	LB3
- ft -	- NO_3-N, ppm -							
0-1	4.4	7.0	15.9	48.6	82.6	4.9	9.8	48.2
1-2	1.5	17.9	62.7	152.0	164.3	23.9	72.8	194.0
2-3	1.7	28.4	72.7	171.7	138.9	51.5	78.6	142.7
3-4	5.1	32.7	54.5	134.0	136.7	28.0	50.1	95.9

Table 6. Summary of analysis of stover and grain samples - 1978.

Treatment	Stover											Grain
	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B	Cl	N
	%					ppm						- % -
CK	.64	.06	1.10	.37	.49	254	9.6	3.9	43	5.8	2517	1.59
FE	.94	.06	1.37	.44	.52	310	14.9	4.8	66	5.5	3883	1.82
SB1	.79	.23	2.04	.35	.32	352	11.1	4.4	59	5.1	3880	1.81
SB2	.94	.36	2.66	.39	.26	311	7.0	2.9	58	5.4	3070	1.85
SB3	1.16	.44	2.84	.33	.22	291	9.6	3.1	53	5.0	2423	1.86
LB1	.75	.12	1.59	.41	.39	312	8.3	4.6	61	5.4	3537	1.80
LB2	.80	.19	1.87	.35	.34	294	6.8	4.7	56	5.8	2737	1.81
LB3	.88	.26	2.36	.40	.30	363	6.9	3.5	68	5.6	2850	1.92
Significance:	**	**	**	*	**	NS	+	NS	NS	NS	NS	*
BLSD(.05):	.19	.07	.37	.07	.09	-	-	-	-	-	-	.18

Table 7. Summary of analysis of corn leaves at silking - 1979.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	1.60	.21	1.65	.51	.43	69	11.1	2.4	35	5.3
FE	3.14	.30	2.04	.52	.48	107	23.4	5.5	82	4.9
SB1	3.11	.45	2.69	.48	.31	98	14.4	5.0	85	5.6
SB2	3.12	.50	2.79	.50	.27	114	23.3	4.9	95	5.9
SB3	3.21	.50	2.78	.43	.22	109	27.6	4.4	83	5.7
LB1	2.79	.34	2.18	.50	.37	95	15.3	4.8	66	4.6
LB2	3.18	.51	2.46	.56	.41	109	13.5	4.8	102	5.4
LB3	3.25	.54	2.75	.53	.34	114	17.6	3.9	102	6.0
Significance:	**	**	**	*	**	**	**	**	**	NS
BLSD(.05):	.21	.06	.21	.07	.05	9	3.9	1.4	22	-

Table 8. Summary of plant measurements - 1979.

Treatment	Early plant height inches	Early plant (10) dry wt. grams	Grain: Ear moisture at harvest %	Grain: Yield @ 15.5% M. bu/A	Silage: Dry matter at harvest %	Silage: Silage yield (D.M.) lb/A	Silage: Ear wt. ÷ silage wt. %
CK	16.0	26.9	33.6	41.1	35.2	9043	47.1
FE	21.6	48.3	27.5	89.5	36.7	13772	44.3
SB1	28.4	67.8	20.2	108.9	38.0	14199	46.5
SB2	28.3	72.8	18.5	95.5	39.1	13966	49.3
SB3	27.8	74.2	21.4	106.7	29.2	12155	34.0
LB1	24.1	49.9	24.5	102.6	38.0	13125	48.6
LB2	27.5	61.8	23.1	114.3	37.0	15472	50.5
LB3	27.2	67.4	21.2	100.4	38.9	13859	46.1
Significance:	**	**	**	**	+	*	NS
BLSD(.05):	1.8	12.7	2.9	18.2	-	3083	-

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

West Central Experiment Station - Morris

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

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

I. Planting Information

Twenty-four rows of corn (var. Dekalb XL12) were planted in each plot on May 17, 1979. Lorsban @ 8.8 lbs/acre (1 lb/acre active ingredient) was applied to the entire area. Starter fertilizer consisting of 154 lbs/acre of 10-26-26 was applied to the fertilized treatment only. Nitrogen in the form of urea was applied to the fertilized plots to provide 110 lbs/acre of N on October 18, 1978. Lasso (2 lbs/acre) and Bladex (2.2 lbs/acre) were applied broadcast on May 18, 1979.

II. Soil Sampling and Analysis

A. 1978 Measurements

The results of some of the analyses of the soil samples collected to a depth of 16 feet are given in Table 1.

1. NO_3-N - Levels in the top foot were similar to one year before, but levels from 1 to 4 feet changed. The maximum level in the SB and LH treatments was in the 3- to 4-foot zone, while that in the LB treatment remained in the 2- to 3-foot zone. Levels in the 4- to 6-foot zone for all treatments except CK had increased since the last measurements in 1975. Below this depth there were no large increases or decreases.

2. Chloride - Levels in the top 3 feet of the manure treatments decreased, while the level in the 4th foot increased. Below 4 feet chloride levels had not changed greatly since 1975, but there appeared to be some downward movement.

3. Electrical conductivity - The conductivity of the 2- to 3-foot zone decreased and the 3- to 4-foot zone increased compared to one year earlier.

4. Available P - Levels in all the manure treatments were almost identical and 3 times those in the fertilized treatment.

5. Extractable K - Levels in all the manure treatments were much higher than FE and very similar to one year earlier.

B. 1979 Measurements

NO_3-N was the only soil variable measured in 1979. The values shown in Table 2 indicate that levels in the beef manure treated plots were still higher than in the fertilized plot. The total NO_3-N in the top 4 feet of soil decreased for all treatments.

III. Plant Tissue Analysis

A. 1978 Harvest Samples (Table 3)

Stover from the manure treated plots had significantly higher P and K levels and lower Mg and Cl levels than stover from the fertilized plots.

B. 1979 Samples

1. Corn leaves at silking (Table 4)

All manure treatments had higher K and lower Mg and Zn levels than the fertilized treatment. The SB and LB treatments had higher P levels than FE.

2. Samples were taken at harvest but analysis is not complete.

IV. Field and Plant Measurements - 1979 (Table 5)

A. Early plant height and dry matter - All manure treatments had values equal to or larger than the fertilized check.

B. Grain yield - The solid beef treatment yielded significantly more than all other treatments. Yields of FE, LB, and LH were not significantly different.

C. Silage yield - Yields of FE, SB, and LB were not significantly different but were all higher than LH and CK. The LH treatment was significantly higher yielding than CK.

V. Summary

The effects of the manure treatments applied in 1970 and 1971 are still quite evident in most soil and plant measurements. The NO_3-N in the soil has moved down slightly in the soil profile. Plant analysis in the fall of 1978 and summer of 1979 show large effects of the manure treatments.

In 1979 grain yields on the manure treatments were equal to or higher than the fertilized treatment. The silage yield on the LH treatment had decreased to a point where it was significantly lower than the beef manure and fertilized treatments.

Table 1. Effect of high rates of manure and commercial fertilizer eight years (fall 1978) after application on the NO_3-N, Cl, P, and K levels and electrical conductivity of a Tara soil profile.

Depth - ft -	Treatment* CK	FE	SB	LB	LH
	- NO_3-N, ppm -				
0-1	4.1	7.4	13.9	17.2	8.2
1-2	1.0	20.7	25.3	76.9	15.0
2-3	2.7	72.9	96.9	164.3	74.1
3-4	4.4	36.2	116.4	145.6	61.8
4-6	6.5	10.9	65.4	93.3	34.3
6-8	6.3	3.6	28.9	45.4	21.2
8-10	3.5	2.8	15.8	32.8	12.7
10-12	2.7	2.3	7.4	21.6	7.8
12-14	2.8	2.8	7.1	10.5	4.8
14-16	2.3	3.0	5.5	10.6	3.9
	- Chloride, ppm -				
0-1	5.0	12.4	15.3	5.5	12.3
1-2	0.1	8.5	20.9	27.7	13.2
2-3	2.5	44.9	86.8	112.7	46.1
3-4	1.1	27.2	152.7	119.4	44.7
4-6	3.5	8.1	110.0	86.2	24.4
6-8	1.7	1.0	71.8	45.8	14.2
8-10	0.4	0.1	38.0	36.8	7.0
10-12	0.8	0.3	13.8	20.9	17.8
12-14	0.2	0.1	12.5	10.2	2.0
14-16	2.7	0.2	7.3	10.6	14.5
	- E.C., mmhos/cm -				
0-1	.175	.132	.254	.243	.143
1-2	.177	.290	.336	.544	.222
2-3	.202	.537	.624	.906	.484
3-4	.182	.338	.710	.791	.420
4-6	.190	.217	.500	.580	.296
6-8	.178	.181	.335	.365	.246
8-10	.180	.175	.262	.326	.208
10-12	.179	.184	.197	.296	.198
12-14	.191	.230	.207	.292	.191
14-16	.225	.296	.220	.287	.205
	- Available P, ppm -				
0-1	2.8	24.0	74.8	73.7	71.9
	- Extractable K, ppm -				
0-1	118	134	462	353	225

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

Table 2. Effect of high rates of manure and commercial fertilizer nine years (fall 1979) after application on the NO_3-N level of a Tara soil profile.

Depth - ft -	Treatment CK	FE	SB	LB	LH
	- NO_3-N, ppm				
0-1	2.7	6.0	6.4	12.0	5.5
1-2	0.6	22.4	27.2	72.0	15.5
2-3	0.6	50.2	88.9	139.6	56.6
3-4	2.3	32.1	54.2	104.9	38.0

Table 3. Summary of analysis of stover and grain samples - 1978.

Treatment	Stover N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B	Cl	Grain N
	%					ppm						%
CH	.49	.04	.80	.46	.59	515	12.8	2.9	62	5.0	1890	1.43
FE	.78	.06	1.39	.45	.52	597	13.4	4.6	67	5.6	4213	1.79
SB	.81	.22	2.15	.40	.30	582	8.4	4.8	78	5.8	2707	1.77
LB	.86	.25	2.40	.41	.26	486	8.0	3.8	73	6.1	1403	1.79
LH	.67	.12	1.97	.40	.33	461	8.8	4.3	67	5.5	2947	1.73
Signif.:	**	**	**	NS	**	NS	NS	*	NS	NS	**	**
BLSD(.05):	.15	.05	.33	-	.12	-	-	1.0	-	-	1174	.13

Table 4. Summary of analysis of corn leaves at silking - 1979.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	1.20	.15	1.26	.38	.31	52	7.8	1.6	24	4.8
FE	3.00	.29	1.68	.50	.47	98	20.8	3.1	64	4.5
SB	2.81	.40	2.10	.48	.28	89	12.8	3.0	64	3.3
LB	2.89	.47	2.32	.51	.27	102	13.1	3.0	67	3.8
LH	2.45	.30	2.07	.50	.31	83	16.3	2.9	54	4.4
Significance:	**	**	**	*	**	**	**	**	**	NS
BLSD(.05):	.35	.08	.24	.11	.09	11	1.7	.5	15	-

Table 5. Summary of plant measurements - 1979.

Treatment	Early plant height inches	Early plants (10) dry wt. grams	Grain: Ear moisture at harvest %	Grain: Yield @ 15.5% M. bu/A	Silage: Dry matter at harvest %	Silage: Silage yield (D.M.) lb/A	Silage: Ear wt. ÷ silage wt. %
CK	14.9	25.5	34.0	21.8	31.4	4991	22.7
FE	23.3	51.8	24.9	100.6	36.2	12675	45.9
SB	25.3	57.4	20.4	129.1	39.8	13899	49.5
LB	27.3	63.7	21.3	92.1	38.3	13803	50.7
LH	23.8	54.0	26.8	94.2	33.6	10884	48.1
Significance:	**	**	**	**	**	**	**
BLSD(.05)	2.3	7.7	2.6	8.8	3.1	1085	8.0

INFLUENCE OF NITROGEN FERTILIZATION ON FORAGE PRODUCTION AND NITROGEN UTILIZATION BY THREE SMALL GRAIN VARIETIES*

G.L. Malzer and S. Evans

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

EXPERIMENTAL PROCEDURES

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

Dry matter production was determined at three different times during plant growth and analyzed for nutrient composition. Grain was harvested on August 17 by hand harvesting known areas from each plot. Soil samples were obtained at the four samplings above (July 2, July 11, July 30, and August 17) for determination of rooting density, soil moisture and soil nitrate nitrogen. Root samples were obtained utilizing a coring technique. For root analysis, samples were collected over the row and between the row to a depth of four feet. Each core (2 5/8" diameter) was divided into eight 6" increments and each sample consisted of a composite of two cores. The root samples at this time are in the process of being analyzed. Soil samples for moisture and nitrate analysis were taken in a similar manner by obtaining one core in the immediate area from which the root samples were obtained.

GENERAL RESULTS

Preliminary nitrate soil tests indicated a very low nitrate nitrogen content in the 0-2' depth. Appreciable quantities of nitrate nitrogen were present in the 2-4' depth in 1979. Significant dry matter production increases were obtained due to nitrogen application with both Chris and MN 7125 through all three forage harvests. Era wheat showed no dry matter increase to the application of fertilizer nitrogen at any sampling date. There was no difference between varieties when no fertilizer nitrogen had been applied. Era, however, produced significantly less forage than Chris or MN 7125 when nitrogen was applied. Nitrogen content (%) in the

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forage was increased in all three varieties due to nitrogen fertilization with differences being the most evident with early plant growth. Again, variety differences were more apparent at the high nitrogen level than on the control. Era had the highest nitrogen content under high fertility, but this carried through only to the second sampling. Nitrogen removal with the forage reflected mainly the nitrogen fertilization, although some differences were found between varieties with nitrogen treatments. Only MN 7125 produced a significant improvement in grain yield with nitrogen application. Protein (N content) of the grain increased with nitrogen fertilization on Chris and Era, but not MN 7125. Chris, as expected, had the highest protein content, although under low fertility all three varieties were similar. Nitrogen application depressed grain test weight for all three varieties tested.

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

Treatment		Forage Yield			Forage N Content		
		Harvest No.			Harvest No.		
Variety	N Rate	1	2	3	1	2	3
	#/A	--------T/A---------			----------%----------		
Chris	0	0.92	1.50	2.24	2.62	1.77	1.39
Chris	120	1.22	1.91	2.86	2.99	2.23	1.33
MN 7125	0	0.83	1.42	2.16	2.44	1.92	1.28
MN 7125	120	1.12	1.76	2.65	3.13	2.35	1.49
Era	0	0.84	1.45	1.93	2.67	2.10	1.53
Era	120	0.86	1.57	2.15	3.58	2.62	1.55
Signif.		**	**	**	**	**	**
BLSD(.05)		0.14	0.17	0.34	0.21	0.15	0.13

		Forage N Removal					Harvest				
		1	2	3	Grain Yield	Straw Yield	N Content Grain	N Content Straw	N Removal Grain	N Removal Straw	Test Wt.
		---------#/A--------			bu/A	T/A	-----%-----		----#/A----		#/bu
Chris	0	48.3	53.0	62.4	33.4	1.73	2.39	0.43	44.3	14.7	57.2
Chris	120	72.5	84.8	75.8	33.8	2.34	2.88	0.71	54.3	33.2	54.9
MN 7125	0	40.3	54.7	55.4	34.1	1.48	2.52	0.57	47.9	16.8	57.1
MN 7125	120	69.6	82.8	78.9	45.0	1.97	2.51	0.75	63.1	29.7	55.0
Era	0	44.5	61.2	59.3	31.0	1.49	2.43	0.69	42.1	20.4	56.3
Era	120	62.0	82.0	66.9	34.9	1.85	2.62	0.80	51.0	29.7	54.3
Signif.		**	**	**	**	**	**	**	**	**	**
BLSD(.05)		8.6	8.5	10.9	5.5	0.20	0.22	0.07	10.4	3.1	1.2

NITROGEN FERTILIZATION AND NITROGEN UTILIZATION BY SEVEN SMALL GRAIN VARIETIES - Morris, MN. - 1979*

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

The Semi-dwarf varieties of hard red spring wheat account for a major portion of the acreage planted to hard red spring wheat in Minnesota. These short statured varieties not only provided improved physical characteristics, but also provided the potential for a system which might be capable of responding to higher rates of nitrogen application without lodging. The difference that exist between wheat varieties in their ability to utilize soil and fertilizer nitrogen is not well understood. A portion of the differences which exist may be due to the genetic ability of the plant because of some favorable plant characteristic either above or below the soil surface. If selection of plant genotypes can be made for more effective nitrogen uptake and utilization, advancements may be made in increasing present yield levels as well as improving the overall protein content of the grain. Trials were established in 1979 to examine some of the differences which exist between wheat varieties in their response to fertilizer nitrogen and their ability to utilize existing soil nitrogen. Existing popular varieties as well as older varieties and experimental varieties were included for comparison. Similar trails were conducted at Crookston as well as Morris, MN.

EXPERIMENTAL PROCEDURES

Seven varieties of hard red spring wheat were compared at nitrogen application rates of 0, 60, and 120# N/A at the West Central Experiment Station at Morris. Nitrogen was applied as spring applications of ammonium nitrate broadcast and incorporated. The treatments were arranged in a split plot design with nitrogen as the main effect and the seven varieties planted within a uniformly fertilized area. All treatments were replicated three times. Experimental plots were planted into areas 4' x 20' on May 14th.

Total plant dry matter was measured at approximately the "soft dough" stage of growth (July 30th) and samples collected for nitrogen content and calculation of nitrogen uptake. Yield grain was harvested on August 17th by harvesting 16 ft.^{2} of the plot area. The above ground growth (straw + grain) was removed from the experimental plot area, allowed to air dry in a forced air dryer. The samples were then weighed, thrashed and the grain reweighed for yield determination. Straw weights were determined by difference. Samples of straw and grain were collected and analyzed for nitrogen content and determination of nitrogen removal. Lodging scores were obtained from the experimental treatments at harvest time. Lodging rankings were made on a 1-5 scale with a ranking of one having excellent standing characteristics and a rating of five being flat on the soil surface.

GENERAL RESULTS

Grain yields ranged from 25-40 bu/A with no significant yield response attributed to nitrogen fertilization. Nitrogen fertilization did increase protein content in the grain and there was a trend toward increased total nitrogen uptake (forage). Major differences were obtained between varities not only in yield but also in most of the nitrogen utilization characteristics. James was the highest yielding variety with Coteau somewhat lower but still better than the remaining varities. Similar yields were obtained with WS 1809, Era, MN 70170, Chris and Waldron. James, the highest yielding variety was intermediate in protein content when compared to the

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other varieties. The lowest protein contents were obtained with Era and MN 70170, while the highest protein contents were obtained with Coteau, WS 1809 and Chris. Differences were also obtained between varieties in total nitrogen uptake, nitrogen removal in the grain, and nitrogen remaining in the straw. Similar to the results obtained at Crookston, nitrogen had no influence on the lodging score and variations that were encountered could be accounted for because of the varieties.

Data thus far would suggest that the variety and the genetic potential of our plant system must be considered when evaluating nitrogen utilization. Evidence would suggest that selection of varieties on the basis of nitrogen utilization characteristics may be possible. More information in this area is needed.

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

Nitrogen Rate	Variety	Grain Yield	Grain N content	Grain Test wt.	Forage Total Dry Matter	Forage N content	Forage Lodging Score
#/A		bu/A	%	#/bu	T/A	%	
0	-	29.8	2.62	54.0	2.25	1.36	2.0
60	-	30.8	2.70	52.3	2.37	1.46	2.4
120	-	32.6	2.77	51.9	2.56	1.51	2.2
Significance		NS	+	*	NS	*	NS
BLSD(.05)		-	.11	1.3	-	0.11	-
-	Coteau	36.4	2.89	56.8	2.77	1.37	2.1
-	WS 1809	29.5	2.79	52.7	2.12	1.45	2.4
-	Era	29.7	2.55	52.0	2.33	1.58	2.1
-	MN 70170	26.0	2.55	50.1	2.11	1.56	2.0
-	Chris	28.7	2.79	54.2	2.47	1.36	2.8
-	James	40.1	2.68	52.4	2.60	1.41	2.1
-	Waldron	27.0	2.68	51.0	2.33	1.40	2.0
Significance		**	**	**	**	**	**
BLSD(.05)		3.1	.09	1.1	0.14	0.07	0.4
0	Coteau	34.8	2.95	57.4	2.71	1.35	2.0
0	WS 1809	26.9	2.52	53.6	1.99	1.34	2.0
0	Era	28.3	2.55	54.2	2.27	1.48	2.0
0	MN 70170	25.1	2.48	51.7	1.93	1.34	2.0
0	Chris	28.8	2.82	55.6	2.34	1.27	2.7
0	James	37.7	2.62	53.7	2.30	1.45	1.7
0	Waldron	26.7	2.41	52.0	2.18	1.33	2.0
60	Coteau	35.2	2.89	56.4	2.71	1.33	2.3
60	WS 1809	29.9	2.80	53.4	2.08	1.46	2.7
60	Era	30.0	2.36	51.7	2.29	1.61	2.3
60	MN 70170	25.8	2.52	49.3	2.11	1.60	2.0
60	Chris	30.0	2.79	52.8	2.39	1.37	2.7
60	James	39.6	2.69	52.0	2.61	1.34	2.7
60	Waldron	25.2	2.89	50.5	2.40	1.50	2.0
120	Coteau	39.1	2.85	56.8	2.89	1.43	2.0
120	WS 1809	31.8	2.88	51.1	2.31	1.57	2.7
120	Era	30.7	2.75	50.2	2.42	1.64	2.0
120	MN 70170	27.2	2.66	49.4	2.29	1.73	2.0
120	Chris	27.1	2.77	54.3	2.67	1.44	3.0
120	James	42.9	2.73	51.4	2.90	1.43	2.0
120	Waldron	29.1	2.75	50.5	2.40	1.36	2.0
Significance		NS	**	NS	NS	**	NS
BLSD(.05)		-	0.17	-	-	0.15	-

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

Nitrogen Rate	Variety	Harvest Straw		Nitrogen Removal			
		Dry Matter	N content	Forage	Straw	Grain	Grain + Straw
#/A		T/A	%	#/A			
0	-	1.46	0.56	61.3	16.1	43.7	59.8
60	-	1.59	0.70	68.9	22.4	46.5	68.9
120	-	1.81	0.77	77.1	27.3	50.4	77.8
Significance		NS	*	+	+	NS	NS
BLSD(.05)		-	0.13	12.3	6.9	-	-
-	Coteau	1.95	0.55	76.2	21.5	58.6	80.1
-	WS 1809	1.34	0.75	62.0	20.6	45.2	65.8
-	Era	1.51	0.84	73.7	25.9	42.3	68.2
-	MN 70170	1.46	0.83	66.1	24.8	37.0	61.8
-	Chris	1.77	0.60	67.3	21.7	44.6	66.3
-	James	1.74	0.59	73.2	20.7	60.0	80.7
-	Waldron	1.57	0.58	65.2	18.5	40.3	58.8
Significance		**	**	**	**	**	**
BLSD(.05)		0.07	0.06	5.6	2.0	5.3	5.2
0	Coteau	1.76	0.49	73.2	17.2	57.1	74.2
0	WS 1809	1.19	0.63	53.0	15.0	37.9	52.9
0	Era	1.37	0.64	67.4	17.5	40.2	57.7
0	MN 70170	1.29	0.69	51.7	18.1	34.6	52.7
0	Chris	1.55	0.49	59.0	15.1	45.2	60.3
0	James	1.57	0.49	66.6	15.4	55.1	70.5
0	Waldron	1.45	0.50	58.1	14.5	35.8	50.4
60	Coteau	1.93	0.53	72.4	20.8	56.7	77.5
60	WS 1809	1.35	0.80	60.8	22.3	46.6	68.9
60	Era	1.54	0.89	74.2	28.0	39.4	67.4
60	MN 70170	1.43	0.85	67.2	24.6	36.2	60.8
60	Chris	1.66	0.63	65.8	21.6	46.6	62.2
60	James	1.70	0.60	69.8	20.8	59.5	80.2
60	Waldron	1.56	0.60	72.1	19.0	40.5	59.5
120	Coteau	2.13	0.62	83.0	26.4	62.1	88.5
120	WS 1809	1.47	0.82	72.4	24.4	51.2	75.5
120	Era	1.63	0.98	79.4	32.1	47.3	79.4
120	MN 70170	1.67	0.95	79.3	31.8	40.4	72.2
120	Chris	2.11	0.68	77.1	28.5	42.1	70.6
120	James	1.93	0.67	83.2	25.9	65.4	91.3
120	Waldron	1.71	0.64	65.4	22.1	44.7	66.7
Significance		+	NS	+	NS	NS	NS
BLSD(.05)		0.15	-	11.3	-	-	-

PESTICIDE INTERACTION PLOTS AT ROSEMOUNT

Russell S. Adams, Jr.

Carbofuran has been found to fail in several areas in the midwest. Currently intense controversy exists as to whether this failure is due to the development of resistance in the target pest or to the development of a soil microflora that more rapidly degrades it. The problem is associated with high lime or calcareous soils.

Our lab belongs to the group that believes that degrading soil microflora have developed. We have isolated three cultures that can utilize carbofuran as a sole carbon source. These organisms degrade carbofuran much more rapidly at a pH above 7.

An added bit of information that seems to implicate the soil microflora are data obtained at Rosemount this summer. Our continuous corn plots were discontinued after 7 years of identical treatments on each plot. The plot area was planted to oats and stand evaluated as soon as stabilized. The crop was then tandem disced and replanted to oats. Again the stand was evaluated when stabilized. Then the crop was moldboard plowed and planted to soybeans. Since we have found that the stand of soybeans does not predict the yield these were grown to maturity and harvested.

Serious injury to oats and soybeans occurred only after the 8 lb/A treatment of atrazine the previous year. As was found with an earlier study greater injury occurred to the second crop of oats than the first. This was attributed to greater rainfall (4.95 inches) on the second crop than the first (2.95 inches). Clearly less atrazine residue injury occurred where carbofuran was used than where it was not. This suggested that the same microflora favored by carbofuran also degraded atrazine. Data follow in the table below.

Table 1. Stand of oats and yield of soybeans in atrazine x carbofuran residue plots.

	No atrazine			8 lb/A atrazine		
Soil pH	Oats I Stand % Control	Oats II Stand % Control	Soybeans bu/A	Oats I Stand % Control	Oats II Stand % Control	Soybeans bu/A
			No carbofuran			
5.4	100	100	27.8	133	58	24.3
6.3	100	100	25.8	77	36	13.6
6.8	100	100	26.3	73	23	11.7
7.2	100	100	28.9	56	4	2.8
			With 2 lb/A carbofuran			
5.4	105	96	21.9	104	40	27.2
6.3	110	97	24.7	98	48	20.5
6.8	108	84	28.6	85	24	22.0
7.2	125	112	25.4	84	30	8.5

ALFALFA AND RED CLOVER POTASSIUM TRIALS

Staples, Minnesota 1979

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

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

After 1974 only the potassium trials on alfalfa and red clover are continued. The red clover had to be reseeded in 1974 and no red clover yields were obtained that year. In 1977 both alfalfa and red clover areas were plowed and reseeded. The main purpose was to have the higher yielding anchor alfalfa and Arlington red clover in the comparisons.

Yield and soil test results

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

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

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

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

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

Yields of over 5 tons of alfalfa have been measured on the no-potash treated plots (1974 & 1975), while the 0 to 6 inch soil sample is very low, i.e.,

between 40 and 60 pounds of exchangeable K. Subsoil samples taken in 1974 show K tests of 50 at 1 to 2 feet and 20 at 2 to 3 feet deep, indicating that subsoil K source cannot explain the good alfalfa yields on the check plots. In 1978, however, the no-potash plots yielded approximately 2 tons per acre and shows K deficiency symptons.

Plant analysis

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

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

Table 1a. Potassium treatments effect on red clover and alfalfa yields and soil tests.

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

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

*Red clover failed in 1974, was reseeded August 1, 1974
**Crops reseeded in 1977 to Anchor alfalfa and Arlington Red Clover. No yields or soil samples taken in 1977. Treatments of K_2O in 1978 were increased to from 120 to 180 pouncs of K_2O per acre and the 240 pound treatment was increased to 360 (data in Table 1b).

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

	K_2O in lb/A annual and time of application							
1978 Cutting	None	June 360	Oct. 360	June 180	Oct. 180	June 180+ Oct. 180	Significance	BLSD(.05)
Alfalfa								
1	.38	1.31	1.22	1.05	1.05	1.22	**	.20
2	.71	1.19	1.20	1.08	1.12	1.14	**	.14
3	.88	1.31	1.39	1.28	1.25	1.37	**	.12
Total	1.97	3.81	3.81	3.41	3.42	3.73	**	.32
Red Clover								
1	.96	1.40	.95	.87	1.12	1.06	ns	-
2	.97	1.19	1.21	1.20	1.20	1.19	**	.12
3	1.02	1.27	1.20	1.26	1.17	1.21	ns	-
Total	2.95	2.86	3.36	3.33	3.49	3.46	ns	-
1979								
Alfalfa								
1	.58	1.58	1.64	1.41	1.45	1.50	**	.20
2	1.17	1.62	1.59	1.56	1.53	1.70	**	.14
3	.51	.93	.95	.88	.88	.84	**	.21
Total	2.26	4.13	4.18	3.85	3.86	4.04	**	.32
	Soil test K lbs/A (Sept.)							
Alfalfa								
1978	54	287	216	123	91	212		
1979								
0-3"	55	317	249	180	116	261	**	38
3-6"	44	275	303	96	84	206	**	40
Avg(0-6")	50	296	276	138	100	233		

Table 1b. (cont)

	None	June 360	Oct. 360	June 180	Oct. 180	June 180+ Oct. 180
	Soil test K lbs/acre (Sept.)					
Red Clover						
1978	58	300	170	138	86	210
1979	No Crop					

Phosphorus & pH averages for all plots

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

Table 2. Potassium (%) in alfalfa and red clover tops.

	Plant Analysis %K						
				K_2O treatments			
	None	June 240	Oct. 240	June 120	Oct. 120	June 120 Oct. 120	Significance
Alfalfa							
1972-1st cut	2.05	2.76	2.98	2.20	2.74	2.65	
2nd cut	2.00	2.50	2.46	2.27	1.92	2.34	
3rd cut	2.52	3.44	3.08	2.94	2.85	3.18	
1973-1st cut	1.74a	2.74b	2.88b	2.40b	2.45b	2.47b	5%
2nd cut	1.58	2.76b	2.76b	2.48b	2.39b	2.65b	1%
3rd cut	1.64a	2.60b	2.57b	2.45b	2.17b	2.56b	5%
1974-1st cut	1.37	3.08	3.59	2.17	2.32	3.21	
2nd cut	1.29	2.40	2.85	2.25	1.89	2.60	
3rd cut	1.11	2.18	2.48	2.08	1.62	2.46	
1975-1st cut	1.24a	2.19c	2.67d	1.67b	2.15c	2.31c	1%
2nd cut	1.39a	2.74c	2.49bc	2.27b	1.93a	2.67c	1%
3rd cut	1.23a	2.60c	2.85c	2.15b	1.72a	2.56bc	1%
1976-1st cut	1.24a	3.66f	3.26de	1.55b	2.38c	2.99d	5%
2nd cut	1.45a	2.98d	2.83d	2.68c	2.02b	2.90d	5%
3rd cut	1.49a	2.78cd	2.86d	2.26b	2.03b	2.68c	5%
1977-None							
Red Clover							
1972-1st cut	2.14	3.05	2.83	3.02	2.61	3.04	
2nd cut	2.20	2.86	2.60	2.51	2.21	2.44	
3rd cut	2.65	3.54	2.98	3.32	2.87	2.98	
1973-1st cut	1.76a	2.63b	2.65b	2.56b	2.42b	2.66b	5%
2nd cut	2.03a	2.84c	2.97c	2.65bc	2.48b	2.92c	1%
3rd cut	1.81a	3.00d	2.53c	2.40c	2.10b	2.66c	1%
1974-None							
1975-1st cut	1.55a	2.59d	2.33cd	2.01bc	1.87ab	2.45d	1%
2nd cut	1.69a	3.00c	2.18b	2.80c	2.05b	2.89c	1%
3rd cut	1.78a	3.12d	2.37b	2.68c	2.25b	2.87c	1%
1976-1st cut	1.43	2.96	3.18	2.08	2.47	2.80	5%
2nd cut	1.70a	3.09c	2.67b	2.66b	2.47b	3.05c	5%
1977-None							

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

Table 2. (cont.) Plant analysis %K (1978 & 1979)

	K_2O treatments and dates of application							
	None	June 360	Oct. 360	June 180	Oct. 180	June 180 Oct. 180	Significance	
1978								BLSD 5%
Alfalfa								
1st cut	1.51	2.66	2.83	2.33	2.48	2.71	**	.15
2nd cut	1.52	2.74	2.77	2.37	2.30	2.81	**	.14
3rd cut	1.58	2.96	2.86	2.56	2.33	2.81	**	.12
Red Clover								
1st cut	1.64	3.11	2.74	2.40	2.49	2.86	**	.44
2nd cut	1.63	3.12	2.72	2.77	2.50	3.02	**	.15
3rd cut	1.60	3.21	2.74	2.82	2.39	2.94	**	.26

Sufficiency levels for alfalfa 2.5%

1979								
Alfalfa								
1st cut	1.34	3.14	3.04	2.42	2.54	3.08	**	.19
2nd cut	1.49	3.17	3.20	2.68	2.51	3.24	**	.21
3rd cut	0.86	2.09	2.03	1.87	1.60	2.06	**	.12
Red Clover								
No crop								

BARLEY FERTILIZATION TRIALS AT STAPLES

Jerome N. Lensing, A.C. Caldwell, Mike O'Leary, Mel Wiens

Agricultural production on the sandy soils of central Minnesota has expanded in recent years due largely to the development of irrigation. Although corn, potatoes, alfalfa, and some vegetable crops are grown under irrigation, there is wide interest in the production of small grains. Considerable work has been done on the production of wheat under irrigation, but there is an increased interest in producing barley if satisfactory yields and acceptable quality can be obtained for malting. Three separate experiments were continued to determine the importance of nitrogen fertilization on the production of malting barley under irrigation at Staples, Minnesota on a sandy loam soil in 1979.

All experimental areas received 60 #K_2O/A applied broadcast and plowed down. Preplant nitrogen treatments were broadcast over the plot area (12' x 20') and incorporated immediately with a harrow. Plot areas were packed prior to planting at a seeding rate of 90#/A on April 23. Starter fertilizer was applied as 20#P_2O_5/A with the seed. Weeds were controlled with an application of Brominal + (¼ #a.i./A) at the 4 leaf stage. A total of 12.2 inches of water was applied as irrigation with an addition 14 inches received as rainfall.

A. Variety x Nitrogen Rate Trial

This trial was designed to evaluate the performance of a semi-dwarf and two tall varieties of malting barley with various nitrogen rates applied as split applications under irrigation. A split plot design replicated four times with varieties as main plots and nitrogen rates as subplots were used. Varieties included were Manker, Morex and an experimental semi-dwarf, M-32. The nitrogen rates used were 0, 45, 90, and 135 lbs nitrogen per acre applied as ammonium nitrate with 2/3 of nitrogen applied as preplant incorporated and 1/3 applied at tillering stage prior to an irrigation.

There was a significant varietal difference in test weight and percent plump kernals. (Table 1) Nitrogen increased yields significantly up to 90 #N/A with a significant increase in protein and grain nitrogen removal to 135 #N/A. Nitrogen significantly decreased test weight and % plump kernals. Malting grade barley (% protein less than 13.5% and % plump kernals greater than 65%) was produced with nitrogen rates up to 90 #N/A with all varieties.

The nitrogen content of M-32 forage (whole plant samples-soft dough stage) was significantly higher with signficantly lower yield potential. (Table 2) Nitrogen rates signficantly increased forage yields, % N content and nitrogen removal. The interaction of nitrogen with variety showed that Manker and M-32 forage yields were signficantly increased with rates of nitrogen to 135 # N/A compared to Morex with a significant yield increase to 90 # N/A.

Table 1. Effect of variety and N rate on yield, test weight, % plumpness, and % protein of barley grain at Staples, MN in 1979.

Treatment	Yield	Test Weight	Plumpness	Protein
Variety	Bu/A	lbs/bu	%	%
Manker	55.2	49.8	66.6	11.0
Morex	56.6	47.9	72.8	11.3
M-32	51.3	46.1	67.5	11.0
Signif.	NS	**	**	NS
BLSD(.05)	-	1.2	2.7	-
N-Rate				
0 #N/A	30.8	48.2	73.7	10.9
45 #N/A	51.4	48.4	74.8	10.0
90 #N/A	66.2	48.0	67.0	11.2
135 #N/A	69.1	47.2	60.3	12.4
Signif.	**	+	**	**
BLSD(.05)	4.8	1.0	2.5	.4
Interaction				
Manker x 0#N/A	30.1	49.7	73.0	10.7
Manker x 45#N/A	52.9	49.6	70.2	9.8
Manker x 90#N/A	66.3	49.9	64.6	11.2
Manker x 135#N/A	71.3	49.8	58.5	12.4
Morex x 0 "	33.0	47.7	74.5	11.1
Morex x 45 "	56.1	49.2	79.8	9.9
Morex x 90 "	66.8	48.1	71.8	11.2
Morex x 135 "	70.6	46.8	65.1	13.0
M-32 x 0 "	29.2	47.0	73.6	10.9
M-32 x 45 "	45.2	46.4	74.4	10.4
M-32 x 90 "	65.4	46.0	64.6	11.0
M-32 x 135 "	65.5	45.0	57.2	11.8
Signif.	NS	NS	NS	NS
C.V.	13.2	2.0	4.8	4.7

Table 2. Effect of variety and N rate on barley dry matter yield, percent N, and total N removal of forage at soft dough stage at Staples, MN in 1979.

Treatment	Yield	N Content	N Removal
Variety	T/A	%	lbs/A
Manker	2.47	1.06	54.0
Morex	2.31	1.11	51.9
M-32	2.11	1.22	52.8
Signif.	**	**	NS
BLSD(.05)	.17	.08	-
N Rate			
0 #N/A	1.35	1.05	28.3
45 #N/A	2.20	.98	43.3
90 #N/A	2.68	1.14	61.1
135 #N/A	2.95	1.34	78.9
Signif.	**	**	**
BLSD(.05)	.13	.08	6.6
Interaction			
Manker x 0 #N/A	1.35	.93	25.3
Manker x 45 #N/A	2.35	1.00	47.3
Manker x 90 "	2.90	1.07	62.2
Manker x 135 "	3.29	1.23	81.0
Morex x 0 "	1.48	1.10	32.4
Morex x 45 "	2.19	.90	39.3
Morex x 90 "	2.77	1.10	61.1
Morex x 135 "	2.78	1.34	75.9
M-32 x 0 "	1.21	1.12	27.3
M-32 x 45 "	2.06	1.05	43.3
M-32 x 90 "	2.38	1.25	60.0
M-32 x 135 "	2.79	1.44	80.7
Signif.	+	NS	NS
BLSD(.05)	.24	-	-
C.V.	7.4	9.6	15.0

B. Time of Application Trial

This trial was designed to evaluate various application schemes of nitrogen on the production of malting barley under irrigation. A randomized complete block design with four replications of five treatments was used. Nitrogen was applied at various times at a rate of 90 lbs nitrogen per acre as ammonium nitrate.

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

The application of nitrogen significantly increased grain yield and nitrogen removal. (Table 3) 90 #N/A applied as 2/3 preplant and 1/3 early boot significantly decreased yields compared to the other split application schemes. The three time application scheme and the 2/3 preplant, 1/3 boot scheme produced significantly higher protein content and grain N removal. Forage yield and nitrogen removal were signifantly increased with nitrogen (Table 4).

C. Seeding Rate x Nitrogen Rate x Potassium Rate Trial

This trial was designed to evaluate the affects of seeding rate, nitrogen rate, and potassium rate on yield and quality of malting barley under irrigation. Treatments were set out in a factorial arrangement (2 x 2 x 2) replicated four times in a randomized complete block design. Seeding rates of 96 and 144 #/A, nitrogen rates of 45 and 90 #/A, and K_2O rates of 60 and 260 #/A were used. Nitrogen was applied as ammonium nitrate with 2/3 applied preplant incorporated and 1/3 applied at tillering stage. Potassium was applied preplant incorporated.

The high seeding rate significantly decreased percent plump kernals. Yield and percent protein of grain were significantly increased with the 90 #/A N rate. Interactions of the variables were non-significant (Table 5).

Table 3. Effect of time of nitrogen application on Manker barley yield, test weight, percent plumpness and percent protein at Staples, MN in 1978.

Treatment Code	Yield Bu/A	Test Wt. #/bu	Plumpness %	Protein %
A	29.6	48.4	70.1	9.7
B	56.7	50.6	71.2	9.9
C	52.5	50.5	69.6	9.9
D	61.6	51.9	79.2	11.2
E	65.2	51.2	71.4	11.2
Signif.	**	NS	**	**
BLSD(.05)	8.2	-	2.1	.9
C.V.	10.8	3.4	2.9	5.6

Table 4. Effect of time of nitrogen application on Manker barley dry matter yield, percent N, and total N removal of forage at soft dough stage at Staples, MN in 1978.

Treatment Code	Yield T/A	N Content %	N Removal #/A
A	1.20	.97	23.2
B	2.72	.92	49.9
C	2.63	1.08	56.8
D	2.77	1.19	66.1
E	2.79	1.12	62.4
Signif.	**	*	**
BLSD(.05)	.28	.16	9.1
C.V.	8.1	9.5	12.1

Table 5. Effect of seeding rate, nitrogen rate and potassium rate on yield, grain protein, test weight and percent plump kernals of Manker barley at Staples, MN, 1979.

Treatment			Yield	Grain Protein	Test Weight	Plump Kernals
Seeding Rate			Bu/A	%	lbs/Bu	%
96 lbs/A			60.6	10.9	48.2	64.8
144 lbs/A			63.6	10.6	47.7	56.8
Significance			NS	NS	NS	**
BLSD(.05)			-	-	-	3.6
N-Rate						
45 lbs/A			56.6	10.1	47.7	60.9
90 lbs/A			67.5	11.5	48.2	60.7
Significance			**	**	NS	NS
BLSD(.05)			4.6	.5	-	-
K_2O Rate						
60 lbs/A			61.2	10.8	47.9	61.2
260 lbs/A			63.0	10.7	47.9	60.4
Significance			NS	NS	-	-
Interaction						
	lbs/A					
Seeding Rate	N	K_2O				
96	45	60	53.2	10.4	48.4	67.2
96	45	260	58.4	10.2	48.0	64.9
96	90	60	62.8	11.7	48.0	62.6
96	90	260	67.8	11.2	48.4	64.3
144	45	60	60.2	9.7	47.6	56.2
144	45	260	54.8	10.0	46.7	55.2
144	90	60	68.6	11.4	47.8	58.7
144	90	260	70.8	11.5	48.6	57.1
Significance			NS	NS	NS	NS
C.V., %			10.0	6.4	2.4	8.0

NITROGEN FERTILIZER DISTRIBUTION BETWEEN CORN PLANTS, SOIL AND AQUIFER UNDER IRRIGATED CONDITION

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

Introduction

In 1978, a field experiment was established at the Staples Irrigation Center as part of a two year study to investigate nutrient movement under a well fertilized, irrigated corn crop. Objectives in this study were to record the distribution of fertilizer nitrogen, the affects of nitrogen fertilizer application timing and to monitor the movement of nitrogen into the aquifer. A report of the first year's work can be found in Soil Series 103.

Procedures

Fertilizer rates in 1978 were 100 lbs/A phosphate, 500 lbs/A potash, and 50 lbs/A sulfur. Three nitrogen treatments were used; a check plot receiving no nitrogen fertilizer, 160 lbs N/A, applied at planting, and 160 lbs N/A applied in four split applications. The split applications were applied as follows; 20 lbs N/A, at planting, 40 lbs N/A on June 27, 60 lbs N/A on July 7 and 40 lbs N/A on July 25. Those plots receiving fertilizer nitrogen contained subplots on which 15-N labeled fertilizer was applied. In addition, each split nitrogen application was individually labeled. All nitrogen treatments were replicated four times. Urea was used as the nitrogen source.

Soil samples were taken to a depth of ten feet before fertilizer application and after crop harvest. Subplots were sampled to eighteen inches in the fall.

Soil solution samplers were installed in each of the twelve plots to monitor nutrient movement in the rooting zone (2.5 ft.) and just below the rooting zone (5 ft.).

Each plot also contained a well so that the aquifer, at a depth of approximately 14 feet, could be sampled. Water samples were taken twice each week throughout the growing season.

Experimental Results

I. Plant Yields and Analysis

Treatments of 0, 160 lb N/A, at planting and 160 lb N/A in split application resulted in grain yields of 44.1 bu/A, 86.4 bu/A, and 123.8 bu/A, and silage yields of 5183 lb/A, 9564 lbs/A and 13,742 lbs/A respectively. This resulted in total nitrogen removal of 38.4, 73.4, and 149.5 lbs N/A for zero, 160 lbs N/A once and 160 lb N/A split applications respectively.

Recovery of fertilizer N in the split application as indicated by 15-N tracing was 55.9% (with 37.4% in the grain, 17.4% in the stover and 1.1% in the cob). The single nitrogen treatment resulted in a total recovery of 17.2%, with 11.6% in the grain, 5.2% in the stover and 0.4% in the cob. Fertilizer N recovery of individual split applications was; 26.4% of the starter application, 57.2% of the second application, 61.8% recovery of the third split, and 60.4% recovery of the final application.

II. Soil Analysis

Soil samples, taken to a depth of ten feet, were analyzed for chloride, nitrate and sulfate. No significant differences were observed between spring and fall samples or between treatments. Samples taken from 15-N subplots showed 32.6% fertilizer nitrogen recovery in the upper 18 inches of soil for split N treatments. The single N application resulted in 25.6% recovery in the upper 18 inches. In both treatments, the majority of the fertilizer N was recovered in the 0-9 inch soil increment.

III. Soil Solution Samples

The highest concentrations of chloride and nitrate in the soil solution samplers occurred in the first week of July at 2.5 feet and one month later at five feet. Nitrate concentrations were considerably higher under the single N application than under the split method of application which, in turn, were slightly higher than the check plots. Analysis of the nitrates during peak concentrations at the 5 ft. depth showed that less than 1% of the nitrate was from fertilizer nitrogen under the split N treatments; 50.9% of the nitrate under the single N application was attributable to fertilizer nitrogen.

Peak concentrations of sulfates did not occur at the 2.5 foot depth until mid-August and did not reach the 5 foot level until early October.

IV. Well Water Analysis

Wells located in each plot were sampled twice each week. Well water samples were analyzed for orthophosphate, nitrate, sulfate and chloride. Orthophosphate remained below detectable levels in all wells throughout the year. Fluctuations in the nitrate and chloride levels could not be correlated with the 1978 fertilizer applications. Sulfate levels remained constant throughout the year as sulfates from the 1978 application did not reach the aquifer.

Summary

In 1978 a yield response to nitrogen fertilization was observed. At crop harvest, 88.7% of the nitrogen applied in split applications could be accounted for in the soil and plant material. In contrast, when a single application at planting was used, only 42.8% of the fertilizer N was recovered. With single N application, higher concentrations of nitrate at a depth of five feet were observed and over 50% of these nitrates were due to fertilizer nitrogen. At the five foot depth, nitrate concentrations beneath the split application plots were only slightly higher than those beneath check plots.

Peak concentrations of chloride and sulfate were also noted in the soil solution samplers, but as with nitrate, these peaks could not be correlated with fluctuations in the aquifer. Soil samples, taken to a depth of ten feet, did not indicate differences between treatments or increases after fertilization.

INFLUENCE OF NITROGEN RATE, FORM AND USE OF EXTEND ON THE YIELDS AND NITROGEN UTILIZATION OF CORN UNDER IRRIGATION - Staples, MN - 1979

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

Nitrogen management on the coarse textured irrigated soils of Minnesota continues to be a concern that corn producers must consider in their management operation. Nitrogen management includes many aspects of nitrogen fertilization, including nitrogen rates, forms, times, methods of applications and in the relatively recent past additives which might be applied with nitrogen fertilizer. One such product, "Extend" (a product of Kalo Laboratory) has been commercially available for the last several years. Primarily recommended by the company for use with 28% nitrogen solutions, "Extend" is promoted as a chemical which would improve the lasting power of the nitrogen fertilizer by possibly encapsulating some of the fertilizer. Trials were established in 1979 to investigate the potential use of Extend in the nitrogen management programs for irrigated corn production.

EXPERIMENTAL PROCEDURES

Twenty treatments were replicated four times and arranged in a randomized complete block design. The treatments were established on a Sverdrup sandy loam at the CMDIR station at Staples, MN. Potassium (225# K_2O/A) and Phosphorus (30# P_2O_5/A) were broadcast and incorporated prior to planting. The treatments included a control, three rates of nitrogen (60, 120, and 180# N/A), three forms of nitrogen (urea, ammonium nitrate, and 28% nitrogen solution) with all combinations applied with or without Extend at its recommended rate of application. All nitrogen applications were made prior to planting. One additional treatment was included as 180# N/A as urea applied in split applications in order to get some idea of nitrogen loss. Extend treatments were applied with the fertilizer either as a mixture with 28% nitrogen solutions, or as coatings onto the dry fertilizer material. Nitrogen treatments were not incorporated.

Corn (Pioneer 3978-85 day R.M.) was hand planted in 30" rows at a population of 28,000 ppa on May 10th. Weed control was accomplished with a combination of chemical (atrazine - 2# ai/A, Lasso 3# ai/A) and conventional (cultivation) methods. Irrigation started on June 14th and was carried through until September 25th with a total of 17.6 inches (13.2 Net) of irrigation water being applied. An additional 15.24 inches of rainfall was obtained during the growing season.

Leaf samples from opposite and below the ear at silking were obtained on August 10, dried and analyzed for Kjeldahl nitrogen. Dry matter production and yields were obtained on October 17th by hand harvesting two rows 20 feet long. Ears were separated from the stalks, field weights of each obtained and subsamples collected for moisture determination and nitrogen analysis for calculation of nitrogen removal. Grain yields were adjusted back to 15.5% moisture.

GENERAL RESULTS

The 1979 growing season was characterized by being relatively wet with below average growing degree days. Fertilizer nitrogen losses due to early spring nitrogen fertilization were excessive in 1979. The magnitude of the nitrogen loss is reflected in Table 1, where the control produced yields of 57 bu/A while 180# N/A produced 64 bu/A and the split applications of 180# N/A produced 118 bu/A. Regardless of the amount of

of nitrogen applied, relatively large quantities of the early spring nitrogen applications were lost prior to plant demand. In the evaluation of any product such as Extend which advertise longer nitrogen availability or reduced nitrogen losses, a situation must be established where nitrogen losses first occur.

In general even when large nitrogen losses occured significant yield responses were obtained up through the highest rate of nitrogen (180# N/A). Ammonium nitrate and 28% nitrogen solutions appeared to be comparable while urea was significantly lower. It may be possible that leaching losses of nitrogen as the soluble urea form may have occured prior to hydrolysis and ammonium formation. Utilization of Extend with the nitrogen fertilizers had no positive influence on yield, and overall actually significantly reduced yields.

Other aspects of nitrogen utilization (Table 2 and 3) tend to reflect the same trends that were established with yield. Increased dry matter production and nitrogen utilization were obtained with increasing nitrogen rates. Urea was inferior to either ammonium nitrate or 28% nitrogen solution under the conditions tested. The use of Extend either had no influence or a significant negative influence on nitrogen utilizations, yield, or other crop growth parameters.

Table 1. Influence of nitrogen rate, nitrogen form and Extend on leaf N content, grain yield, grain N and grain N removal - Staples, MN - 1979.

Treatments			Leaf	Corn Grain		
N Rate	N Form	Extend	N	Yield 15.5%M	N conc.	N removal
#/A		Yes/No	%	bu/A	%	#/A
0	-	-	1.39	56.6	1.07	28.6
60	Urea	No	1.37	50.3	1.07	25.5
60	Urea	Yes	1.41	48.4	1.06	24.2
60	AN	No	1.32	57.2	1.14	30.8
60	AN	Yes	1.19	48.7	1.10	25.3
60	28%	No	1.61	52.7	1.07	26.7
60	28%	Yes	1.39	48.9	1.09	25.1
120	Urea	No	1.29	51.0	1.08	26.2
120	Urea	Yes	1.40	49.3	1.08	25.1
120	AN	No	1.43	57.4	1.14	30.8
120	AN	Yes	1.47	61.1	1.10	31.9
120	28%	No	1.53	60.7	1.18	33.9
120	28%	Yes	1.44	54.5	1.10	28.3
180	Urea	No	1.44	54.6	1.08	28.0
180	Urea	Yes	1.39	50.3	1.13	26.9
180	AN	No	1.78	70.0	1.18	39.2
180	AN	Yes	1.68	65.6	1.07	33.3
180	28%	No	1.66	71.0	1.11	37.4
180	28%	Yes	1.64	69.3	1.14	37.7
180(split)	Urea	No	2.94	118.5	1.30	73.2
Significance			**	**	**	**
BLSD(.05)			0.17	8.9	0.09	6.3

Factorial arrangement (Excludes control and split N application)

N Rate - #/A				
60	1.38	51.1	1.09	26.3
120	1.43	55.6	1.11	29.4
180	1.60	63.5	1.12	33.7
Significance	**	**	*	**
BLSD(.05)	0.07	3.4	0.03	2.0
N Form				
Urea	1.38	50.6	1.08	26.0
Ammonium Nitrate	1.48	60.0	1.12	31.9
28% N Soln.	1.55	59.5	1.12	31.5
Significance	**	**	*	**
BLSD(.05)	0.07	3.4	0.03	2.0
Extend				
Without	1.49	58.3	1.12	30.9
With	1.45	55.1	1.10	28.6
Significance	NS	*	+	*
BLSD(.05)		3.1	0.02	1.8

Table 2. Influence of nitrogen rate, nitrogen form and Extend on corn forage production and dry matter content.

Treatment			Corn Forage Production				
			Dry Matter Production			Dry Matter at Harvest	
N Rate	N Form	Extend	Stover	Grain	Total	Stover	Grain
#/A		Yes/No	T/A			%	
0	-	-	1.29	1.34	2.63	43.0	56.2
60	Urea	No	1.28	1.19	2.47	43.4	56.8
60	Urea	Yes	1.23	1.14	2.38	44.3	57.2
60	AN	No	1.31	1.35	2.66	45.2	57.9
60	AN	Yes	1.34	1.15	2.49	45.5	58.3
60	28%	No	1.36	1.25	2.61	42.4	57.7
60	28%	Yes	1.20	1.16	2.35	41.5	56.8
120	Urea	No	1.28	1.21	2.48	41.4	57.0
120	Urea	Yes	1.24	1.16	2.40	40.0	55.6
120	AN	No	1.37	1.36	2.73	41.5	58.6
120	AN	Yes	1.47	1.44	2.92	42.2	59.4
120	28%	No	1.51	1.44	2.95	37.2	58.7
120	28%	Yes	1.49	1.29	2.78	39.0	57.9
180	Urea	No	1.32	1.29	2.61	41.8	57.9
180	Urea	Yes	1.27	1.19	2.46	40.1	57.6
180	AN	No	1.66	1.66	3.31	40.6	60.6
180	AN	Yes	1.61	1.55	3.16	35.8	60.3
180	28%	No	1.88	1.68	3.56	41.5	59.4
180	28%	Yes	1.72	1.64	3.36	42.0	60.1
180(split)	Urea	No	2.23	2.80	5.04	39.4	56.0
Significance			**	**	**	*	**
BLSD(.05)			0.28	0.21	0.41	5.8	3.0
Factorial Arrangement (Excludes control and split N application)							
N Rate #/A							
60			1.29	1.21	2.49	43.7	57.5
120			1.39	1.32	2.71	40.2	57.9
180			1.58	1.50	3.08	40.3	59.3
Significance			**	**	**	**	**
BLSD(.05)			.09	.08	0.14	1.7	0.9
N Form							
Urea			1.27	1.20	2.47	41.8	57.0
Ammonium Nitrate			1.46	1.42	2.88	41.8	59.2
28% N Soln.			1.53	1.41	2.93	40.6	58.4
Significance			**	**	**	NS	**
BLSD(.05)			.09	0.28	0.14	-	0.9
Extend							
Without			1.44	1.38	2.82	41.7	58.3
With			1.40	1.30	2.70	41.1	58.1
Significance			NS	*	+	NS	NS
BLSD(.05)			-	0.07	0.11	-	-

Table 3. Influence of nitrogen rate, nitrogen form, and Extend, on the nitrogen content of and nitrogen removal by corn forage.

Treatments			Corn Forage				
			N Content		N Removal		
N Rate	N Form	Extend	Stover	Grain	Stover	Grain	Total
#/A		Yes/No	--------%---------		----------#/A----------		
0	-	-	0.44	1.07	11.0	28.6	39.6
60	Urea	No	0.50	1.07	12.9	25.5	38.4
60	Urea	Yes	0.50	1.06	12.4	24.2	36.5
60	AN	No	0.42	1.14	10.9	30.8	41.6
60	AN	Yes	0.42	1.10	11.3	25.3	36.6
60	28%	No	0.44	1.07	12.1	26.7	38.9
60	28%	Yes	0.38	1.09	9.1	25.1	34.2
120	Urea	No	0.48	1.08	12.3	26.2	38.5
120	Urea	Yes	0.44	1.08	10.6	25.1	35.8
120	AN	No	0.38	1.14	10.4	30.8	41.3
120	AN	Yes	0.40	1.10	11.6	31.9	43.6
120	28%	No	0.56	1.18	16.6	33.9	50.5
120	28%	Yes	0.40	1.10	11.9	28.3	40.2
180	Urea	No	0.44	1.08	11.6	28.0	39.6
180	Urea	Yes	0.52	1.13	13.3	26.9	40.2
180	AN	No	0.42	1.18	14.1	39.2	53.3
180	AN	Yes	0.52	1.07	16.3	33.3	49.6
180	28%	No	0.39	1.11	14.6	37.4	52.0
180	28%	Yes	0.44	1.14	15.1	37.7	52.7
180(split)	Urea	No	0.91	1.30	41.3	73.2	114.5
Significance			**	**	**	**	**
BLSD(.05)			0.10	0.09	4.8	6.3	9.6
Factorial Arrangement (Excludes control and split N application)							
N Rate #/A							
60			0.44	1.09	11.4	26.3	37.7
120			0.44	1.11	12.3	29.4	41.6
180			0.46	1.12	14.2	33.7	47.9
Significance			NS	*	**	**	**
BLSD(.05)			-	0.03	1.2	2.0	2.6
N Form							
Urea			0.48	1.08	12.2	26.0	38.2
Ammonium nitrate			0.43	1.12	12.4	31.9	44.3
28% N Soln.			0.43	1.12	13.2	31.5	44.7
Significance			*	*	NS	**	**
BLSD(.05)			0.04	0.03	-	2.0	2.7
Extend							
Without			.45	1.12	12.8	30.9	43.8
With			.45	1.10	12.4	28.6	41.0
Significance			NS	+	NS	*	*
BLSD(.05)			-	0.02	-	1.8	2.4

INFLUENCE OF NITROGEN RATE, TIMING OF APPLICATION AND USE OF NITRIFICATION INHIBITORS ON IRRIGATED CORN - Staples - 1979

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

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

EXPERIMENTAL PROCEDURES

Nine treatments were replicated four times and arranged in a randomized complete block design. The treatments were established on a Sverdrup sandy loam at the CMDIR station at Staples, MN. Potassium (225 # K_2O/A) and Phosphorus (30 # P_2O_5/A) were broadcast and incorporated prior to planting. The treatments included a check, two nitrogen rates, (80 and 160 # N/A as urea), to methods of application (single vs. split) and two nitrification inhibitors (N-Serve-Dow Chemical Co. and Dwell (Terrazole -Olin Corporation). Nitrogen treatments were applied in either one single preplant application or in multiple applications during the growing season. Split applications of nitrogen were applied on May 3 (preplant), July 3 (8 leaf stage), July 16 (12 leaf stage) and on July 26 (tasseling) in a ratio of 1/6, 1/6, 3/6, and 1/6 respectively.

Nitrification inhibitor treatments were applied with the single nitrogen application treatments as coatings onto urea (0.5 # ai/A) for both N-Serve and Dwell. The preplant nitrogen applications were broadcast over the plot area and immediately incorporated by discing. Corn(Pioneer 3978) was hand planted on May 9 in 30 inch rows at a population of 28,000 seeds/A. Weed control was obtained using a combination of chemical (Atrazine-2#ai/A and Lasso 3#ai/A) and conventional (cultivation) management. Irrigation of the plot area was started on June 14 and concluded on October 1 with a total of 17.2 inches of water being applied through irrigation. An additional 15.24 inches were obtained through precipitation during the growing season.

Leaf samples from opposite and below the ear at silking were collected on August 10, dried and analyzed for Kjeldahl nitrogen. Dry matter production and grain yields were obtained on October 17 by hand harvesting two rows 20 ft. long. Ears were separated from the stalks, field weights obtained, and samples removed for moisture determination and nitrogen analysis. Corn grain yields were adjusted to 15.5% moisture.

GENERAL RESULTS

The 1979 growing season was characterized by being unusually cold and wet. Nitrogen losses due to early spring applications on these coarse textured soils were very severe. Overall yields ranged from 74 to 129 bu/A with nitrogen management being critical, (Table 1). Control areas receiving

no nitrogen produced 74 bu/A while areas receiving 160 #N/A in a single preplant application yielded only 77 bu/A. This would suggest that nearly all of the fertilizer nitrogen was lost from the soil system prior to plant demand. Management of nitrogen fertilization by splitting the applications resulted in appreciable yield increases. Use of nitrification inhibitors with the single nitrogen application treatments appeared to slow nitrogen losses and gave some yield increases, but these were only evident at the higher rate of nitrogen application. The use of nitrification hinhibitors did not stop nitrogen losses and should not be considered as techniques to substitute for good nitrogen management practices. The other parameters measured tend to support the yield results and reflect the differences in nitrogen utilization and nitrogen losses that were encountered with the various management treatments.

Table 1. Influence of nitrogen rate, timing of nitrogen application, and nitrification inhibitors on leaf nitrogen concentration, grain yield and dry matter production of corn under irrigation.

Treatments			Leaf	Grain	Dry Matter Production		
N Rate	No. of Appl.	Inhibitor	N	Yield	Grain	Stover	Total
#/A			%	bu/A		T/A	
0	-	0	1.64	74.2	1.76	1.19	2.95
80	1	0	1.64	82.4	1.95	1.40	3.35
80	1	N-S	1.66	90.3	2.14	1.42	3.56
80	1	Dwell	1.64	85.5	2.02	1.52	3.54
80	4	0	2.80	124.2	2.94	2.22	5.16
160	1	0	1.55	76.8	1.82	1.49	3.31
160	1	N-S	1.73	93.1	2.20	1.84	4.04
160	1	Dwell	1.82	102.7	2.43	1.88	4.31
160	4	0	2.76	129.4	3.061	2.34	5.40
Significance			**	**	**	**	**
BLSD(.05)			.22	15.3	0.36	0.31	0.56

Table 2. Influence of nitrogen rate, timing of nitrogen application and nitrification inhibitors on nitrogen content and total nitrogen uptake of corn at physiological maturity.

Treatments			Leaf	Grain	Dry Matter Production		
N Rate	No. of Appl.	Inhibitor	N	Yield	Grain	Stover	Total
#/A			%	bu/A		T/A	
0	-	0	1.08	.44	38.2	10.5	48.7
80	1	0	1.12	.37	43.5	10.3	53.8
80	1	N-S	1.14	.43	48.7	12.2	60.9
80	1	Dwell	1.12	.38	45.4	11.3	56.7
80	4	0	1.27	.51	74.7	22.8	97.6
160	1	0	1.09	.38	39.6	11.3	50.9
160	1	N-S	1.13	.40	49.6	14.8	64.5
160	1	Dwell	1.18	.38	57.4	14.3	71.7
160	4	0	1.36	.61	83.2	28.5	111.6
Significance			**	**	**	**	**
BLSD(.05)			0.05	0.10	9.0	4.3	10.6

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

H. Meredith, M. Wiens, and J. Lensing

1979 was the fifth crop year involving studies of N rates on oats and wheat under intensive irrigation. A dryland study evaluating N rates initiated in 1977 was continued.

Era wheat and Noble oats were used as the test varieties. Nitrogen was applied to wheat at the rate of 0, 60, 120, and 180 pounds per acre, and to the oats at rates of 0, 40, 80, and 120 pounds per acre.

Plots were moldboard plowed on April 24 and seeded on April 25. Oats harvest was completed August 2 and the wheat was harvested on August 12.

One-third of the N was applied to the wheat at planting, one-third at stooling and one-third just prior to heading.

N was applied to the oat plots in two applications. One-half of the desired N was applied prior to seeding and one-half applied just prior to boot formation.

Table 1. Wheat Grain Yield as Influenced by N Fertilization - 1979. (Chemical weed control and intensive irrigation)

Lbs N/A	Bu/A	Test wt Lbs/Bu	% N in Grain	Lbs N Removed in Grain
0	10.9	52.5	2.55	16.7
60	27.5	55.0	2.56	42.1
120	32.6	53.5	2.90	56.5
180	34.6	53.2	2.86	59.2
Signif	**	N.S.	*	**
BLSD (.05)	5.4	--	.24	9.0
C.V.	13.6	2.8	5.3	11.2

Table 2. Wheat Grain Yield as Influenced by N Fertilization - 1979. (Chemical Weed Control - Dryland

Lbs N/A	Bu/A	Test wt Lbs/Bu	% N in Grain	Lbs N Removed in Grain
0	6.2	52.6	2.44	9.0
60	20.6	54.2	2.70	33.1
120	16.2	52.2	2.96	28.7
180	16.0	52.4	3.02	28.8
Signif	**	N.S.	**	**
BLSD (.05)	4.0		.25	4.6
C.V.	18.8	2.3	5.8	12.3

Table 3. Oat Grain Yield as Influenced by N Fertilization - 1979. (Chemical Weed Control - Intensive Irrigation)

Lbs N/A	Bu/A	Test wt Lbs/Bu	% N in Grain	Lbs N Removed in Grain
0	38.7	36.6	1.81	22.5
40	56.2	36.1	1.74	31.3
80	68.9	34.1	1.77	39.1
120	75.9	33.2	1.93	47.0
Signif	**	*	*	**
BLSD (.05)	16.8	2.6	.15	11.4
C.V.	17.6	6.8	4.4	20.3

Table 4. Oat Grain Yield as Influenced by N Fertilization - 1979. (Chemical Weed Control - Dryland)

Lbs N/A	Bu/A	Test wt Lbs/Bu	% N in Grain	Lbs N Removed in Grain
0	25.9	35.8	1.84	15.0
40	38.4	32.6	1.88	23.2
80	57.0	31.3	2.04	37.3
120	56.7	32.0	2.12	38.1
Signif	**	*	*	**
BLSD (.05)	8.1	3.1	.18	3.4
C.V.	12.1	5.6	5.6	8.1

Table 5. Wheat Grain Yields, Bu/A, Staples Station, 1975-1979.

	Irrigated												Dryland			
	Chemical Weed Control				Red Clover Underseeding				Plow Down of Red Clover							
N, Lbs/A	0	60	120	180	0	60	120	180	0	60	120	180	0	60	120	180
1975 1/	7	18	21	24	5	13	16	17								
1976	24	53	66	68	53	58	55	57	59	70	69	67				
1977	27	47	65	69	51	50	52	41	53	58	58	59	9	17	22	20
1978	14	35	38	36	26	24	24	22	31	34	35	37	12	24	24	21
1979	11	28	33	35	Discontinued after 1978 Harvest Year								6	21	16	16
Ave.	19	41	50	52	32	33	33	30	48	54	54	54	9	21	21	19

1/ N rates 0, 40, 80, and 120 Lbs/A in 1975 only.
Late spring, excessively high temperatures May and June

Table 6. Oat Grain Yields, Bu/A, Staples Station, 1975-1979.

	Irrigated								Dryland			
	Chemical Weed Control				Red Clover Underseeding							
N, Lbs/A	0	40	80	120	0	40	80	120	0	40	80	120
1975	24	36	41	35	24	45	52	41				
1976	54	84	101	111	86	88	90	93				
1977	45	90	106	114	84	101	110	101	32	63	60	62
1978	38	77	100	102	84	88	86	80	32	54	50	61
1979	39	56	69	76	Discontinued after 1978 Harvest Year				26	38	57	57
Ave. (Excludes 1975)	44	77	94	101	85	92	95	91	30	52	56	60

Potassium Soil Tests

The potassium values were deemed too low to achieve optimum yields under intensified management. Relatively high rates of potassium were added over a three year period, Table 7. Since potassium was not a separate study, a uniform application was broadcast over the entire area.

Table 7. Broadcast Potash Annually 1975-1977, Pounds Per Acre.

Year	K_2O Lbs/A
1975	500
1976	600
1977	510
Total	1610

All plots were individually sampled in Block 1 & 1A for four years. Soils were sampled following harvest of grain and removal of the forage. A total of 1610 pounds of K_2O were added which increased the K test to over 400. However after cropping for two years, the K test dropped to under 200. It has long been observed that maintenance of high K values on coarse textured soils on these soils is a difficult task.

Table 8. Potassium Soil Tests from Small Grain Plots.

	Soil K Tests Block 1 & 1A (Chemical Weed Control)				
*N/A	1975 1/	1976	1977	1978	1979
0	250	242	478	277	225
50		188	452	274	190
100		188	436	310	171
150		183	401	248	175
Average		200	442	278	190

Soil K Tests - Block 2 & 2A
(Red Clover Underseeding)

#N/A	1975	1976	1977	1978	1979
0	170	None	451	209	167
50		"	409	215	167
100		"	436	189	149
150		"	373	195	153
Average			417	202	159

Soil K Tests - Block 3 & 3A
(Red Clover Plowed Down)

0	120	202	342	165	None
50		210	324	159	"
100		180	334	171	"
150		168	312	162	"
Average		190	328	164	

Soil K Tests - 4 & 4A (Dryland - No K added)

#N/A	1978	1979
0	137	137
50	135	106
100	114	125
150	127	119
Average	128	122

1/ Sampled April, all other samplings in late August.

Table 9. Soil pH Tests Reflecting Changes Due to Alkalinity in Irrigation Water.

Soil pH Tests - Blocks 1 & 1A

#N/A	1975 1/	1976	1977	1978	1979
0	5.9	6.3	6.7	6.7	7.0
50	5.9	6.2	6.5	6.5	6.8
100	5.9	6.1	6.4	6.3	6.6
150	5.8	6.0	6.3	6.2	6.5

Soil pH Tests - Blocks 2 & 2A

#N/A	1975 1/	1976	1977	1978	1979
0			6.4	6.4	6.4
50			6.4	6.5	6.4
100			6.3	6.2	6.2
150			6.2	6.1	6.2
			Blocks 3 & 3A		
0		6.3	6.8	6.7	
50		6.4	6.8	6.7	
100		6.2	6.8	6.6	
150		6.2	6.8	6.5	
			Blocks 4 & 4A		
0				5.7	5.8
50				5.7	5.8
100				5.5	5.6
150				5.2	5.4

1/ Sampled in April, all other sampling late August

Table 10. Acre Inches Water Applied to Small Grain Plots and Approximate Calcium Carbonate Equivalent Added in Irrigation Water 1975-1979.

Year	Acre Inches Water Applied	Lbs $CaCO_3$ Equivalent Per Acre Per Year
1975	13.5	470
1976	24.1	796
1977	15.8	706
1978	13.3	617
1979	10.0	550
Total		3139

Table 11. Nitrogen Content in Wheat and Oats Grain as Influenced by Nitrogen Rates, Staples Station, 1979.

Lbs N/A	N - Percent Wheat-Dryland	Wheat-Irrigated
0	2.44	2.55
60	2.70	2.56
120	2.96	2.90
180	3.02	2.86
Signif.	**	*
BLSD (.05)	.25	.24
C.V.	5.8	5.3

	Oats-Dryland	Oats-Irrigated
0	1.84	1.81
40	1.98	1.74
80	2.04	1.77
120	2.12	1.93
Signif.	*	*
BLSD (.05)	.18	.15
C.V.	5.6	4.4

PHOSPHATE RATE STUDIES OF IRRIGATED AND DRYLAND WHEAT AND OATS, STAPLES, 1979

H. Meredith, M. Wiens, and J. Lensing

This study was initiated in 1979 to determine the effect of broadcast phosphorus on small grain yields.

Era Wheat and Noble oats were used as the test varieties. Phosphate (0-44-0) was broadcast and incorporated at rates of 0, 30, 60 and 90 pounds of P_2O_5 per acre.

There was no significant difference in yield from wheat or oats as a result of the phosphorus addition.

Table 1. Wheat and Oat Grain Yields as influenced by Broadcasts P_2O_5 treatments, Staples Station, 1979.

Lbs P_2O_5/A	Yield-bu/A Wheat	Test wt Lbs/bu
0	21.9	49.4
30	21.4	47.4
60	24.6	51.3
90	27.8	48.3
Signif	NS	NS
C.V.	17.6	6.8
	Oats	
0	85.2	36.6
30	72.5	36.9
60	84.1	36.4
90	70.6	36.8
Signif	NS	NS
C.V.	15.3	3.4

Table 2. Content of Selected Elements in Grain of Wheat as Influenced by Phosphate treatments, Staples Station, 1979.

Lbs P_2O_5/A	PPM (Wheat)							
	P	K	Ca	Mg	MN	Zn	Cu	B
0	.43	.48	.12	.16	45	41	2.8	2.3
30	.42	.44	.13	.16	47	39	1.8	1.2
60	.43	.48	.12	.16	45	38	1.8	1.4
90	.43	.44	.13	.16	48	39	1.8	1.2
Signif	NS	NS	NS	NS	NS	NS	NS	NS
C.V.	4.0	9.0	7.1	2.1	7.4	6.2	29.3	34.6

Water Quality Studies

H. Meredith, M. Wiens & R. Munter

Water samples from farmers' irrigation wells were analyzed in 1979. Analyses were limited to conductivity, sulfur and calcium carbonate equivalent, Table 1.

Only two samples were taken from pits. Both samples had low calcium carbonate equivalents and both had low conductivity measurements.

Excluding the two pit samples, the average calcium carbonate equivalent was 45 pounds per acre inch of water. If ten acre inches of irrigation water were applied in 1979, the average value would be the equivalent of 450 pounds of finely ground 100 percent calcium carbonate per acre.

Frequently questions arise as to the plant nutrients contained in irrigation water. Table 2 is a partial summary of the major elements contained in irrigation water from the Staples, Minnesota area.

Table 2. Analyses of Water Samples, Staples, Minnesota.

	PPM						
Farmer	P	K	Ca	Mg	Na	Zn	B
McAdams	.36	3.1	53	19	2.5	.009	.06
Cypher	.31	7.4	81	26	5.6	.006	.05
Werk	<.25	3.3	66	20	3.7	.006	.02
Lorin	<.25	3.9	73	22	2.6	.031	.03
Gack	<.25	2.9	56	15	3.4	.006	.03
Schrader	.34	3.6	56	18	10	.006	.02
Rack	<.25	4.3	66	17	2.5	.007	.04
Butler	<.25	8.5	116	31	7.6	.203	.04
Hanson	<.25	3.1	37	10	5.8	.006	.06
Nielson	<.25	2.1	40	7.0	4.5	.030	.03
Heiniche	.30	2.9	53	18	18	.008	.08
Winger	<.25	5.1	97	37	10	.006	.08
*Mursu	<.25	1.1	.28	.11	201	.017	.03

*Sample from kitchen after passing water softener.

Table 5. Irrigation Water Samples, Various, 1978. (Data Expressed in PPM).

	Name	Date Sampled	County	Township	Section	S	Total Alkalinity	P	K	Ca	Mg	Na	Mn	Zn	Cu	B
1.	Staples[1/]	5/15	Wadena	Thomastown	26	3.2	223	<.25	1.3	66	23	1.7	.12	.16	.01	.07
2.	Staples[2/]	5/2	"	"	"	<1	216	"	1.3	72	19	1.7	.30	.04	.12	.05
3.	Staples[3/]	6/14	"	"	"	2.6	259	"	1.6	98	27	2.7	.45	.02	T	.03
4.	Staples[4/]	6/14	"	"	"	9.3	226	"	3.7	80	21	2.6	.54	.04	"	.02
5.	Staples[2/]	5/24	"	"	"	2.1	226	"	1.6	72	19	1.6	.28	.73	"	.03
6.	Staples[3/]	5/24	"	"	"	2.2	285	"	1.7	95	26	2.9	.48	.05	"	.04
7.	Staples[5/]	6/14	"	"	"	5.8	232	"	.8	87	21	2.4	.32	.22	"	.04
8.	L.Grove	5/11	"	"	"	3.2	238	"	2.9	74	17	4.6	T	.08	"	.05
9.	B.Winger	6/6	Ottertail	Aurdal	33,SE¼	17.8	334	"	4.2	98	34	7.6	.28	.04	"	.09
10.	Staples[1/]	5/24	Wadena	Thomastown	26	2.3	270	"	.99	81	23	2.0	.34	.05	"	.04
11.	Staples[2/]	5/2	"	"	"	1.0	224	"	1.6	65	17	1.9	.56	.41	.06	.04
12.	Staples[3/]	5/2	"	"	"	1.8	264	"	1.2	93	25	2.5	.59	.07	T	.04
13.	Malzer	6/14				1.8	246	"	1.5	98	27	2.8	.43	.02	"	.04
14.	"A"	8/1	Stearns	Paynesville	17	-	225	"	2.8	32	40	2.7	T	.02	"	.14
15.	"B"	7/31	"	Crow R.	9	13.0	202	"	<.25	86	34	7.3	T	.78	"	.03

1/ Staples Station, Center Plot Well
2/ " " South " "
3/ Staples Station, North Plot Well
4/ Staples Farm #4 Well
5/ Staples Farm, two-tower well

Table 1. Farmer Irrigation Water Samples by Location, 1979.

Name	County	Township	Section	Description	Depth of Well Feet	1st Yr Pumped	Gal/Min	Prin Crop	S Lbs/A Inch	$CaCO_3$ (Lime) Lbs/A In	*Conduct. µmhos @25° C
J. James	Hubbard	Nevis	28	W½ of SW¼	50	1971	800	Truck	1.1	50	448
R. Waddell	Morrison	Bellevue	26	--	140	1977	1125	Corn	1.8	44	390
G. Klein	Ottertail	Parker Prairie	28	--	52	1977	550	Alf Soy-beans	.6	58	686
L. Hackler	Wadena	Wadena	13	W½ of W½	15	1978	600	Corn	.4	17	173
B. Winger	Ottertail	Aurdal	32	SE¼	52	1975	300	Hay Garden	9.0	65	729
W. Gabling	Benton	Langola	2	NW¼	160	1978	1000	Corn	.7	35	312
W. Gabling	Benton	Langola	2	SE¼	153	1978	1300	Corn	.9	25	252
R. Meyers	Wadena	Bullard	1		Pit			Cucs	.7	6	72
D. Hemenway	Hubbard	Hubbard	32	E½	150	1977	750	Corn	.9	42	364
S. Collins	Cass	Becker	14	SW½	Pit	1979			.8	4	120
L. Weyer	Wadena	Thomastown	10		37		720	Corn	1.4	45	442
L. Weyer	Wadena	Bullard	34		Leaf River		500	Corn	1.2	52	452
G. Gablenz	Benton	Langola	2	NE¼	209	1978	2000	Corn	.9	65	561

*Conductivity

Indicates amount of soluble salts in solution
Generally, below 1000 - no problems

Table 3. Farmer Irrigation Water Samples by Location, 1978. (See also Table 1.)

Name	County	Township	Section	Depth of Well	1st yr. Pumped	Gal./Min.	Prin. Crop	S Lbs/A	$CaCO_3$ eq. Inch Water
F. McAdams	Hubbard	Todd	8	165	1977	900	Corn Alf.	.3	42
H. Cypher	Wadena	Aldridge	33	Pit	1977	550	"	5.1	45
A. Werk	Wadena	Aldridge	12	Pit	--	--	"	2.3	45
W. Torin	Ottertail	Compton	20	Pit	1977	550	"	1.8	51
M. Gack	Hubbard	W. Oak	29	117	1977	600	"	.7	41
D. Schrader	Wadena	Wing R.	6	Pond	--	--	--	2.2	40
L. Rach	Wadena	Aldrich	27	14	1977	500	"	1.1	47
C. Butler	Wadena	Wadena	36	20	--	--	--	1.5	66
D. Hanson	Cass	Pooler	--	Pit	1977	450	"	1.3	25
P. Nielson	Wadena	N. Germany	13	20	1976	40	"	.6	17
D. Heinecke	Cass	May	7	117	--	--	--	.3	54
B. Winger	Ottertail	Ayrdal	33	52	1975	300	Veg	2.8	85
G. Bursu	Ottertail	Otto	36	138	--	--	--	.4	.06

Table 4. Farmer Irrigation Water Samples by Location, 1978.

	Name	Date Sampled	County	Township	Section	S	Total** Alkalinity	B	Ca	Mg	Na	P	K
		Data Expressed in Pounds Per Acre Inch of Irrigation Water											
1.	L. Hanson	Detroit Lakes				.5	53	T	14.5	4.7	.6	.05*	.6
2.	C. Butler	7/7/78	Wadena	Wadena	36-NW¼	1.4	50	T	16.9	5.7	1.2	.05*	1.4
3.	G. Mursa	6/24/78	Ottertail	Otto	36-	.7	90	T	.0	.0	43.4	.05*	.1
4.	H. Cypher	6/22/78	Wadena	Aldrich	33	3.7	52***		17.6	4.5	1.2	.10	2.5
5.	P. Nielson	6/22/78	Wadena	N.Germany	13	.9	13***		4.5	.8	.8	.11	.4
6.	L. Rach	6/22/78	Wadena	Aldrich	23	1.0	40		12.9	2.9	.8	.07	1.1
7.	M. Gack	6/22/78	Hubbard	W. Oak	29-NW¼	.7	39***		13.5	3.3	.9	.07	.6
8.	D. Karwatz	6/22/78	Wadena	Wadena	17 SWSE	.7	60		13.8	3.8	.7	.06	.7
9.	A. Werk	6/22/78	Wadena	Aldrich	12	2.1	35***		11.3	3.2	.8	.08	.9
10.	C. Mackay	6/22/78	Wadena	N. Germany	14-S½NE¼	.8	8		5.2	1.6	4.6	.06	1.1
11.	G. Lottman	6/22/78	Wadena	Shell River	4-NE¼	.2	44		1.6	.5	1.1	.05*	.7
12.	D. Schrader	6/22/78	Wadena	Wing River	6	1.2	40***		12.0	2.6	.7	.06	.5
13.	F. McAdams	6/22/78	Hubbard	Todd	8 E½	.7	45		10.6	3.5	2.3	.20	6.8
14.	D. Hanson	6/22/78	Cass	Popbre (?)	6	1.9	16***	T	11.8	4.0	.7	.08	.6
15.	Modland	6/22/78	Ottertail	Compton	22	2.2	54***	.006	5.6	1.7	2.0	.26	1.2

*** Pit
** Expressed as $CaCO_3$ equivalent
* Less than .05

Table 6. Irrigation Water Samples, Various, 1978. (Data Expressed in PPM).

Name	Date Sampled	County	Township	Section	S	Total Alkalinity	P	K	Ca	Mg	Na	Mn	Zn	Cu	B
1. H. Tawn[1/]	8/31	Todd	Morgan	3	2.1	305	<.25	.55	96	26	3.6	.18	.02	T	.02
2. D. Nielson[2/]	8/7	Wadena	Thomastown	22	3.8	190	"	1.4	54	18	1.8	.10	.03	T	.01
3. "	"	"	"	25	3.1	190	"	T	78	22	2.0	.18	.02	T	.01
4. Staples[2/]	8/29	"	"	26	7.2	130	"	.78	68	18	1.6	.2	.02	T	T
5. Staples[3/]	7/7	"	"	"	2.6	270	"	2.0	80	21	5.2	T	.01	T	T
6. Staples[4/]	8/7	"	"	"	1.2	220	"	1.8	64	18	4.4	T	.01	T	.01
7. Staples[5/]	7/7	"	"	"	2.7	250	"	.47	64	19	2.4	T	.08	T	.01
8. Staples[4/]	7/10	"	"	"	1.6	230	"	.50	27	17	1.7	T	.03	T	T
9. -	-	Meeker	-	-			T	1.8	76	21	1.9	.29	.28	T	.05
10.		"	-	-			T	2.4	75	21	2.5	.28	.25	.02	.05

[1/] Creek

[2/] Pit

[3/] N. Plot Well

[4/] S. Plot Well

[5/] Center Plot Well

SOUTHERN EXPERIMENT STATION - WASECA
WEATHER DATA - 1979

Month	Period	Precipitation 1979	Precipitation Normal	Avg. Air Temp. 1979	Avg. Air Temp. Normal	Growing Degree Days 1979	Growing Degree Days Normal
		inches		°F			
January	1-31	1.76	.73	-2.4	12.9		
February	1-28	1.10	.96	4.7	17.5		
March	1-31	4.93	1.94	24.4	28.5		
April	1-30	2.66	2.48	40.2	45.6		
May	1-10	1.43		48.0		40.0	
	11-20	0.36		53.6		88.5	
	21-31	0.93		59.3		133.0	
	Total	2.72	3.86	53.8	57.7	261.5	323
June	1-10	0.52		64.4		148.5	
	11-20	2.26		67.2		169.0	
	21-30	2.50		66.2		162.5	
	Total	5.28	4.75	66.0	67.1	480.0	521
July	1-10	-0-		70.2		200.0	
	11-20	1.00		69.6		195.5	
	21-31	8.64		70.5		226.0	
	Total	9.64	4.02	70.2	71.4	621.5	637
August	1-10	2.93		71.2		210.0	
	11-20	0.87		62.8		136.0	
	21-31	3.89		66.4		181.5	
	Total	7.69	3.60	66.8	69.7	527.5	583
September	1-30	0.90	3.45	61.0	60.3	392.5	310
October	1-31	3.11	1.89	47.1	50.3	41.5	44
November	1-30	2.43	1.25	31.6	32.9		
December	1-31	0.69	1.02	23.9	19.0		
Year	Jan-Dec	42.91	29.95	40.6	44.4	2324.5	2418
Growing Season	May-Sept	26.23	19.68	63.6	65.3	2283.0	2374

Notes:

1) Highest temp. on June 7 -- 95°

2) Highest 24-hour precipitation on July 23 -- 4.55"

3) Third highest growing season rainfall on record

4) Frost on October 7

CONTINUOUS CORN TILLAGE STUDY

Waseca, 1979

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

A field experiment was initiated in 1969 to evaluate tillage systems for continuous corn production in south central Minnesota. Eleven tillage treatments were established in a randomized complete-block design with four replications. Each treatment has been superimposed on the same plot since establishment. The experiment is located on a Nicollet clay loam soil with a 2-5% south-facing slope. Tile lines spaced 75' apart lie perpendicular to the rows within all plots.

Beginning in 1975, 7 of the 11 original tillage treatments were dropped. The four that were continued from 1975 are: (1) fall plow-field cultivate, (2) fall chisel-field cultivate, (3) disk only (spring secondary treatment) and (4) continuous no tillage (Table 1).

Fall primary tillage operations were conducted on October 25. All plots were stalk chopped before tillage. Broadcast P and K (0+50+180 lb $N+P_2O_5+K_2O$/A) were applied in the fall of 1978. Nitrogen (175 lb N/A as ammonium nitrate) was broadcast on the surface on May 15. The spring secondary tillage treatments were performed on May 17.

Corn (Pioneer 3732) was planted at a rate of 26,100 ppA on May 18. A John Deere plateless planter with fluted coulters was used to plant all plots. Starter fertilizer was not applied. An insecticide (1 lb active Counter/A) was applied at planting time. Chemical weed control consisted of 3 qt Lasso/A (A.I.) and 2½ lb atrazine/A (A.I.) applied preemergence. None of the plots were cultivated. Yields were taken by hand harvesting 2-25' rows from each plot on October 8.

RESULTS

Grain yield, grain moisture and final population were affected significantly in this tenth year of continuous tillage (Table 1). Yield differences among the moldboard plow, chisel plow and spring disk tillage treatments were not significant, although the yields with the moldboard tillage were approximately 8 bu/A higher. Continuous no tillage resulted in about a 40 bu/A yield loss and in significantly higher grain moisture than the other treatments. Even with the use of fluted coulters final plant population was significantly lower with no tillage. This along with somewhat poorer weed control may have been part of the reason for the reduced yields with continuous no tillage. Grain N was not influenced by the primary tillage treatments.

Table 1. Influence of tillage treatments on continuous corn production at Waseca in 1979.

Tillage Treatments		Final	Grain		
Primary	Secondary	popl'n	Moisture	Yield	N
		x 10^{-3}	%	bu/A	%
Fall plow	Field cult.	24.0	37.2	176.8	1.33
Fall chisel	Field cult.	24.1	38.0	168.7	1.29
None	None	20.3	40.2	131.8	1.26
None	Disk	24.5	37.6	169.1	1.32
	Significance:[1/]	*	**	**	NS
	BLSD(.05) :	2.6	.7	12.8	
	CV(%) :	6.7	1.3	5.2	3.3

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

Marked differences in surface residue accumulation (mulch from the preceding corn crops) and early plant growth were found among the treatments (Table 2). Residue amounts of about 2 T/A with the chisel and spring disk treatments apparently reduced soil temperatures slightly resulting in somewhat slower early plant growth. With continuous no tillage, over 5 tons/A of residue covered the soil surface. Subsequently, early plant growth was reduced by 70%; probably a direct result of cooler soil temperatures. The correlation between grain yield and early plant growth was highly significant (r=.856**) and is shown by the following linear regression equation (Yield=120.9 + 10.594 EPG) where EPG = grams per plant.

Table 2. Effect of primary tillage treatments on the surface residue accumulation and early plant growth after ten years of continuous corn at Waseca.

Tillage Treatment		Surface residue	Early plant growth
Primary	Secondary	T/A (Dry Matter)	g/dry plant
Fall plow	Field cult.	Trace	5.3
Fall chisel	Field cult.	2.2	4.3
None	None	5.1	1.4
None	Disk	2.1	4.4
	Significance:	**	**
	BLSD(.05) :	1.2	.7
	CV(%) :	23.	11.

Plant emergence was affected greatly by the primary tillage treatments (Table 3). The first plants emerged 10 days after planting with the moldboard plow treatment showing the earliest emergence. Emergence was essentially completed within 3 days with the moldboard plow treatment. Emergence with the fall chisel and spring disk treatments was about 1 day later and was essentially complete within 4 days. With no tillage emergence was much slower and continued over an 8-day period. Surface residue accumulations shown in Table 2 more than likely reduced soil temperature sufficiently to result in the delayed emergence. In addition, the prolonged emergence period with no tillage was probably due to poor seed to moist soil contact even though fluted coulters were used with this system.

Table 3. Influence of primary tillage on the emergence rate of corn at Waseca in 1979.

Tillage Treatment	Days after planting							
	10	11	12	13	14	15	17	20
	% emerged							
Fall plow - field cult.	19	78	91	96	96	96	99	100
Fall chisel - field cult.	1	24	68	88	90	92	99	100
No Tillage	0	1	4	23	33	43	89	100
Spring disk only	1	30	79	92	94	94	100	100

Nutrient concentrations in the whole small plants (approximately 4 weeks after emergence) were influenced by tillage (Table 4). Phosphorus, Zn and Cu concentrations were highest with no tillage and lowest with fall plowing. These differences more than likely were due to the extreme differences in EPG among these treatments; hence, a dilution effect. The high Fe and Mn levels with the plots that received some form of tillage are probably due to contamination from soil splashing on the plants.

Table 4. Nutrient concentrations in the small whole plant as influenced by tillage methods at Waseca in 1979.

Tillage Treatment	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%				ppm				
Fall plow - field cult.	.38	4.35	.47	.35	746	53	39	7.4	8.2
Fall chisel - field cult.	.41	4.40	.48	.37	654	53	42	8.4	7.8
No Tillage	.43	4.10	.43	.34	293	45	47	10.5	7.6
Spring Disk only	.42	4.36	.46	.38	575	52	41	8.5	7.6
Significance:	*	NS	NS	NS	**	*	+	**	NS
BLSD(.05) :	.04				166	7		1.3	
CV(%) :	5.4	6.8	7.8	8.1	19	8.0	8.5	9.2	10

Nutrient uptake (the product of nutrient concentration times EPG) of all nutrients was influenced by the tillage treatments (Table 5). Uptake from the no tillage treatment was significantly less than from the other treatments and was primarily due to smaller EPG. Potassium, Ca, Mg, Fe, Mn and B uptake

was generally less with the chisel and disk treatments than with the moldboard plow.

Table 5. Nutrient uptake by small whole plants as influenced by tillage methods at Waseca in 1979.

Tillage Treatment	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	----g/10 plants-----				-----mg/10 plants------				
Fall plow - field cult.	.202	2.29	.25	.18	39	2.8	2.1	.39	.44
Fall chisel - field cult.	.175	1.88	.20	.16	28	2.2	1.8	.36	.33
No Tillage	.061	0.58	.06	.05	4	.6	.7	.15	.11
Spring Disk only	.186	1.92	.20	.17	26	2.3	1.8	.37	.34
Significance:	**	**	**	**	**	**	**	**	**
BLSD(.05) :	.034	.38	.04	.02	6	.4	.4	.08	.10
CV(%) :	15	15	16	12	17	14	15	17	20

With the exception of K, Mg and Mn, earleaf nutrient concentrations were not influenced by the tillage treatments (Table 6). Leaf K was significantly depressed by the reduced tillage treatments with concomittant increase in Mg. Concentrations of all nutrients, however, were sufficient for optimum crop production.

Table 6. Nutrient concentrations in the earleaf at silking as influenced by tillage methods at Waseca in 1979.

Tillage Treatment	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	---------%---------				----------ppm----------				
Fall plow - field cult.	.30	2.28	.45	.37	127	36	24	7.0	5.1
Fall chisel - field cult.	.29	1.93	.48	.47	122	34	22	7.4	5.0
No Tillage	.30	1.71	.48	.50	131	25	23	7.2	4.6
Spring Disk only	.30	1.97	.47	.50	130	28	23	7.2	5.0
Significance:	NS	**	NS	**	NS	*	NS	NS	NS
BLSD(.05) :		.25		.06		9			
CV(%) :	3.4	7.8	10	8.6	7.0	17	9.7	6.2	6.5

Soil NO_3-N levels from the 0-5' profile in April and the 0-10' profile were influenced significantly by the tillage treatments (Table 7). In April the fall chisel, spring disk and no tillage treatments contained 64, 77 and 54%, respectively, of the NO_3-N found in the 0-5' profile with the fall plow treatment. These proportions are slightly higher than shown in the fall of 1978. After the 1979 crop NO_3-N proportions in the 0-5' profile with the same three treatments were 70, 58 and 45%, respectively, of the moldboard plow. Sampling to 10' resulted in similar proportions of 74, 69 and 50%, respectively. Apparently, severe losses due to denitrification and/or leaching, reduced mineralization and/or immobilization of the fertilizer N are associated with these reduced tillage systems.

Distribution of NO_3-N in the top 5' varied with the time of sampling. In April, lowest concentrations were found in the 1-3' zone. By October concentrations were lowest in the top 3' with the moldboard plow and the top 4' with the other tillage systems.

Nitrate-N distribution in the 10' profile was not markedly affected by tillage. Over 57, 59, 61 and 64% of the NO_3-N was found below the 5' depth for the moldboard plow, chisel, spring disk and no tillage treatments, respectively. However, the absolute amounts of NO_3-N below 5' were almost doubled by tillage. Amounts remaining in the soil between 5' and 10' after the 1979 crop ranged from 166 lb NO_3-N/A with no tillage to 242 and 238 with disk and chisel, respectively, to 312 with the moldboard plow. These high levels of NO_3-N below the rooting depth of corn will more than likely be lost to the ground water.

Table 7. Nitrate-N distribution in the 0-5' soil profile in April and the 0-10' soil profile in October, 1979, as influenced by ten years of continuous tillage for corn at Waseca.

Depth	Fall plow-f. cult.		Fall chisel-f. cult.		No Tillage		None-Spr. Disk	
	Apr	Nov	Apr	Nov	Apr	Nov	Apr	Nov
ft.	ppm							
0-1	11.7	7.8	9.2	8.4	12.1	5.9	13.9	7.6
1-2	8.1	7.8	4.1	6.2	3.8	4.6	5.6	6.3
2-3	10.4	10.8	5.1	6.4	3.4	3.9	6.3	5.1
3-4	18.8	14.8	11.9	8.6	7.2	5.6	12.6	6.4
4-5	19.5	17.8	13.3	12.0	10.3	6.7	13.9	9.1
5-6		17.4		11.3		7.8		10.6
6-7		18.4		11.7		8.1		14.3
7-8		15.6		11.6		9.2		13.9
8-9		13.8		11.9		8.6		11.7
9-10		12.8		12.8		7.9		9.8
lb NO_3-N/A[1/] in profile								
(0-5')	274	236	174	166	147	107	210	138
(0-10')		548		404		273		380

[1/] Assuming 2 million lb soil/every 6" depth of soil.

The above data generally indicate that the efficiency of surface-applied fertilizer N tends to decrease as the intensity of the primary tillage is decreased. Annual applications of 175 lb N/A have resulted in substantial N accumulations throughout the 10' profile with moldboard plowing. This would suggest that this application rate is higher than needed especially considering the two very dry years (1975 and 1976) when crop removal was small. Nitrate accumulations with the chisel and disk systems range from 26 to 31% less and is largely concentrated below 5'.

These data also indicate that this N rate is too high when dry years are included, but is appropriate under normal growing conditions. The lower NO_3-N levels throughout the profile with continuous no tillage suggest poorer N efficiency compared to the other treatments and perhaps that the N rate may need to be increased under continued optimum growing conditions.

Soil samples to a depth of 6" were taken and separated into 0-1", 1-2", 2-3", 3-4" and 4-6" layers in October (Table 8). Soil pH of the surface soil was not influenced by the moldboard plow or chisel treatments but was reduced some with the light spring disk treatment. No tillage showed a substantial pH depression in the top 2 inches probably as a result of the nitrification of the surface-applied N. This continued pH depression could lead to substantial weed control problems with certain preemergence herbicides.

Table 8. Soil pH, P and K distribution in the 0-6" soil profile in October 1979 as influenced by ten years of continuous tillage for corn at Waseca.

Depth inches	Fall plow-f. cult.	Fall chisel-f. cult.	No Tillage	None-Spr. Disk
		Soil pH		
0-1	6.6	6.6	5.7	6.1
1-2	6.6	6.4	5.9	6.2
2-3	6.6	6.6	6.6	6.4
3-4	6.7	6.8	6.8	6.7
4-6	6.7	6.9	6.9	6.9
		Soil P (lb/A)		
0-1	66	90	108	114
1-2	62	90	94	99
2-3	57	76	59	71
3-4	60	72	31	52
4-6	56	56	27	34
		Soil K (lb/A)		
0-1	394	577	559	732
1-2	294	363	406	401
2-3	273	310	311	278
3-4	288	257	225	215
4-6	262	212	197	180

Soil P and K distribution throughout the 6-inch layer was relatively uniform with moldboard plowing. Stratification of both P and K was enhanced by reduced tillage with the disk = no tillage > chisel plow. In comparison to the moldboard plow, the chisel plow incorporated P to a depth of 6" and K to 4". With the disk and no tillage systems P and K were largely accumulated in the top 2 to 3 inches. Soil test P and K levels in the 0-1 inch layer were 2.5 to 3.4 times as high as in the 3-4" layer and 3 to 4 times as high in the 4-6" layer with these systems.

TEN-YEAR YIELD SUMMARY

Corn yields were affected significantly (P=.10 level) by the tillage treatments in 8 out of the 10 years (Table 9). In the first 5 years, climatological differences among growing seasons may have been largely responsible for the year to year inconsistency among treatments. For instance, 1971 was dry and highest yields were obtained from the fall plow and chisel treatments without any secondary tillage. In other years secondary tillage following chiseling generally increased yields. Five-year averages show highest yields with fall moldboard plowing or fall chiseling with secondary tillage. Spring chiseling and no tillage generally produced the lowest yields.

Results over the last 5 years were also affected by the climate during the growing season. Hot, dry conditions coupled with heavy amounts of road dust during pollination led to greater than 45% barrenness in the plants and extremely low yields in 1975. In 1976, extremely dry conditions along with 40 to 60% lodging due to rootworms resulted in very low yields. For these reasons the 1975 and 1976 yields were excluded from the 1970-79 averages. In the last three years yields from the plow, chisel and disk systems have been comparable and were significantly higher than with no tillage.

Average corn yields over the 10-year period indicate only a 2.7 bu/A advantage for moldboard plowing over chiseling and a 1.4 bu/A advantage for chiseling over spring disking. These differences were not significant at the P=.10 level. Yields with no tillage averaged 10% less and were significantly below (P=.01 level) the yields from the other treatments. These yield results may have been tempered somewhat due to the south facing slope and the good drainage. With poor drainage or a north facing slope the yield differences perhaps would have been greater and would have favored moldboard plowing.

Table 9. Yields from continuous corn tillage experiment at Waseca from 1970-1979.

Tillage Treatment		Year					5-Yr.	Year					10-Yr[2]
Primary	Secondary	1970	1971	1972	1973	1974	Avg	1975	1976	1977	1978	1979	Avg
		bu/A											
Fall plow	None	164.7	114.8	135.3	141.2	97.9	130.8						
" "	Conv.[1]	166.8	104.7	131.8	144.9	103.4	130.3						
" "	F. cult.	163.7	102.8	136.2	144.1	99.7	129.3	52.8	68.1	131.0	157.4	176.8	139.0
Spring plow	Conv.	161.5	100.6	134.9	140.5	90.4	125.6						
Fall chisel	"	164.2	106.6	130.8	155.1	99.2	131.2						
" "	F. cult.	156.7	110.5	133.1	145.7	92.1	127.6	48.7	66.6	128.0	155.3	168.7	136.3
" "	None	161.1	116.2	126.2	134.3	90.4	125.6						
Spring "	Conv.	150.2	100.1	139.9	138.4	92.1	124.1						
Spring "	Disk	159.5	110.2	133.6	131.5	95.7	126.1						
Zero	None	155.9	96.2	130.1	133.4	85.9	120.3	49.7	83.2	121.6	129.5	131.8	123.0
Zero	Disk	157.9	104.1	130.8	145.8	93.7	126.5	49.4	79.3	125.4	152.1	169.1	134.9
Significance:[3]		*	+	NS	**	**	*	NS	**	*	**	**	**
BLSD(.10)	:	8.3	9.7		7.7								5.8
(.05)	:	9.9			9.0	9.0	7.7		7.6	6.7	5.3	12.8	6.8
CV(%)	:	3.6	5.9	5.1	4.4	5.9	3.8	14.9	6.5	3.1	2.4	5.2	5.0

[1] Conventional = Disk and field cultivate.

[2] Excluding 1975 and 1976.

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

N RATE, SOURCE AND INCORPORATION STUDY-CORN

Gyles Randall and Harvey Meredith

Objective of Study: Determine the nitrogen uptake and corn yields when various sources of nitrogen are surface applied or soil incorporated. A secondary objective of the study is to correlate soil nitrate levels and corn yields.

Location: Waseca Experiment Station

N Source: Urea, Ammonium nitrate and 28 percent urea-ammonium nitrate.

N Rate: 50 and 100 pounds N per acre. Zero N plots deliniate N response.

Results: Rainfall was adequate to slightly excessive in 1979. A dramatic response to applied nitrogen was evident both in N uptake and yield. High yields in 1977 and 1978 tended to lower the level of soil nitrates although the soil nitrate levels in June indicated an average of 142 pounds of nitrogen in the top 60 inches. There were no significant differences between sources of N or incorporation.

Table 1. Yield of Corn Grain, Waseca Experiment Station in Response to Applied N, 1979. (bu/A).

Lbs-N/A	Yield - Bu/A					
	Am Nitrate		Urea		28% N Soln	
	I	N	I	N	I	N
75	129.1	128.8	133.0	128.2	122.4	127.8
150	146.8	148.8	148.6	149.5	141.2	143.4

NO N: 88.7 bu/A BLSD (.05)=7.2 bu/A

Table 2. Nitrogen Content of the 6th leaf of Corn as influenced by N source and rate, Waseca Experiment Station, 1979.

Lbs-N/A	N Content - Percent					
	Am Nitrate		Urea		28% N Soln	
	I	N	I	N	I	N
75	2.44	2.32	2.62	2.32	2.26	2.26
150	2.55	2.76	2.83	2.84	2.56	2.56

NO N: 1.84 BLSD (.05)=.17

Table 3. Soil pH of Zero N plots of N Source, Rate, Incorporation Study, Waseca Experiment Station, 1979.

	Soil pH					
Plot No.	111	207	308	404	510	610
Depth, In.						
0-12	7.4	7.4	6.8	7.6	7.1	6.9
12-24	7.6	7.6	7.4	7.8	7.4	7.5
24-36	7.7	7.8	7.5	7.8	7.5	7.7
36-48	7.7	7.8	7.6	7.9	7.4	7.8
48-60	7.7	7.7	7.7	7.8	7.6	7.9

Sampled June 1979.

Table 4. Soil Nitrate Values of Zero N Plots from N Source, Rate, Incorporation Study, Waseca Experiment Station, 1979.

	Lbs NO_3 - N/A					
Plot No.	111	207	308	404	510	610
Depth, In.						
0-12	59	62	44	55	60	20
12-24	20	18	18	16	23	11
24-36	17	18	16	17	22	16
36-48	24	26	25	27	29	26
48-60	27	28	33	29	33	32
	147	152	136	142	167	105

Average: 142

ROTATION NITROGEN STUDY

Waseca, 1977-1979

Gyles W. Randall

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

EXPERIMENTAL PROCEDURES

The crop sequences (continuous corn, corn-soybean, corn-wheat and corn-wheat + alfalfa) were begun in 1974 on a Webster clay loam. Each N plot within each crop sequence is 15' wide (6 rows) by 50' long. Rates of N (0, 40, 80, 120, 160 and 200 lb N/A) were applied as anhydrous ammonia each in the spring. Wheat annually received 50 lb N/A as urea before planting. Broadcast P and K (averaging 0 + 80 + 140 lb P_2O_5 and K_2O/A) was applied annually to all plots. Row P and K (0 + 30 + 45 lb P_2O_5 and K_2O/A) was applied to the corn.

Corn was planted in 30" rows at 26,100 ppA in early May each year. The hybrid was Pioneer 3780 in 1978 and 1979 and Pioneer 3709 in 1977. Era wheat and Hodgson soybeans were planted in late April and/or in mid-May, respectively, each year. A non-winter hardy alfalfa was planted with the wheat in 1974 and 1975. Agate was the alfalfa variety used.

Each year weeds were chemically controlled along with one cultivation of the corn. A combination of 3 qt Lasso plus 2½ lb Bladex/A was applied preemergence each year for corn. Soybeans received 3 qt Lasso plus 5 qt Amiben/A applied preemergence. Broadleaf weeds in the wheat were controlled with ¼ lb MCPA plus ¼ lb Bromoxynil/A. Wheat + alfalfa received no herbicide.

All corn plots regardless of the preceding crop received a band-applied insecticide at planting. The insecticide rotation included Counter at 1 lb/A in 1977 and 1979 and Furadan at 1 lb/A in 1978.

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

Soil NO_3-N analyses were conducted on samples taken in increments of 1' to a depth of 5' each fall. The treatments sampled included all 0 and 160 lb N rates for corn plus random samples from the soybeans, wheat and wheat + alfalfa areas.

All plots were moldboard plowed in early November each year.

RESULTS

Corn yields with varying rates of N following the four previous crops are shown in Table 1. Yields in 1977 were high and reflected about a 20 to 30 bu/A advantage when following soybeans, wheat or wheat plus alfalfa. This advantage was greater at the lower N rates and somewhat narrower at the 200 lb rate. Yields were optimized with the 80-lb N rate except with continuous corn when 120 lb N/A was needed.

In 1978 and 1979 a significant response to N was obtained following all crops. Response was greatest for continuous corn and least with corn following wheat which had been interseeded with alfalfa. Corn yields were substantially higher when following soybeans and wheat. This was especially true at the low N rates. Even at the 200 lb N rate a 10-25 bu/A advantage was shown with soybeans or wheat.

Three-year yield averages (Table 1) over all N rates indicate an approximate 26 bu/A yield advantage for corn following soybeans, wheat, and wheat + alfalfa. Corn yields were optimized with 160 lb N/A following corn, 120 lb/A following soybeans and wheat + alfalfa, and 80 to 120 lb/A following wheat.

SUMMARY

These results indicate significant and economic yield depressions associated with continuous corn as compared to corn following soybeans, wheat or wheat plus alfalfa, regardless of N rate. Leaf and soil NO_3-N analysis (not included in this report) indicate slight affects of the previous crop. Hence, primary causative reasons or explanations must lie with factors other than soil fertility.

Table 1. Corn yields following various crops at Waseca in 1977, 1978 and 1979.

N rate		Corn yield following			
		Corn	Soybeans	Wheat	Wheat + Alfalfa
lb N/A		bu/A			
			1977		
0		96.8	145.6	147.3	120.2
40		124.2	158.4	158.6	140.4
80		129.5	165.0	167.0	161.2
120		143.4	168.3	171.6	161.4
160		147.3	174.3	168.3	168.2
200		151.1	171.1	171.2	163.0
	Avg.	132.0	163.8	164.0	152.4
			1978		
0		89.0	110.2	111.1	135.2
40		124.4	143.8	153.2	154.3
80		135.5	162.0	171.7	164.2
120		142.9	167.8	171.4	179.3
160		154.1	178.5	174.3	176.2
200		156.7	176.0	181.6	179.3
	Avg.	133.8	156.4	160.6	164.8
			1979		
0		88.1	129.8	119.8	147.5
40		122.9	146.5	151.9	158.6
80		141.9	169.4	165.6	167.8
120		156.7	180.8	164.6	173.6
160		167.2	178.5	178.8	183.5
200		170.0	186.4	182.0	171.7
	Avg.	141.1	165.2	160.4	167.1
			1977-79 AVG.		
0		91.3	128.5	126.1	134.3
40		123.8	149.6	154.6	151.1
80		135.6	165.5	168.1	164.4
120		147.7	172.3	169.2	171.4
160		156.2	177.1	173.8	176.0
200		159.3	177.8	178.3	171.3
	Avg.	135.6	161.8	161.7	161.4

USE OF TERRAZOLE (DWELL) AS A NITRIFICATION INHIBITOR IN FALL VS. SPRING NITROGEN APPLICATION PROGRAMS FOR CORN PRODUCTION IN SOUTHERN MINNESOTA

G.L. Malzer and G.W. Randall

The use of nitrification inhibitors on the heavy wet soils of southern Minnesota has gained considerable attention over the last several years. There are several chemicals known which are capable of delaying the rate of nitrification, but there is only one currently on the market (N-Serve-Dow Chemical, U.S.A.). An experimental chemical Terrazole (Olin Corporation) has shown nitrificide characteristics and was evaluated under field conditions at the Southern Experiment Station at Waseca, MN in 1979. The objectives of the trial were to evaluate not only rate of nitrogen application but also timing of application and comparisons of different nitrogen forms with and without the use of Terrazole.

Experimental Procedures

Seventeen treatments including a control, two rates of nitrogen (75 and 150 #N/A), with two nitrogen forms (urea and anhydrous ammonia) were applied as fall (Oct. 30) or spring (May 7) treatments with or without Terrazole (0.5 #ai/A). Urea was broadcast and immediately incorporated after application with Terrazole (Dwell) treatments consisting of coatings on the urea fertilizer. The anhydrous ammonia treatments were injected at 30" knife spacings, and Terrazole applications were made simultaneously with the use of a dual-tube anhydrous shank and a separate pressurized system for application of the Terrazole. All treatments were replicated four times and arranged in a randomized complete block design. Corn (Pioneer 3732) was planted into the experimental area in 30" rows at a seeding rate of approximately 27,000 seeds/A.

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

General Results

Grain yields were excellent in 1979 with yield responses to the application of nitrogen fertilizer up through the 150 #N/A rate. In general there was very little difference between times of fertilizer nitrogen application. Urea did not appear to perform as well as anhydrous ammonia. The nitrification inhibitor did not result in across-the-board yield increases, although significant yield advantages were obtained with the use of Terrazole when it was applied with fall urea. The difference obtained within yield on these treatments were, however, not reflected in corn forage production or total nitrogen removal. Care should therefore be exercised in evaluating those treatments.

Table 1. Influence of nitrogen form, rate of application, time of application, and use of Terrazole (Dwell) as a nitrification inhibitor on various yield components and nitrogen utilization characteristics of corn.

Treatments						Corn Forage Production							
						Stover			Grain			Total	
Date of Appl.	N Rate	N Form	Inhibitor	Leaf N	Yield Grain	Yield	N	N Removal	Yield	N	N Removal	Yield	N Removal
	#/A		0.5#ai/A	%	bu/A	T/A	%	#/A	T/A	%			
Control	-	-	-	2.06	124.4	4.43	0.43	37.9	3.05	1.10	67.2	7.48	105.1
Fall	75	Urea	No	2.74	161.2	4.91	0.53	51.5	3.96	1.23	97.2	8.87	148.7
Fall	75	Urea	Yes	2.70	173.3	4.97	0.57	57.1	4.07	1.23	100.6	9.03	157.7
Fall	75	A.A.	No	2.78	177.9	5.09	0.60	60.3	4.00	1.28	102.5	9.10	162.8
Fall	75	A.A.	Yes	2.74	176.3	4.68	0.54	50.7	3.94	1.25	98.3	8.62	149.0
Fall	150	Urea	No	2.88	173.4	5.16	0.60	62.1	4.35	1.26	109.4	9.51	171.5
Fall	150	Urea	Yes	2.87	187.2	5.08	0.59	59.9	4.22	1.28	107.9	9.30	167.8
Fall	150	A.A.	No	2.88	185.6	4.83	0.63	61.2	4.18	1.32	110.3	9.01	171.5
Fall	150	A.A.	Yes	2.86	178.4	5.44	0.58	63.2	4.43	1.25	111.2	9.87	174.4
Spring	75	Urea	No	2.68	166.6	4.87	0.56	55.6	3.99	1.19	94.9	8.86	150.5
Spring	75	Urea	Yes	2.71	167.8	4.59	0.50	46.5	3.75	1.16	87.0	8.35	133.5
Spring	75	A.A.	No	2.85	171.9	5.01	0.57	57.6	4.15	1.26	104.1	9.16	161.7
Spring	75	A.A.	Yes	2.86	172.6	5.01	0.64	64.1	4.15	1.26	104.6	9.16	168.7
Spring	150	Urea	No	2.98	180.6	4.97	0.71	70.5	4.05	1.25	101.5	9.02	172.0
Spring	150	Urea	Yes	2.84	176.3	5.16	0.63	64.5	4.14	1.25	103.4	9.30	167.9
Spring	150	A.A.	No	2.96	183.4	4.96	0.71	70.5	4.19	1.29	108.2	9.15	178.7
Spring	150	A.A.	Yes	2.93	184.5	5.03	0.71	71.4	4.00	1.30	103.8	9.03	175.2
Significance				**	**	*	**	**	**	**	**	**	**
BLSD(.05)				0.17	10.5	0.55	0.09	11.1	0.33	0.05	9.4	0.73	17.3

CORRECTING CHLOROSIS OF SOYBEANS BY FOLIAR APPLICATION OF IRON

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1979

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

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

Experimental Procedures

Two experimental sites were selected in late June on farmers fields in Nicollet and Redwood Counties. After application of the iron materials to the Redwood County site (July 1), the farmer applied Basagran to the field and severely injured the plants in the chlorotic area. No visual response to the foliar-applied iron was observed three weeks after application. This could have been due to the late application at the 3rd to 4th trifoliate stage which is somewhat after the recommended 2nd trifoliate stage. Because of no response and the poor condition of the plants, yields were not taken and the site was abandoned.

At the Nicollet County site (John Bluhm) the iron materials were applied on July 6 to Corsoy soybeans in the 3rd trifoliate stage. Treatments were replicated 8 times in single-row plots measuring 20' long. Application was at 9:30-10:30 A.M. on a cloudy mild day. All materials were applied with a stainless steel hand sprayer at a gallonage rate of 50 gpa with X-77 at 0.25% v/v. The iron application rates (lb Fe/A) are shown in Table 1. Response notes (color and phytotoxicity) were taken on July 26. Yields were taken on October 10 by hand harvesting 16' of row per plot and threshing with a stationary soybean thresher.

Results

Visual color response three weeks after iron application was apparent with only two treatments. A healthy, dark-green color appeared with the 138-Fe treatment; whereas, only a slight improvement in the green color was noted with Hamp-Iron.

Although phytotoxicity symptoms were not severe, greatest wrinkling of the leaves and leaf loss occurred with Eagle Iron applied at the high rate. Only slight phytotoxicity was seen with the lower rates of Eagle Iron and with Hamp-Iron and KE-MIN.

Yield results shown in Table 1 indicate a significant response to both 138-Fe and Hamp-Iron. The 138-Fe treatment was clearly superior to all treatments. Variability within the site was extremely high (CV=61). The 138-Fe and Hamp-Iron materials were the only treatments which resulted in a consistent, harvestable yield from all replications. Plants were completely dead and yields were not taken from 16 of the plots which were treated with the other materials.

Table 1. Influence of various iron products applied to the foliage of chlorotic soybeans in Nicollet County in 1979.

Iron Treatment Material	Rate	Seed Yield
	lb Fe/A	bu/A
Check	0	6.6
EDDHA chelate	1/	8.8
Sequestrene 138-Fe	.15	25.0
Fe KE-MIN	1.0	7.8
Hamp-Iron	0.2	15.5
Eagle Iron	0.6	6.8
" "	1.2	7.7
" "	2.4	5.9
Significance:		**
BLSD(.05) :		6.6
CV(%) :		61.

1/ Applied at the same chelate rate as the 138-Fe treatment.

Summary

Soybean yields were improved 378 and 234% by 138-Fe and Hamp-Iron, respectively, applied to severely chlorotic foliage at the 3rd trifoliate stage. Yield responses were not shown with the foliar application of Fe KE-MIN or Eagle-Iron.

SOYBEAN TILLAGE-HERBICIDE STUDY*

Waseca, 1979

G. W. Randall and G. E. Ham

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

EXPERIMENTAL PROCEDURES

To evaluate various tillage-herbicide systems on soybean production following corn, an experiment consisting of 8 tillage-herbicide treatments was established in the fall of 1978 on a Webster clay loam (2 reps) and Nicollet clay loam (4 reps) at the Southern Experiment Station. The primary tillage treatments include no tillage, fall moldboard plow, fall chisel plow, combined fall and spring disking and a double spring disking. The latter three treatments were split to also evaluate methods of herbicide application with minimum tillage. A preplant incorporate herbicide (Treflan) was compared to a preemergence herbicide (Lasso). All plots were 125' long and 20' wide (8-30" rows).

In the fall of 1978, fertilizer was broadcast at a rate of 0+100+200 ($N+P_2O_5+K_2O$/A) before any tillage was started. Row-placed fertilizer at planting was not used.

The no tillage, moldboard and chisel plow treatments were stalk chopped on October 27 and were immediately followed by the fall moldboard, chisel and disk tillage operations. Corn stalks on the spring disk treatments were allowed to stand throughout the winter. Secondary tillage was conducted on May 24. All chisel and disk treatments were disked with Treflan being applied at 1 qt/A to the PPI treatments. The fall plow and chisel treatments were field cultivated the same day.

Soybeans (Corsoy) were planted at 8.5 beans/foot on May 25. A John Deere Max-Emerge planter with 2" fluted coulters was used on all plots. On May 25 the preemergence herbicide treatment (Lasso, 3 qt/A) was applied. Amiben at a rate of 5 qt/A was superimposed over all plots on the same date. All plots were cultivated once on July 3.

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Thermocouples were installed at the 4-inch depth directly below the soybean row on June 1. Surface residue amounts were measured on June 12. On July 11 population counts were taken and early plant growth was determined by harvesting and drying the above ground portion of 16 randomly selected plants from each plot. Nutrient composition of these samples was also determined. Uppermost, mature trifoliate samples were taken on August 3 for chemical analysis. Volunteer corn population counts were taken by counting the total number of single plants or clumps (if a large number of plants emerged from one ear) on July 11. Seed yields were determined by combine harvesting the center 4 rows from each plot on October 12.

RESULTS

Few differences in early plant nutrient concentrations were found (Table 1). Iron levels were lowest with no tillage due to reduced soil splash onto the tissue with the high level of surface residue present.

Table 1. Influence of primary tillage-herbicide combinations for soybeans following corn on the nutrient concentration of small whole soybean plants in 1979.

Treatment		Nutrient								
Tillage	Herbicide[1]	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%				ppm				
No tillage[2]	Pre	.32	2.38	1.56	.61	165	52	36	6.3	34
Fall plow[2]	Pre	.33	2.60	1.62	.57	237	59	36	6.4	31
Fall chisel[2]	Pre	.33	2.75	1.52	.54	205	54	34	6.6	31
Fall chisel[2]	PPI	.34	2.46	1.64	.59	228	54	39	6.6	33
Spr. disk (2x)	Pre	.32	2.57	1.56	.57	222	51	37	6.8	32
Spr. disk (2x)	PPI	.33	2.52	1.61	.59	254	52	40	6.6	33
Fall & Spr. disk	Pre	.33	2.67	1.50	.54	197	49	38	6.8	32
Fall & Spr. disk	PPI	.34	2.36	1.58	.59	222	48	39	7.4	33
Significance:		NS	NS	NS	NS	*	NS	NS	*	+
BLSD (.05) :						56			0.7	
CV (%) :		4.6	11.0	6.3	9.3	19.0	18.0	8.8	8.0	5.6

[1] Pre = Lasso (3 lb/A) PPI = Treflan (1 lb/A)

[2] These treatments were stalk chopped.

Dry matter per acre (product of DM/plant times plants/A) was affected significantly by the tillage treatments (Table 2). Dry matter accumulation five weeks after emergence was significantly less with no tillage compared to all other treatments. Differences among the moldboard plow, chisel or disk treatments were not significant.

These dry matter differences coupled with the associated nutrient concentration resulted in large tillage treatment differences in uptake of all nutrients (Table 2). No tillage showed significantly lower P, K, Ca, Fe, Cu and B uptake values than any other tillage treatment. Significant differences in uptake values were not found among the other tillage treatments.

Table 2. Influence of primary tillage-herbicide combinations for soybeans following corn on small plant dry matter accumulation and nutrient uptake in 1979.

Treatment			Nutrient								
Tillage	Herb.	DM	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		lb/A									
No tillage	Pre	625	2.03	14.7	9.8	3.83	.104	.032	.023	.0040	.021
Fall plow	Pre	911	2.98	23.8	14.7	5.21	.214	.053	.033	.0059	.028
Fall chisel	Pre	862	2.86	23.4	13.1	4.69	.178	.046	.030	.0057	.027
Fall chisel	PPI	823	2.77	20.6	13.3	4.87	.181	.044	.033	.0055	.027
Spr. disk (2x)	Pre	812	2.60	20.8	12.6	4.69	.184	.041	.030	.0056	.026
Spr. disk (2x)	PPI	887	2.96	22.4	14.3	5.26	.225	.047	.036	.0059	.030
Fall & Spr. disk	Pre	899	3.00	24.2	13.4	4.88	.174	.043	.034	.0061	.028
Fall & Spr. disk	PPI	884	3.00	21.0	13.9	5.26	.195	.043	.035	.0066	.029
Significance:		**	**	**	**	*	**	*	**	**	**
BLSD (.05)	:	116	0.44	5.0	2.1	0.93	.058	.012	.007	.0013	.004
CV (%)	:	11.7	13.1	18.3	13.2	14.3	25.3	20.3	17.1	17.7	12.7

At the mid-bloom stage (three weeks after the whole plants were sampled), differences in the nutrient concentrations of the plants were generally not found among the eight tillage treatments (Table 3). Only slight unexplainable differences in Ca and Mn were found.

Table 3. Influence of primary tillage-herbicide combinations for soybeans following corn on the leaf nutrient concentration of soybeans in 1979.

Treatment		Nutrient[1/]								
Tillage	Herbicide	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%				ppm				
No tillage	Pre	.46	2.53	1.05	.39	92	74	35.7	7.0	51
Fall plow	Pre	.43	2.41	0.98	.39	93	57	34.9	6.4	50
Fall chisel	Pre	.44	2.40	0.96	.36	93	68	34.2	5.9	49
Fall chisel	PPI	.44	2.61	1.00	.37	92	70	35.2	5.9	51
Spr. disk (2x)	Pre	.43	2.61	1.01	.36	83	66	35.2	6.3	50
Spr. disk (2x)	PPI	.42	2.46	0.98	.35	95	64	35.7	6.3	50
Fall & Spr. disk	Pre	.42	2.35	1.00	.36	104	61	35.4	6.1	47
Fall & Spr. disk	PPI	.43	2.44	0.97	.35	92	60	35.3	6.8	49
Significance:		NS	+	**	NS	NS	**	NS	NS	NS
BLSD (.05)	:			0.04			7.4			
CV (%)	:	8.0	6.9	3.5	9.5	15.7	9.5	8.3	12.3	4.9

[1/] Uppermost, mature trifoliate leaf at mid-bloom.

Very high corn residue levels were found after the 1978 corn crop. However, about 70% of the surface residue was incorporated by chisel plowing (Table 4). Double spring disking incorporated approximately 44% of the residue. Slightly more residue (56%) was incorporated with the combined fall and spring disk treatment.

Soil temperatures at the 4-inch depth after planting were quite high and ranged from 64 to 72°F over the four-week period (Table 4). Fairly consistent temperature differences among tillage treatments were noticed. Moldboard plowing always resulted in the highest temperatures with lowest temperatures found under no tillage. Intermediate temperatures were associated with the disk and chisel treatments.

Table 4. Surface residue accumulation and average 4-inch soil temperature as influenced by tillage method for soybeans following corn in 1979.

Treatment		Surface residue	Soil temperature			
Tillage	Herb.	accumulation	6/4-8	6/11-15	6/18-22	6/25-29
		T DM/A	°F			
No tillage	Pre	5.9	68.1	65.8	63.7	70.3
Fall plow	"	0.6	70.0	67.7	64.1	72.2
Fall chisel	"	1.7	68.9	66.5	64.0	71.9
Spr. disk (2x)	"	3.3	68.3	66.2	64.1	71.1
Fall & Spr. disk	"	2.6	68.0	65.9	64.0	71.2
Significance:		**				
BLSD (.05) :		0.6				
CV (%) :		15.0				

Statistical differences in early plant growth were found among the tillage treatments in 1979 (Table 5); perhaps partly due to the soil temperature differences. Smallest plants were associated with no tillage. No differences were found among the other treatments.

Volunteer corn was not a problem at this site in 1979. Although a trend toward reduced volunteer corn population was evident with Treflan, these differences were not significant because of the high variability and low corn levels. Contrary to popular opinion, moldboard plow tillage did not reduce volunteer corn population and showed the highest level.

Nitrogen fixation values were obtained by Dr. Ham and students in July (Table 5). Highest N fixation was shown with the double spring disk treatment, intermediate values with the chisel and the fall and spring disk treatments and lowest values with no tillage and moldboard plowing.

Slight differences in the final bean population were shown in 1979 (Table 5). Highest population was obtained with moldboard plow tillage with slightly lower stands occurring with reduced tillage. In contrast to past years, Treflan did not reduce stand in comparison to Lasso. Stands were considered to be adequate for maximum yields in all cases.

Soybean yields were depressed considerably and statistically with no tillage (Table 5). Little difference in yields was found among the other treatments. The highest yield was obtained with the double spring disk treatment with Treflan. A trend toward slightly lower yields with the preemergence herbicide compared to the preplant incorporated herbicide was noticed. Similarily, weed control (primarily grass) was slightly better with the PPI herbicide in 1979; probably due to the higher surface residue levels which may have inactivated the preemergence herbicide somewhat.

Three-year averages show that optimum soybean yields can be obtained with reduced tillage following corn (Table 5). Marked yield reductions only occurred with no tillage.

Table 5. Influence of primary tillage-herbicide combinations for soybeans following corn on early growth, volunteer corn, population and soybean yield in 1979.

Treatment		Early plant growth	Volunteer[1/] corn	Nitrogen fixation index	Final population	Seed Yield	
							1977-79
Tillage	Herb.					1979	Avg.
		g/plant	plants/A	ul/plant /hr	beans/ft.	----bu/A----	
No tillage	Pre	2.3	0	6.4	7.0	30.8	41.1
Fall plow	Pre	3.1	38	6.2	7.6	46.1	51.4
Fall chisel	Pre	3.1	23	7.6	7.2	44.9	49.9
Fall chisel	PPI	3.1	6		7.0	46.8	51.2
Spr. disk (2x)	Pre	3.0	32	9.8	7.0	43.7	49.1
Spr. disk (2x)	PPI	3.4	6		6.7	47.9	49.9
Fall & Spr. disk	Pre	3.2	17	7.6	7.2	43.6	49.3
Fall & Spr. disk	PPI	3.3	9		7.1	46.7	49.9
Significance:		**	NS		*	**	
BLSD (.05) :		0.5			0.5	4.0	
CV (%) :		12.8	160.		5.0	7.5	

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

SUMMARY

Optimum soybean yields were obtained in 1979 with reduced tillage systems. Surface residue accumulations of up to 5.9 T/A did influence soybean development somewhat and appeared to hinder weed control slightly. No tillage resulted in slightly cooler soils, smaller plants and in very poor weed control (primarily broadleaves and some grasses). Grass control was slightly better with Treflan with the disk and chisel systems. Volunteer corn populations were too small to evaluate the treatments thoroughly. These results indicate that soybean production following corn can be excellent with tillage systems that manage surface residue, thus, limiting soil erosion.

PLANTERRA AND SOIL INOCULANT

1979

Waseca, Minnesota

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

In 1978 World Agrisearch Corporation marketed a product called Planterra which contained non-symbiotic forms of N fixing bacteria and blue-green algae. With the change of supplier in 1979 the product was called Soil Inoculant which is basically the same product with one less bacteria species. That change also enabled Soil Inoculant to be combined with pesticides or liquid fertilizers for application. World Agrisearch claims that their product "decomposes crop residues, builds soil humus, and accelerates the nitrogen cycle". They state that this totally natural and safe product makes available the nitrogen, phosphorous, potassium, secondary and trace elements needed for crop production. Another claim is that a more stable form of "nitrogen is slowly released all through the growing season for even feeding of the growing crop". The purpose of this study was to evaluate Planterra on corn production and Soil Inoculant on soybean production in south-central Minnesota.

Experimental Procedures

Planterra-corn

The study was established on a Nicollet clay loam soil which had corn removed as silage the previous year. Fall P and K fertilizer was applied to the area at the 100 + 200 lb/A rate, respectively, (oxide basis). Treatments were arranged in a six-replicate, randomized, complete-block design and included a check, Planterra, 60 and 150-lb N treatments. The 60-lb N treatment was chosen as economically comparable in price to the Planterra treatment. After tillage Planterra was applied November 8, 1978 at the recommended rate of 0.1 gal Planterra + 30 gal H_2O/A. Corn (Pioneer 3732) was planted at a rate of 27,900 ppA in 30-inch rows on May 16 with 1 lb Counter/A and 140 lb 0-23-30 as starter fertilizer. Chemical weed control consisted of 3 lb Lasso and 2½ lb atrazine/A applied pre-emergence.

The leaf opposite and below the ear was sampled from 12 plants at silking and submitted for nitrogen analysis. Silage samples taken from 15 feet of row at physiological maturity (black layer stage) were measured for yield and submitted for nitrogen analysis. Grain yield, moisture and protein were determined on corn combine harvested from the center two rows of each 4-row plot. Grain yields were converted to 15.5% moisture.

Soil Inoculant-soybeans

Two different soybean lines (Hodgson 78 and 129-nonnod) were planted May 21 on a Nicollet clay loam soil at a rate of 5 beans/foot in 14-inch rows. This area received 100 + 200 lb P and K/A (oxide basis) the previous fall. Treatments were arranged in a six-replicate, randomized, complete-block design. The Soil Inoculant was soil-applied June 6 at the recommended rate of 0.1 gal Soil Inoculant + 30 gal H_2O/A. Chemical weed control consisted of 1 qt Treflan/A ppi and 5 qts Amiben/A postemergence. Seed yield was determined on soybeans combine harvested from the center four rows of each plot.

Results

Planterra-corn

Nitrogen concentration in the corn leaf was significantly higher in the 60 and 150-lb N treatments compared to the check and Planterra (Table 1). The fodder nitrogen content shows the 150-lb N treatment to be significantly better than all the other treatments and the 60-lb N superior to the check and Planterra. Grain and silage yields with the 150-lb N treatment were significantly better than all other treatments with the 60-lb N treatment superior to the check and Planterra treatments. Grain protein and moisture showed a significant advantage for the 60 and 150-lb N treatments over the check and Planterra. All of the above results would indicate no positive effect due to Planterra on corn production in south-central Minnesota.

Table 1. Influence of Planterra on the nitrogen concentrations in the corn leaf and fodder, silage yield, grain yield, moisture and protein content at Waseca in 1979.

Treatment	Nitrogen		Yield		Grain	
	Leaf	Fodder	Silage	Grain	Moisture	Protein
	-----%------		T DM/A	bu/A	--------%--------	
Check	1.74	.318	6.69	108.7	32.1	6.56
Planterra	1.60	.353	6.68	110.8	32.1	6.36
60 lb N	2.55	.456	8.54	159.6	30.2	7.69
150 lb N	2.68	.539	9.18	172.4	30.4	8.05
Signif:	**[1]	**	**	**	**	**
BLSD(.05):	.17	.068	.45	8.9	.6	.41
CV (%):	7.0	14	5.2	5.8	1.8	5.2

[1] ** designates significance at the 99% level.

Soil Inoculant-soybeans

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

Table 2. Influence of Soil Inoculant on soybean yield of two different lines at Waseca in 1979.

Line	Treatment	Yield
		bu/A
Hodgson 78	Control	36
Hodgson 78	Soil Inoculant	36
129-Nonnod	Control	14
129-Nonnod	Soil Inoculant	14

Summary

Corn leaf nitrogen, fodder nitrogen, silage yield, grain yield, grain moisture and grain protein were not affected positively by Planterra. Soil Inoculant, the World Agrisearch product that is similar to, and is being marketed in place of Planterra, showed no effect on soybean yield at Waseca in 1979.

SYMBEX

1978-79 Summary

Waseca, Minnesota

D.K. Langer and G.W. Randall

The Symbex system was developed and is being marketed by the Agro-K Corporation. The Symbex system includes three phases: (1) Symbex soil inoculant, (2) Sym-Coat seed treatment, and (3) Sym-Spray foliar spray. Symbex soil inoculant contains inactive ingredients of 41% water and 57% whey. The 2% active ingredients contain fungi, bacteria, yeasts, and according to Agro-K an enzyme system with activator which causes rapid breakdown of crop residue. Agro-K claims that this should release and make available the nitrogen, phosphorus, and potassium already in the soil so they can be utilized by the crop. Sym-Coat seed treatment increases and accelerates germination states Agro-K with resulting healthier stands. Sym-Spray foliar feeds micronutrients and is a growth regulator declares Agro-K. The purpose of this two-year study was to evaluate the effect of the Symbex system compared to conventional fertilizer and a check on continuous corn production on a medium fertility soil in south-central Minnesota.

Experimental Procedures

1978

The experiment was established in 1978 on a Nicollet clay loam soil which had not received fertilizer since 1974. Corn grown on the area the previous year was removed as silage. Treatments were arranged in a four-replicate, randomized, complete-block design and included a check, Symbex, Symbex + 30 lb N/A, and 175 lb N/A. The complete Symbex system was applied to the Symbex treatments at the recommended rates (Symbex:1 gal/A, Sym-Coat:10 g powder/10 lb seed, Sym-Spray: .05 gal + 9 lb N/A).

Symbex soil inoculant was applied May 1 and corn (Pioneer 3780) was planted at a rate of 26,100 ppA in 30-inch rows with 1 lb Furadan/A on May 15. The Symbex plots received Sym-Coated seed. Chemical weed control consisted of 3 lb Lasso/A plus 2½ lb Bladex/A applied preemergence. The nitrogen for the Symbex + 30 lb N/A treatment was sidedressed as feed-grade urea and the 175 lb N/A treatment was sidedressed as fertilizer-grade urea. The addition of 30-lb N/A to the Symbex treatment was done at the request of Agro-K because the Symbex soil inoculant was spring-applied rather than fall-applied. Both sidedressed treatments were cultivated in after application on June 17. Sym-Spray plus 9 lb N/A as feed-grade urea was applied to the Symbex treatments on July 24 just prior to tasseling. After the yields were determined the corn was removed as silage.

1979

The 1979 plots were superimposed over the 1978 plots to retain the accumulative effect of the treatments. Symbex plots thus received the soil inoculant in the spring of 1978 and again on November 7, 1978. In 1979 the Symbex plots also received the Sym-Coat and Sym-Spray treatments at the same rates as in 1978.

Soil samples taken after the 1978 crop indicated a NPK fertilizer recommendation of 160 + 80 + 100 lb/A (oxide basis). It was suggested by Agro-K to split the fertilizer treatment: (a) 100% NPK (160 + 80 + 100 lb/A) and (b) 50% NPK (80 + 40 + 50 lb/A). Each fertilizer rate was applied with and without the Symbex system and was superimposed by splitting the plots established in 1978 (the Symbex + 30 lb N and the 175 lb N treatments). The other treatments included in the experiment were the Symbex system alone and a check. Treatments were again arranged in a four-replicate, randomized, complete-block design. Corn (Pioneer 3780) was planted at a rate of 26,100 ppA in 30-inch rows with 1 lb Counter/A on May 18. Chemical weed control consisted of 3 lb Lasso plus 2½ lb atrazine/A applied pre-emergence. Sym-Spray plus 9 lb N/A as feed-grade urea was applied to the Symbex treatments on July 26.

In both years the leaf opposite and below the ear was sampled from 12 plants at silking and submitted for chemical analyses. Silage yields were obtained at physiological maturity (black layer stage) from 10 feet of row in 1978 and 20 feet of row in 1979. In both years corn grain yield, moisture and protein were determined on corn harvested from 40 feet of the center two rows. The grain data were collected at physiological maturity and yields were converted to 15.5% moisture because the corn in the plot area was to be removed as silage.

Results

1978

The nutrients N, P, Mg, Mn, Zn, and Cu were all increased significantly in the corn leaf with the addition of 175 lb N/A (Table 1). Symbex without the 30 lb N treatment had no effect on leaf nutrient concentration. Symbex + 30 lb N/A did tend to increase some of the nutrient concentrations probably due to the added nitrogen; however, none of these increases was statistically significant.

Table 1. Influence of Symbex on the nutrient concentrations in the corn leaf at Waseca in 1978.

Treatment	Nutrient[1] N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
Check	1.79	.19	1.58	.62	.43	119	37	22	5.2	9
Symbex	1.91	.20	1.59	.57	.44	109	39	20	4.6	9
Symbex + 30 lb N/A	2.10	.21	1.60	.60	.45	120	40	25	5.7	9
175 lb N/A	2.58	.24	1.51	.64	.53	124	51	32	7.8	9
Signif. :	*[2]	+	NS	NS	**	NS	**	**	**	NS
BLSD(.05):	.58				.04		8	6	1.3	
CV (%) :	16.2	12.3	6.5	8.8	5.2	11.1	11.5	14.6	14.1	9.4

[1] Leaf opposite and below the earleaf was sampled at silking.

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

Silage yield, grain yield and grain protein with the 175 lb N/A treatment were significantly higher than with any of the other treatments (Table 2). The Symbex + 30 lb N/A treatment resulted in a significantly better grain yield than the check and significantly higher grain protein than the check and the Symbex treatment. This indicates that the additional 30 lb N/A with the Symbex caused the increase in protein percentage. These results show that Symbex did not enhance corn production in south-central Minnesota in 1978.

Table 2. Influence of Symbex on corn yields, protein, and moisture content at Waseca in 1978.

Treatment	Yield: Silage	Yield: Grain	Grain: Moisture	Grain: Protein
	T DM/A	bu/A	%	%
Check	3.85	73.6	43.1	5.88
Symbex	4.69	77.1	43.0	6.00
Symbex + 30 lb N/A	4.80	92.2	41.2	7.12
175 lb N/A	5.82	112.8	40.2	9.81
Significance:	**	**	NS	**
BLSD (.05) :	.96	16.7		.88
CV (%) :	12.3	11.8	4.3	8.6

After harvest soil samples were taken from each plot and submitted for a complete soil analysis by Harris Laboratories (Table 3). The resulting data indicate that the various treatments had little effect over the background level of the check treatment.

Table 3. Influence of Symbex on soil test results at Waseca in 1978.

Treatment	OM	pH	NO_3-N	P	K	Ca	Mg	Na	S	Fe	Mn	Zn	Cu	B
	%	ppm												
Check	3.2	6.2	4.0	16	100	2325	400	22	10	60.8	8.0	.9	.7	1.2
Symbex	4.1	6.2	2.5	11	98	2375	452	21	10	68.6	9.0	1.0	.7	1.0
Symbex + 30 lb N/A	3.2	6.2	2.2	13	112	2350	395	20	9	58.0	9.1	1.0	.8	1.0
175 lb N/A	3.4	6.0	5.0	13	98	2375	372	20	10	68.4	9.2	1.0	.7	1.0

1979

Nutrient concentrations of N, P, Ca, Mg, Fe, Zn and Cu in the corn leaf showed the check and Symbex treatments to be significantly inferior when compared to the fertilizer treatments either with or without Symbex (Table 4). The 100% NPK with or without Symbex was significantly better than the 50% NPK with or without Symbex with respect to N, P and K. The 100% NPK with or without Symbex and the 50% without Symbex treatments resulted in significantly more Mn than the other treatments. Nutrient concentrations of B in the corn leaf showed no significant differences among the treatments. These nutrient concentration data give no indication that the Symbex treatments result in consistent increases in nutrient uptake by corn.

Table 4. Influence of Symbex on the nutrient concentrations in the corn leaf at Waseca in 1979.

Treatment	Nutrient[1/] N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
Check	1.26	.174	1.38	.53	.43	70	30	18	3.0	7
Symbex	1.42	.188	1.35	.55	.48	75	34	18	3.1	8
50% NPK(bdct)	2.61	.241	1.31	.72	.65	87	56	38	6.3	7
Symbex + 50% NPK(bdct)	2.44	.240	1.38	.71	.66	86	42	38	6.3	8
100% NPK(bdct)	2.78	.262	1.44	.72	.62	90	72	40	7.0	7
Symbex + 100% NPK(bdct)	2.84	.278	1.57	.67	.59	92	59	38	6.9	8
Significance:	**	**	**	**	**	**	**	**	**	NS
BLSD (.05) :	.17	.017	.13	.09	.05	7	14	5	.8	
CV (%) :	5.7	5.6	6.0	9.1	6.8	6.0	20	7.1	10	14

1/ Leaf opposite and below the earleaf was sampled at silking.

The nutrient concentrations in the fodder as affected by the treatments are somewhat difficult to interpret (Table 5). Significantly higher concentrations of P and Zn were found with the check and Symbex treatments. This may be explained as a concentration of these elements due to the very low dry matter accumulations shown with these two treatments (Table 6). The NPK treatments resulted in lower P and Zn levels with no difference shown for the addition of Symbex. Concentrations of N, K, Ca, Mg and Cu were generally increased by the NPK treatments with and without Symbex over the check and Symbex treatments. With the exception of K, the addition of the Symbex did not appear to increase nutrient levels in the corn fodder.

Table 5. Influence of Symbex on the nutrient concentrations in the corn fodder at Waseca in 1979.

Treatment	Nutrient[1/]									
	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
Check	.36	.118	.61	.27	.26	58	47	24	1.1	6
Symbex	.42	.073	.64	.27	.26	50	51	26	1.2	5
50% NPK(bdct)	.48	.046	.67	.38	.38	51	51	14	1.5	5
Symbex + 50% NPK(bdct)	.51	.043	.74	.33	.33	42	43	16	1.6	5
100% NPK(bdct)	.66	.054	.80	.41	.37	58	60	19	1.9	5
Symbex + 100% NPK(bdct)	.51	.048	1.00	.35	.33	52	40	14	2.1	5
Significance:	**	**	**	**	**	NS	NS	**	**	NS
BLSD (.05) :	.13	.012	.10	.07	.07			4	.5	
CV (%) :	18	14	9.8	14	14	18	20	16	20	10

[1/] Corn silage minus the grain.

Grain yields showed the check to be inferior to all other treatments and the Symbex significantly inferior to all the NPK treatments (Table 6). The 100% NPK treatments were significantly better than the 50% with no significant advantage for the addition of Symbex. One possible explanation for the Symbex being superior to the check for grain yield could be the addition of the 9 lb N/A supplied in the Sym-Spray. This is theorized because of the greener color and increased vigor of the plants after the Sym-Spray + 9 lb N/A application. Silage yields show that the check and Symbex were inferior to the NPK treatments with the 100% significantly better than the 50% and no effect of Symbex. Protein was increased significantly by the NPK treatments over the check and Symbex treatments. The 100% NPK treatments contained more protein than the 50% treatments with no advantage from the addition of Symbex. For grain moisture the 100% NPK treatments and the Symbex + 50% NPK were significantly better than the check and Symbex alone.

Table 6. Influence of Symbex on corn yields and moisture and protein content at Waseca in 1979.

Treatment	Yield		Grain	
	Silage	Grain	Moisture	Protein
	T DM/A	bu/A	%	%
Check	3.87	67.8	47.6	5.38
Symbex	4.18	79.0	47.8	5.53
50% NPK (bdct)	6.98	139.7	45.4	7.42
Symbex + 50% NPK (bdct)	6.97	143.8	43.6	7.08
100% NPK (bdct)	7.60	152.1	43.5	8.24
Symbex + 100% NPK (bdct)	7.64	158.0	43.9	8.34
Significance:	**	**	*	**
BLSD (.05) :	.34	8.9	3.2	.68
CV (%) :	4.1	5.4	4.4	7.2

Summary

Nutrient concentrations in the corn leaf were not affected by Symbex in either year. The nutrient concentrations in the fodder were not increased with the addition of Symbex except for K in 1979. Thus nutrient uptake by corn does not appear to be consistently increased by Symbex. Silage yield was not affected by Symbex in 1978 or 1979. The only positive effect Symbex had on grain yield was an increase over the check treatment in 1979. This increase was possibly due to the 9 lb N/A supplied in the Sym-Spray treatment. Grain yields with the N or NPK treatments were vastly superior to those from the Symbex alone treatment. Symbex had no effect on protein in this two-year study. At this time we would not recommend the Symbex system for corn production in Minnesota.

DEEP SAMPLING OF SOILS FOR RESIDUAL NITRATES AND ITS POTENTIAL AS A DIAGNOSTIC TECHNIQUE FOR CORN PRODUCTION IN SOUTHWESTERN MINNESOTA

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The rates of fertilizer nitrogen recommended for corn production in Minnesota are currently based upon yield goal and previous cropping history. In many respects depending on the climatic conditions, these recommendations have the potential of being either too high or too low. Research experiments were therefore, established with the following objectives: 1) To determine if the residual nitrates within the top five feet of soil or to a lesser depth could be used in predicting nitrogen fertilizer requirements for corn; 2) To evaluate fall vs. spring soil sampling; 3) to ascertain the importance of nitrate accumulation and movement within the soil profile.

Experimental Procedures

Nine locations in southwestern Minnesota were established in the fall of 1978. One location was located on the Southwest Experiment Station-Lamberton, one at the West-Central Experiment Station-Morris, and seven locations on farmer cooperator fields (Table 1). At each location, four treatments were established with four replications. The four treatments were applied as fall applications of ammonium nitrate at rates of 0, 40, 80, and 120 #N/A. Soil samples were collected from each plot prior to fertilizer application in the fall and from the control plots (zero N/A) in the spring. Samples were collected to a depth of five feet in increments of one foot, except for the surface which was split into six inch increments. All samples were analyzed for nitrate nitrogen and soil moisture (Table 3). All cooperators were asked to follow normal management practices for the areas except for nitrogen fertilization or manure application. Treatments were evaluated by obtaining leaf samples from opposite and below the ear at silking for nitrogen analysis, grain yields and nitrogen utilization by the grain (Table 2).

Grain Results

Of the nine locations established for 1979, one location was lost due to hail (location 3); three locations showed significant positive yield increases due to nitrogen application, and five locations revealed no significant yield response to applied nitrogen. Other nitrogen utilization characteristics would suggest that location 1 which did not show a significant yield response should be included into the areas which responded favorably to nitrogen fertilization.

Nitrogen content in leaf tissue at silking time was influenced by the nitrogen treatments on seven out of eight locations. Three of these locations were, however, above the critical level (2.5-2.7%) even on the control so we would not expect a yield response. The four locations where nitrogen was limiting correspond to the same locations that provided yield responses. Nitrogen content in the grain and total nitrogen removal with grain, substantiate the fact that four locations did not respond to nitrogen fertilization while four locations responded to at least the first increment of nitrogen fertilization.

Yields and nitrogen utilization appeared to be highly correlated with soil nitrate nitrogen. The two foot nitrate nitrogen test currently used for small grains and sugarbeets in this area of the state did not do a satisfactory job in predicting nitrogen needs. Most locations ranged from 40-80 pounds of NO_3^--N in the top two feet, which would not provide the necessary flexibility for making fertilizer recommendations. Inclusion of the nitrate nitrogen to a depth of four feet did a much better job in predicting nitrogen responses. On seven out of eight locations, if the total nitrate nitrogen in the top four feet was greater than 150 #N/A yield responses were not obtained. In only one location (8) did the four foot sample nitrate soil sample not make an accurate prediction of nitrogen response.

The use of a nitrate test for making fertilizer recommendations for corn appears to be a promising technique. Additional research to verify the depth necessary for sampling and the availability of the deeper soil nitrates under varying climatic conditions appear to be warranted.

Table 1. Location number, cooperator and county of the experimental site.

Location No.	Cooperator	County
1	Charles Anderson	Yellow Medicine
2	Cornelius Boerboom	Lyon
3	Clarence Feste	Murray
4	Donald Lensing	Redwood
5	Lamberton Station	Redwood
6	Carsten Madsen	Lincoln
7 (8)	Morris Station	Stevens
8 (9)	Lawrence Quade	Cottonwood
9 (12)	Donald Werner	Pipestone

Table 2. Influence of nitrogen treatments on grain yield, leaf N at silking, grain N and grain nitrogen removal at eight locations in S.W. Minnesota.

Nitrogen Rate	Location No. 1	2	4	5	6	8	9	12
#/A	Yield-bu/A							
0	125.2	90.0	137.9	127.6	132.2	92.5	115.7	75.1
40	127.3	109.1	128.4	131.6	131.8	109.8	136.2	82.9
80	132.4	109.2	140.6	129.7	124.9	114.0	134.4	96.8
120	143.0	117.2	138.4	131.3	133.1	124.8	129.3	84.2
Signif.	NS	**	NS	NS	NS	*	**	NS
BLSD(.05)	-	14.6	-	-	-	21.1	7.2	-
	Leaf N-%							
0	2.06	2.18	2.93	2.63	2.67	2.21	2.54	2.41
40	2.46	2.26	2.68	2.61	2.78	2.52	2.88	2.59
80	2.74	2.30	2.73	2.76	3.00	2.62	2.95	2.37
120	2.24	2.60	3.06	2.78	2.97	2.64	2.98	2.63
Signif.	**	+	*	NS	**	*	**	*
BLSD(.05)	0.24	0.28	0.29	-	0.19	0.27	0.26	0.21
	Grain N %							
0	1.19	1.24	1.21	1.44	1.46	1.33	1.34	1.14
40	1.32	1.13	1.20	1.43	1.42	1.37	1.49	1.15
80	1.41	1.18	1.22	1.36	1.48	1.41	1.62	1.24
120	1.41	1.24	1.26	1.43	1.50	1.48	1.57	1.25
Signif.	**	+	NS	NS	NS	+	**	NS
BLSD(.05)	0.09	0.09	-	-	-	0.10	0.10	-
	N Removal with Grain-#/A							
0	70.6	52.7	78.7	87.1	91.1	58.3	73.7	40.8
40	79.4	58.3	72.8	89.1	88.8	71.4	96.1	46.2
80	88.5	60.8	80.9	83.7	87.4	76.2	103.2	56.6
120	95.5	68.8	82.7	89.1	94.1	87.1	96.1	50.5
Signif.	**	*	NS	NS	NS	**	**	NS
BLSD(.05)	13.3	8.8	-	-	-	14.2	9.7	-

Table 3. Residual nitrate nitrogen content by depth at nine experimental locations in S.W. Minnesota measured in the fall and spring before the growing season

depth -ft-	Nitrate Nitrogen - #/A depth increment					
	Loc. 1(Soybeans)		Loc. 2(Soybeans)		Loc. 3(Corn)	
	Fall	Spring	Fall	Spring	Fall	Spring
0-½	14	14	16	18	12	29
½-1	9	11	13	9	21	30
1-2	18	25	13	17	42	45
2-3	31	29	12	17	53	30
3-4	34	31	14	16	31	23
4-5	22	25	15	14	19	14
TOTAL	128	135	83	91	178	171

	Loc. 4(Soybeans)		Loc. 5(Sunflowers)		Loc. 6(Corn)	
	Fall	Spring	Fall	Spring	Fall	Spring
0-½	18	26	21	25	24	23
½-1	15	30	19	18	17	19
1-2	18	28	29	27	22	24
2-3	40	28	37	41	40	30
3-4	57	113	43	82	61	52
4-5	57	125	37	60	50	52
TOTAL	205	350	186	253	214	200

	Loc. 8(Corn)		Loc. 9(Soybeans)		Loc. 12(Corn)	
0-½	19	19	31	22	12	38
½-1	11	14	13	16	11	18
1-2	37	34	17	34	14	34
2-3	64	50	25	23	15	32
3-4	41	26	27	19	18	68
4-5	26	18	30	21	19	42
TOTAL	198	161	143	135	89	232

( ) = previous crop

ECO-GRO STUDIES ON CORN

Lamberton and Morris, 1979

S. D. Evans and W. W. Nelson

The product Eco-Gro is a low analysis liquid fertilizer manufactured mainly from liquid fish and seaweed. It contains 6 lbs of pure fish per gallon with 4% seaweed added. In addition it is fortified with urea, phosphoric acid and potassium hydroxide ending up with a product with an 8-4-4 (N-P_2O_5-K_2O) analysis. It is to be used on corn as a supplement to the standard fertilizer program. Instructions for corn were to make one application of 1 quart per acre as a foliar spray when the corn was 24-30 inches tall and 1 quart per acre 8-10 days before tasseling.

The objectives of the experiments were to measure the effect of Eco-Gro on corn yield and nutrient uptake and to compare this with conventional fertilizer materials.

Treatment Description - Lamberton

1. Check - No fertilizer material of any kind added.

2. 1 qt/A of Eco-Gro (8-4-4) applied as a foliar spray on July 16 (corn 20 inches tall) and 1 qt/A of Eco-Gro on August 1 (10 days prior to tasseling)--both applied with Wex, a wetting agent.
   Total plant food ($N + P_2O_5 + K_2O$) = 0.39 + 0.19 + 0.19.

3. 65.6 lbs/A of N as urea prior to planting plus 154 lbs/A of 10-26-26 starter. Total plant food = 80.00 + 40.00 + 40.00.

4. Combination of treatments 2 and 3, but corn 36 inches tall on July 16 and first tasseling on August 1.
   Total plant food = 80.39 + 40.19 + 40.19.

5. 103.3 gal/A of Eco-Gro applied prior to planting and worked into the soil. Total plant food = 80.00 + 40.00 + 40.00.

Treatment Description - Morris

1. Check - No fertilizer material of any kind added.

2. 1 qt/A of Eco-Gro (8-4-4) applied as a foliar spray on July 6 (corn 29 inches tall) and 1 qt/A of Eco-Gro on July 25 (corn tasseled on August 4)--both applied with Wex, a wetting agent.
   Total plant food ($N + P_2O_5 + K_2O$) = 0.39 + 0.19 +0.19.

3. 65.6 lbs/A of N as urea prior to planting plus 154 lbs/A of 10-26-26 starter. Total plant food = 80.00 + 40.04 + 40.04.

4. Combination of treatments 2 and 3, but corn was 43 inches tall on July 6 and tasseled on July 30. Total plant food = 80.39 + 40.23 + 40.23.

5. 103.3 gal/A of Eco-Gro applied prior to planting and worked into the soil. Total plant food = 80.00 + 40.00 + 40.00.

The yield data for the trials at Lamberton and Morris for 1979 are given in Table 1. At Lamberton there were highly significant (**) differences in both silage and grain yield with treatments 1 and 2 lower yielding than 3, 4, and 5. The Eco-Gro foliar treatments--2 and 4--did not increase yields significantly over treatments 1 and 3, respectively. Treatment 5 was not significantly different from the conventional treatment 3.

At Morris there were again highly significant differences in both silage and grain yields. Treatments 1 and 2 were lower yielding than all other treatments. The silage yield for treatment 5 was significantly lower in yield than the conventional treatment. The Eco-Gro foliar treatments--2 and 4--did not increase yields significantly over Treatments 1 and 3, respectively.

The economic analysis (Table 2) shows that the conventional treatment resulted in the highest return over the check at both Lamberton and Morris. In treatments 2 and 4 where Eco-Gro was used as a foliar spray, the return over the check was less than where Eco-Gro was not used. Treatment 5, the Eco-Gro soil treatment, resulted in a loss of over $2200/A because of the high cost of the Eco-Gro needed to provide sufficient nutrients for the corn. At both Lamberton and Morris, the lowest plant food cost was with the conventional treatment.

Table 1. Silage and Grain Yields in 1979.

	Silage Yield (Tons/A)		Grain Yield (Bu/A)	
Treatment	Lamberton	Morris	Lamberton	Morris
1. Check	3.6	3.2	37.6	38.2
2. Eco-Gro (foliar)	3.6	3.3	36.6	38.4
3. Conventional	4.6	6.2	82.8	83.8
4. Conventional + Eco-Gro (foliar)	5.3	5.6	86.6	73.9
5. Eco-Gro (soil)	4.6	5.1	79.5	73.8
Significance	**	**	**	**
Bayes LSD (5%)	0.8	0.8	8.4	11.9

Table 2. Economic Return* Based on Corn Grain Yield.

Treatment	Extra Corn over Check (Bu/A)	Value of Corn ($)	Total Fertilizer Cost ($)	Plant Food Cost ($/lb)	Return† over Check ($)
2. Eco-Gro (foliar)					
Lamberton	-1.0	-2.25	11.20	14.55	-13.45
Morris	+0.2	+ .45	11.20	14.55	-10.75
3. Conventional					
Lamberton	+45.2	+101.70	24.12	.15	+77.58
Morris	+45.6	+102.60	24.12	.15	+78.48
4. Conventional + Eco-Gro (foliar)					
Lamberton	+49.0	+110.25	35.32	.22	+74.93
Morris	+35.7	+80.33	35.32	.22	+45.01
5. Eco-Gro (soil)					
Lamberton	+41.9	+94.28	2314.95	14.47	-2220.67
Morris	+35.6	+80.10	2314.95	14.47	-2234.85

* Prices used: Eco-Gro - $22.41/gallon, urea - 20¢/lb of N, 10-26-26 - $144/ton, and corn - $2.25/bushel.

† If anhydrous ammonia @ 13¢/lb of N were used as the broadcast N source in treatments 2 and 3, increase return on these treatments by $4.59/acre.

HIGH PHOSPHORUS AND POTASSIUM RATES FOR CONTINUOUS CORN

1979

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

EXPERIMENTAL PROCEDURES

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

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

Trt. No.	Application Year (Fall) 1973	1974,'75,'77	1976	1978
	----------lbs. P_2O_5 + K_2O/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	150 + 100	0 + 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 + 150	100 + 0
9	150 + 100	0 + 0	0 + 0	150*+ 100
10	100 + 150	0 + 0	0 + 0	100 + 150*

* Was not applied at Lamberton.

Treatment numbers 2-10 were broadcast on cornstalks and plowed down at all locations in the fall of 1978. Phosphorus was applied as CSP (0-46-0) and K as muriate of potash (0-0-60). Starter fertilizer was not used.

Specific experimental procedures used at each of the stations are presented in Table 2. Management practices providing for optimum yields were employed at each location. Nitrogen rates were slightly higher than optimum. Plant populations were increased in 1979.

Table 2. Experimental procedures for the high P and K rate study on continuous corn at the three branch stations in 1979.

Variable	Lamberton	Morris	Waseca
Planting date	5/17	5/16	5/18
Row spacing	30"	30"	30"
Population	25,000	25,000	30,000
Hybrid	Pioneer 3780	Dekalb XL12	Pioneer 3732
Nitrogen rate	125#N	110#N	200#N
Herbicide	2½# Eradicane + 1½# Bladex/A (Bdct)	2½# Lasso + 2½# Bladex/A (Bdct)	3# Lasso + 2½# Atrazine/A (Bdct)
Insecticide	1# Counter/A	1.3# Lorsban/A	1# Furadan/A
Harvest date	10/25	10/17	10/20

RESULTS AND DISCUSSION

Soil samples were taken at the end of the 1979 growing season. Results obtained in 1979 were quite similar to those obtained in 1978. Soil test P was affected significantly at all three locations (Table 3). There appeared to be a linear response to annual P application. Soil test P was always lowest with treatments 1 and 2, which received no P, and treatments 9 and 10, which received an initial application in 1973 and again in 1978. Intermediate P levels were found with treatment 3 (50 lb P_2O_5 annually) and treatment 5 (150 lb P_2O_5 every third year). Highest soil test P values were associated with the annual 100 lb P_2O_5 treatments at all locations. Use of the 1:50 soil to Bray P_1 solution ratio on the calcareous Aastad soil at Morris indicates high amounts of extractable P in this soil; over twice that indicated by the 1:10 ratio.

Soil test K was influenced (P=.05) for the first time by the K treatments at Lamberton and Morris but not at Waseca (Table 3). The response to the annual K applications was not as pronounced as with P. Soil pH was not related to the P and K treatments.

Approximately 5-6 weeks after planting, ten plants randomly selected from each plot were measured, harvested, dried and weighed to determine early plant growth. Early plant weight was increased significantly (P=.01) by the treatments at all three locations (Table 4). Plant height at Morris and Waseca were increased significantly but was not at Lamberton. Both plant weight and height were generally lowest with the check treatment (no. 1), the 0 P_2O_5 treatment (no. 2) and the two treatments which were not applied between 1973 and 1978 (nos. 9 and 10). The growth response was due primarily to P. Early weight was increased over the 0 P_2O_5 rate (no. 2) by the 50 and 100 lb P_2O_5 rates by 0 and 25% at Lamberton, 10 and 23% at Morris, and 35 and 56% at Waseca, respectively. No effect of K was noticed except at the Waseca location where a 26% weight increase was noted with the 100 lb K_2O treatment.

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

Treatment No.	Description[2]	pH La	pH Mo	pH Wa	P La	P M_{10}	P M_{50}	P Wa	K La	K Mo	K Wa
	lb P_2O_5+K_2O/A				lb/A						
1	0 + 0	5.8	7.6	5.9	40	9	29	27	266	366	237
2	0 + 100	5.8	7.7	5.9	37	10	32	22	332	464	251
3	50 + 100	6.3	7.7	5.8	50	31	80	41	342	444	255
4	100 + 100	5.8	7.6	6.0	62	53	136	61	316	460	269
5	0 + 100	5.9	7.6	5.9	62	30	74	40	310	426	253
6	100 + 0	5.7	7.6	6.0	76	60	144	54	265	360	237
7	100 + 50	5.8	7.6	6.0	71	52	135	54	326	410	244
8	100 + 0	5.9	7.5	5.8	72	72	163	54	292	391	241
9	150 + 100	6.2	7.6	6.0	36	18	47	37	274	397	244
10	100 + 150	5.8	7.6	6.1	40	13	40	29	277	411	248
Significance:[3]		NS	NS	NS	**	**	**	**	**	**	NS
BLSD(.05)	:				14	9	19	16	39	46	
CV(%)	:	5.3	27	3.5	19	21	16	26	8.6	7.7	6.7

[1] Samples were taken in October before the 1979 treatments were applied.

[2] Rates applied in fall of 1978 for 1979 crop. Treatments 9 and 10 had received 0 + 0 lb P_2O_5 + K_2O/A since 1973.

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

Table 4. Early plant growth characteristics as influenced by high P and K rates at the three experimental sites in 1979.

Treatment No.	Description	Weight La	Weight Mo	Weight Wa	Height La	Height Mo	Height Wa
	lb P_2O_5+K_2O/A	g/dry plant			---inches----		
1	0 + 0	2.9	6.4	4.6	16	24	24
2	0 + 100	3.2	6.1	4.3	16	26	24
3	50 + 100	3.1	6.7	5.8	16	28	26
4	100 + 100	4.0	7.5	6.7	17	30	27
5	0 + 100	3.3	6.6	4.5	16	29	24
6	100 + 0	4.2	7.2	5.3	16	28	25
7	100 + 50	4.4	7.1	5.9	18	29	26
8	100 + 0	4.0	7.6	5.5	17	30	26
9	150 + 100	2.9	5.9	5.2	17	26	24
10	100 + 150	3.4	6.5	5.1	17	26	24
Significance:		**	**	**	NS	**	**
BLSD(.05)	:	.8	.8	1.1		1.9	1.3
CV(%)	:	15	7.7	14	9.1	5.0	3.6

Table 5. Effect of high P and K rates on the nutrient concentrations in the small whole plants at the three experimental sites in 1979.

Treatment No.	Description (lb P_2O_5+K_2O/A)	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%				ppm				
						Lamberton				
1	0 + 0	.37	3.74	.58	.48	620	74	48	7.8	9.4
2	0 + 100	.40	4.48	.51	.39	655	69	43	8.1	9.8
3	50 + 100	.42	4.35	.54	.42	748	71	39	7.6	10.1
4	100 + 100	.43	4.52	.54	.40	606	71	38	6.5	9.4
5	0 + 100	.41	4.38	.56	.42	764	77	50	7.8	10.6
6	100 + 0	.42	3.85	.65	.50	689	84	43	6.5	9.9
7	100 + 50	.42	4.36	.54	.40	646	74	42	6.5	9.7
8	100 + 0	.44	3.91	.60	.44	654	75	39	6.8	10.2
9	0 + 100	.41	3.85	.60	.47	581	74	45	8.4	11.0
10	100 + 0	.40	4.18	.58	.45	673	76	47	7.7	9.6
	Significance:	**	**	**	**	NS	NS	NS	**	NS
	BLSD(.05) :	.02	.41	.04	.04				.8	
	CV(%) :	4.1	6.6	5.4	6.9	13	12	16	7.6	10
						Morris				
1	0 + 0	.36	3.51	.54	.47	1040	88	45	8.9	5.8
2	0 + 100	.35	4.06	.50	.45	969	87	48	8.8	5.9
3	50 + 100	.40	4.01	.54	.44	1098	87	39	8.6	5.7
4	100 + 100	.42	4.22	.55	.45	776	81	36	8.0	5.7
5	0 + 100	.39	4.21	.51	.46	889	83	43	8.1	5.6
6	100 + 0	.44	3.31	.64	.55	920	90	35	8.3	5.5
7	100 + 50	.43	3.70	.59	.48	856	82	34	8.0	5.4
8	100 + 0	.41	3.52	.64	.51	1169	96	36	8.0	6.0
9	150 + 100	.38	3.26	.60	.58	1104	95	44	8.9	5.8
10	100 + 150	.34	3.23	.60	.51	1296	100	44	9.3	6.2
	Significance:	**	**	*	**	NS	NS	*	**	NS
	BLSD(.05) :	.05	.42	.09	.07			7	.6	
	CV(%) :	8.1	7.9	10	9.1	38	18	11	4.6	9.6
						Waseca				
1	0 + 0	.34	3.23	.50	.40	659	55	40	7.2	8.8
2	0 + 100	.34	3.90	.42	.29	634	51	40	7.2	8.7
3	50 + 100	.35	4.03	.44	.31	749	52	39	7.0	8.0
4	100 + 100	.39	4.02	.45	.31	566	49	34	5.7	7.8
5	0 + 100	.34	3.80	.45	.33	597	51	39	7.2	8.8
6	100 + 0	.39	3.06	.52	.39	642	53	34	6.2	8.4
7	100 + 50	.36	3.44	.48	.34	768	53	36	5.9	8.2
8	100 + 0	.37	3.26	.50	.38	636	54	39	6.2	8.3
9	150 + 100	.36	3.54	.48	.35	560	50	35	6.6	8.4
10	100 + 150	.36	3.75	.47	.33	682	51	42	7.0	8.7
	Significance:	**	**	**	**	NS	NS	+	**	+
	BLSD(.05) :	.04	.41	.03	.05				.9	
	CV(%) :	6.0	7.9	5.1	10	20	12	9.8	8.8	5.6

Table 6. Effect of high P and K rates on the nutrient concentrations in the corn leaf at the three experimental sites in 1979.[1]

Treatment No.	Description (lb P_2O_5+K_2O/A)	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%				ppm				
					Lamberton					
1	0 + 0	.24	1.68	.60	.42	87	53	22	3.2	9.0
2	0 + 100	.23	1.86	.54	.34	84	36	19	2.7	9.2
3	50 + 100	.23	1.82	.56	.36	78	37	16	2.8	10.1
4	100 + 100	.24	1.92	.56	.37	81	40	16	2.7	8.5
5	0 + 100	.23	1.88	.54	.35	83	40	18	2.9	9.1
6	100 + 0	.25	1.69	.63	.42	83	51	17	2.7	8.9
7	100 + 50	.25	1.90	.56	.36	83	44	18	3.2	8.9
8	100 + 0	.26	1.81	.61	.40	86	45	16	3.0	9.8
9	150 + 100	.24	1.81	.61	.40	86	44	20	3.5	9.3
10	100 + 150	.25	1.74	.60	.42	87	44	20	3.0	8.9
	Significance:	+	+	**	**	NS	NS	*	NS	+
	BLSD(.05) :			.05	.05			4		
	CV(%) :	5.4	6.5	5.5	8.1	6.7	19	14	16	7.3
					Morris					
1	0 + 0	.24	1.72	.55	.59	14	61	29	5.7	5.2
2	0 + 100	.23	1.93	.53	.53	14	56	28	5.0	4.9
3	50 + 100	.29	2.06	.60	.54	14	60	21	5.1	4.3
4	100 + 100	.32	2.06	.62	.58	16	67	20	5.3	5.1
5	0 + 100	.29	1.95	.56	.57	14	63	22	5.3	4.6
6	100 + 0	.33	1.77	.64	.68	15	76	18	5.0	5.0
7	100 + 50	.32	1.83	.60	.63	15	70	19	5.5	5.0
8	100 + 0	.31	1.88	.64	.61	15	69	21	5.0	4.5
9	150 + 100	.29	1.69	.61	.69	14	73	24	5.6	4.8
10	100 + 150	.27	1.76	.56	.63	14	66	25	5.4	4.5
	Significance:	**	**	*	**	**	**	**	NS	NS
	BLSD(.05) :	.03	.13	.07	.05	13	7	4		
	CV(%) :	8.6	4.8	7.7	6.2	5.7	7.7	12	13	11
					Waseca					
1	0 + 0	.28	1.58	.52	.44	101	74	29	7.8	5.5
2	0 + 100	.27	2.02	.46	.36	97	57	27	8.6	6.6
3	50 + 100	.28	1.95	.48	.36	100	70	26	7.6	6.4
4	100 + 100	.30	2.02	.48	.36	98	58	21	7.3	6.1
5	0 + 100	.28	1.93	.48	.39	99	62	25	7.7	6.6
6	100 + 0	.30	1.59	.54	.46	102	70	21	7.0	5.8
7	100 + 50	.29	1.77	.51	.40	99	70	22	6.8	5.6
8	100 + 0	.30	1.68	.52	.42	102	74	23	7.0	5.8
9	150 + 100	.28	1.82	.48	.42	97	63	24	7.3	6.0
10	100 + 150	.28	1.77	.51	.40	99	61	26	7.7	6.4
	Significance:	**	**	NS	**	NS	+	**	**	NS
	BLSD(.05) :	.01	.16		.04			3	.8	
	CV(%) :	3.4	6.4	8.2	7.4	5.0	13	9.3	6.6	16

[1] Leaf opposite and below the ear at silking.

The small plants were chemically analyzed with the results from all locations shown in Table 5. Concentrations of P, K, Ca, Mg and Cu were affected significantly by the treatments at all locations. Whole plant P and K were consistently increased by the P and K treatments while Ca and Mg were generally decreased by the K additions. The response to K rate was more linear than was the P response. Zinc concentrations were depressed by the 50 and 100 lb P_2O_5/A rates at Morris and to a lesser degree at Waseca.

Analysis of the leaf opposite and below the ear at silking indicated significant effects of the P and K treatments at all locations (Table 6). At Morris and Waseca, both leaf P and K were increased (P=.01) with increasing rates of P and K. At Waseca a linear response (P=.01) to applied K was noted with increased leaf K and decreased leaf Mg concentrations. A consistent effect of applied P or K on leaf P or K was not found (P=.05) at Lamberton. Leaf Zn concentrations were reduced by the P treatments at all sites.

Final populations were higher in 1979 than in previous years but significant differences were not found among the 10 treatments at all three sites (Table 7). Grain moisture an indication of maturity at harvest was affected inconsistently by both the treatments at Waseca (Table 7). At Morris grain moisture was reduced about 4 points by the P treatments but this difference was not significant (P=.10) due to the high variability.

The influence of the six years of P and K application on silage and grain yields for all three locations is given in Table 8. Silage yields were not increased significantly (P=.10) by the P and K treatments at Lamberton or Morris. At Waseca silage yields were improved significantly; primarily by the K treatments. For the first time in six years grain yield increases were significantly increased by the P treatments at Morris. The same trend was evident at Waseca but the 12 bu/A increase with the 50 and 100 lb P_2O_5 rates was not statistically significant at the 10% level even though the variability was quite low (CV=5.2). This quite vividly points out that even though yield increases are economical and may be highly profitable, statistical significance may not easily be shown at these <u>high</u> yield levels. Inconsistent significant yield differences were shown at Lamberton. However, yields were not increased over the check and did not appear to be related to either the P or the K treatments.

Table 7. Population and grain moisture at harvest as influenced by high P and K rates in 1979.

Treatment No.	Treatment Description	Final Population La	Final Population Mo	Final Population Wa	Grain Moisture La	Grain Moisture Mo	Grain Moisture Wa
	lb P_2O_5+K_2O/A	plants/A x 10^{-3}			-------%--------		
1	0 + 0	24.4	22.0	28.0	30.7	24.0	30.2
2	0 + 100	23.5	22.8	27.0	31.2	22.2	31.4
3	50 + 100	23.2	21.9	28.5	30.6	20.0	30.2
4	100 + 100	23.5	22.4	27.0	30.1	20.5	29.1
5	0 + 100	23.2	22.1	27.0	30.0	20.2	30.2
6	100 + 0	24.7	22.2	28.2	29.8	19.0	29.2
7	100 + 50	24.4	22.7	28.5	29.8	19.7	30.1
8	100 + 0	21.8	22.5	28.5	29.2	18.9	29.7
9	150 + 100	24.4	22.2	28.2	29.6	20.4	30.5
10	100 + 150	24.1	22.2	27.2	30.9	21.5	30.3
	Significance:	NS	NS	NS	NS	NS	**
	BLSD(.05) :						1.0
	CV(%) :	8.9	2.3	5.8	3.7	12	2.1

Table 8. Corn, silage and grain yields as influenced by high P and K rates in Minnesota in 1979.

Treatment No.	Treatment Description	Silage Yield La	Silage Yield Mo	Silage Yield Wa	Grain Yield La	Grain Yield Mo	Grain Yield Wa
	lb P_2O_5+K_2O/A	-----T DM/A-----			-------bu/A--------		
1	0 + 0	6.08	6.01	7.20	118.0	90.9	163.6
2	0 + 100	5.91	6.04	7.99	112.8	90.7	164.8
3	50 + 100	6.02	6.63	7.49	106.5	99.6	175.5
4	100 + 100	5.86	7.02	8.11	117.6	110.5	176.6
5	0 + 100	5.89	6.91	7.22	108.0	110.6	174.0
6	100 + 0	5.84	6.78	7.36	124.1	113.3	171.2
7	100 + 50	6.18	6.70	8.18	120.9	105.7	172.6
8	100 + 0	5.91	6.83	6.92	126.6	107.9	176.6
9	150 + 100	6.10	6.52	7.74	119.2	102.8	167.6
10	100 + 150	6.06	6.78	8.22	120.7	101.0	171.2
	Significance:	NS	NS	**	*	*	NS
	BLSD(.05) :			.79	13.8	17.5	
	CV(%) :	8.5	8.2	6.5	6.8	9.9	5.2

THE INFLUENCE OF NITRATE-NITROGEN IN THE SOIL PROFILE ON THE RESPONSE OF CORN TO NITROGEN FERTILIZER IN SOUTHEASTERN MINNESOTA - 1979 AND 1977-79 SUMMARY

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Nitrogen fertilizer recommendations for corn production in Minnesota are presently estimated on the basis of previous crop, yield goal, and soil organic matter level. These recommendations may be too high or too low in a given year depending on weather and other conditions. The purpose of this study is to evaluate use of a nitrate-nitrogen test to measure residual nitrogen in the soil profile as a means of refining nitrogen recommendations.

The 1979 study is a continuation of one started in 1977 in cooperation with farmers in 7 southeastern Minnesota counties - Dodge, Goodhue, Houston, Olmsted, Steele, Wabasha, and Winona. Soils range from the well-drained Fayette/Seaton and related silt loams in the hilly eastern part of the region to the level, poorly drained Skyberg, Floyd, and Webster soils in Dodge and Steele counties.

Experimental Procedures

On each farm a site was selected in a field to be planted to corn, avoiding fields where alfalfa was the preceding crop or where manure had been applied in the past year. Each site was sampled in the spring to a depth of 5 feet and samples were divided into the following increments for nitrate testing: 0-6", 6-12", 12-24", 24-36", 36-48", and 48-60". Farmers applied their normal rate of nitrogen on the field but left 3 or 4 alternating strips the width of their applicator without nitrogen. Grain yields and N content of the grain at harvest were determined for the nitrogen and no nitrogen treatments.

In 1979 N rates ranged from 100 to 170 pounds per acre with an average of 140. Liquid dairy manure at approximately 20 tons per acre was used in one case. In addition to this N rate a standard starter fertilizer rate supplying between 8 and 32 lbs. N per acre was applied on both N and no N strips.

The 0 to 6" surface soil samples were analyzed for pH, phosphorus, potassium, and organic matter. The average values and ranges are as follows:

pH	6.6 (5.9-7.9)	P	60 lbs/acre (23-151)
K	244 lbs/acre (160-360)		

Percent organic matter varied considerably from 2% to 8.5%. Actual values are shown in Table 2.

All but 2 of the 1979 sites were in corn the previous year, most for 2 or more years. One site was in soybeans (Hoschiet) and one in oats (Klemmenson).

1979 Results and Discussion

The amounts of nitrate-N found in different increments of the soil profile at each of the sites in spring of 1979 is shown in Table 1. All but 2 of the 14 sites tested between 40 and 120 lbs/acre in the top 2 feet. Nitrate-N in

Table 1. Nitrate-Nitrogen by Depth (Spring, 1979) and Soil Types at 14 Locations in Southeastern Minnesota.

Cooperator	Depth Increment 0-6"	6-12"	12-24"	24-36"	36-48"	48-60"	0-24"	0-36"	0-48"	0-60"	Soil Type*
	Nitrate-Nitrogen (lb/acre)										
Dodge County											
Moenning	35	30	39	34	30	20	104	138	168	188	Floyd si l
Rehwaldt	24	20	32	22	30	30	76	98	128	158	Skyberg/Kasson si l
Houston County											
Beranek	8	7	12	26	22	17	27	53	75	92	Rushford si l
Davison	16	18	30	29	28	49	64	93	121	170	not determined
Hempstead	25	28	39	34	25	36	92	126	151	187	Hokah l
Hoscheit	11	17	13	20	32	40	41	61	93	133	not determined
McCormick	32	24	47	49	68	68	183	232	300	368	Seaton si l
Olmsted County											
Pagel	16	12	12	8	10	21	40	48	58	79	Atkinson l
Randall	32	12	14	16	25	48	58	74	99	147	Port Byron si l
Steele County											
Abbe	36	28	56	65	30	20	120	185	215	235	Webster cl l
Klemmenson	28	15	10	8	10	9	53	61	71	80	Bixby l
Wabasha County											
Drysdale	16	14	25	26	28	26	55	81	109	135	Minnieska si l
Graner	14	12	19	14	12	13	45	59	71	84	Fayette si l
Winona County											
Redig	42	16	24	26	31	46	82	108	139	185	Fayette si l

*Determined from soil survey maps.

Table 2. N Rates, Grain Yields and % N, and Related Data for 14 Sites in Southeastern Minnesota. 1979.

Cooperator	N Rate* (lb/A)	Grain Yield (bu/A @15.5% M)		Yield Increase Due to N		Grain % N (D.W.)		Grain N Removal (lb/A)		Nitrate-N (lb/A, 0-2')	Soil %O.M.
		N	No N	bu/A	%	N	No N	N	No N		
Dodge County											
Moenning	150	150	149	1	1	1.51	1.46	107	103	104	8.3
Rehwaldt	165	166	140	26	19	1.69	1.52	133	101	76	4.3
Houston County											
Beranek	125	157	109	48	44	1.52	1.12	113	58	27	2.0
Davison	170	169	154	14	10	1.51	1.47	121	107	64	3.5
Hempstead	145	138	132	6	5	1.51	1.39	99	87	92	6.9
Hoschiet	130	136	117	19	16	1.60	1.46	103	81	41	3.9
McCormick	130	122	120	2	2	1.64	1.62	95	92	183	3.1
Olmsted County											
Pagel	150	138	109	19	17	1.78	1.40	116	72	40	3.7
Randall	150	122	108	14	13	1.57	1.44	91	74	58	4.4
Steele County											
Abbe	150	142	122	20	16	1.65	1.50	111	87	120	8.5
Klemmenson	135	147	122	25	20	1.69	1.32	118	76	53	4.0
Wabasha County											
Drysdale	100	153	126	27	21	1.74	1.42	126	85	55	3.0
Graner	125	125	115	10	9	1.47	1.42	87	77	45	2.2
Winona County											
Redig	20 tons manure	133	128	5	4	1.56	1.45	98	88	82	3.4

*An additional 8 to 32 lbs/A applied in starter on N and no N strips.

the 0 to 5' profile ranged from 79 to 368 lbs/acre. On the average 46% of this amount was found in the top 2 feet.

Yields with and without nitrogen and other related information are shown in Table 2. All yields were over 120 bu/acre with nitrogen. Average yields were 125 without and 143 with nitrogen for an 18 bu/acre response to N. In general yield response decreased with increasing nitrate-N. However, the Abbe site in Steele County showed a 20 bushel response to N even though nitrates were quite high, 120 lbs/acre in 0-2' and 235 in 0-5', and organic matter was 8.5%. The soil was a poorly drained Webster clay loam. Apparently the excessive rainfall this season caused a considerable amount of denitrification loss. At the Moenning site, which was also fairly high nitrates and a poorly drained Floyd soil, however, no N response occurred. But here the farmer-cooperator reported considerably lower rainfall in midsummer than much of the surrounding area.

Nitrogen content of the grain is reported in Table 2. In general where grain yields responsed well to nitrogen, percent N in the grain was also increased substantially by the addition of N. There was little effect on grain N where yields did not respond to N. Most of the N fertilized grain fell in the 1.5 to 1.7% range whereas those without N were 1.4 to 1.5% N. Substantial amounts of N were released by these soils, even without added N, as indicated by the amount of N removed in the grain.

Summary of 1977-1979 Results

Yield increases due to N application at various 2 ft. nitrate-N levels for the 50 site - years are summarized in Table 3. For sites with nitrate-N levels of 60 lbs/acre or less yield response to N was substantial, greater than 5 bu/acre in all cases. When nitrate-N was higher than 120, N responses were quite small, only one of 12 exceeding 5 bu/acre. In the intermediate range of 61 to 120 N response was variable, ranging from 0 to 27 bu/acre. About half of the sites in this range showed yield increases of greater than 5 bu/acre.

Table 4 shows average yield response and selected nitrate levels for each of the 3 years of the study. Average yield response to nitrogen was considerably greater in 1979 than in the 2 previous years. This corresponds to a lower average nitrate level in 1979 at both the 0 to 2 and 0 to 5 ft. depths.

Over the past 3 years 22 of the 50 sites, or 44%, showed a yield response of only 5 bu/acre or less. Most of these occurred in 1977. The dry weather and low yields of 1976 left higher than normal residual nitrogen, as measured by the high nitrate levels in spring of '77.

The percent increase in grain yield due to addition of nitrogen is correlated with the amount of nitrate-nitrogen (lbs/acre) in the top two feet prior to planting. The relationship for the 50 sites during the 3 years of trials is described by the following linear and quadratic equations:

$$y = 19.18 - .098\,x \qquad r = .566^{**}$$
$$y = 33.22 - .383\,x + .001\,x^2 \qquad r = .726^{**}$$

where y = % yield increase due to N fertilizer and x = lbs/acre nitrate-N in the 0 to 2 ft. depth.

Equations were developed for the 0-3', 0-4', and 0-5' nitrate-N values but r^2 values were lower than these for 0-2'. The linear and quadratic equations for percent yield increase vs. 0-2 ft. nitrate-N are graphed in Figure 1.

Table 3. Corn Grain Yield Increase Due to Nitrogen Fertilization at Various 0 to 2 ft. Nitrate-N Levels in Southwestern Minnesota. 1977-1979.[1/]

Nitrate N (lb/A, 0-2')	Number of Sites Total	Number of Sites N Response >5 bu/A	Yield Increase (bu/A)[2/] Average	Yield Increase (bu/A)[2/] Range
0-30	3	3	39	20-49
31-60	12	12	17	6-27
61-90	9	4	11	0-27
91-120	14	8	7	0-20
121-150	2	0	0	0-1
151-180	5	0	3	0-5
>180	5	1	4	1-8
TOTAL	50	28		

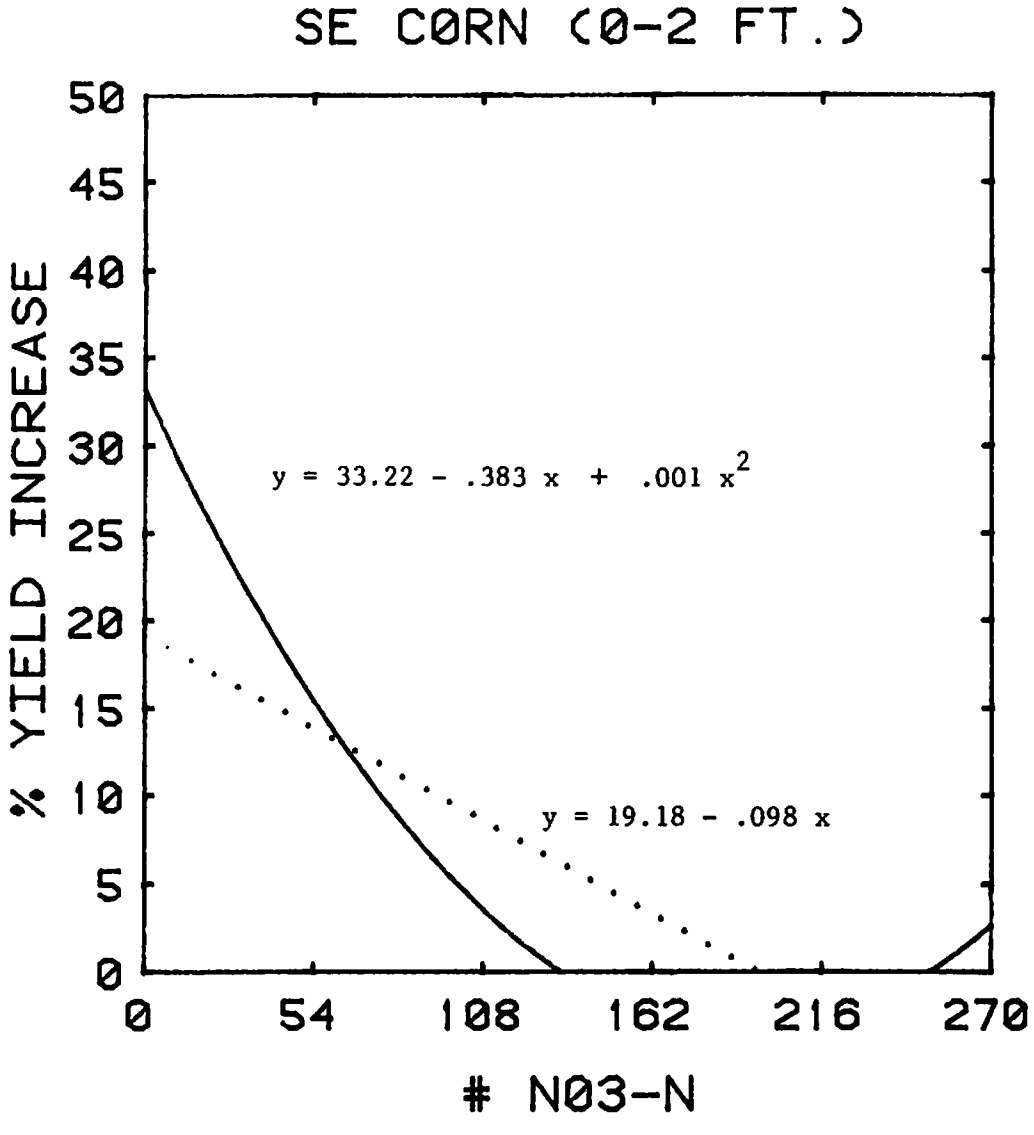
1/ Excludes Hempstead site in '78 which was flooded.
2/ Decreases are counted as 0.

Table 4. Corn Grain Yield Response to Fertilizer N and Average Nitrate-N Levels for Separate Years 1977, 1978, and 1979.

Year	Number of Sites Total	Number of Sites N Response >5 bu/A	Yield (bu/A) N	Yield (bu/A) No N	Yield Increases Due to N bu/A	Yield Increases Due to N %	Nitrate-N (lb/A) 0-2'	Nitrate-N (lb/A) 0-5'
1979	14	11	143	125	18	14	74	160
1978	16	10	140	129	11	9	105	260
1977	20	7	138	130	8	6	106	178

Results from the 3 years of this study indicate that the nitrate test can be a useful tool for predicting corn N response on well-drained soils in southeastern Minnesota. A 2 foot sample has been as reliable as deeper samples during these 3 years. Soils testing higher than 120 to 150 lb/acre nitrate-N in the top 2 feet showed little or no response to added N, whereas those testing less than 60 lb/acre showed large yield increases. The nitrate test is not well suited to fields where drainage is poor or where flooding may occur.

Figure 1. Percent Corn Grain Yield Increase as a Function of Nitrate-N (lb/acre) in 0 to 2' Depth. 50 Site-Years in Southeastern Minnesota. 1977-79.



USE OF N-SERVE IN FALL VS. SPRING NITROGEN APPLICATION PROGRAMS ON FINE TEXTURED SOILS OF MINNESOTA

G.L. Malzer, G.W. Randall, W.W. Nelson, S. Evans, and G. Varvel

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

Experiments were established at four University of Minnesota Experiment Stations with the following objectives: 1) to evaluate the importance of timing of nitrogen application (fall vs. spring) on yield components and nitrogen utilization of corn and spring wheat; 2) to determine the importance of soil temperature on the rate of nitrification with early and late applied nitrogen; and 3) to examine the influence of N-Serve on yield components, nitrogen utilization by the crops, and its influence on the rate of nitrification within the soil.

Experimental Procedures

Four similar experiments were established one each at the Southern Experiment Station at Waseca, the Southwest Experiment Station at Lamberton, the West Central Experiment Station at Morris, and the Northwest Experiment Station at Crookston. Each experiment, (except for Lamberton), consisted of four times of nitrogen application (3 fall and 1 spring) two rates of nitrogen in addition to a check and all potential nitrogen treatments and times of application either had N-Serve at 0.5 # ai/A applied with it or contained no N-Serve. Times and rates of nitrogen application were adjusted for each experimental site to conform with the geographic area. The experimental treatments at each location are included in Table 1.

Each experimental site was fertilized with phosphorus and potassium according to soil test recommendations prior to establishment of treatments. All nitrogen applications were made with anhydrous ammonia with N-Serve injected into the tank for the appropriate treatments. Anhydrous knife spacings were 30" for corn production and approximately 15" for wheat. All primary tillage was done prior to the first nitrogen application with only secondary tillage prior to planting. Several areas within each plot received no tillage after nitrogen application for use in collection of soil samples from the anhydrous application zones.

Treatment influences on nitrogen utilization by the crop were evaluated in several manners. Corn leaf samples from opposite and below the ear at 50% silking were collected and analyzed for Kjeldahl nitrogen content. Forage dry matter production and nitrogen removal was measured by hand harvesting 15' of row from the corn plots, separation of samples into ear and stover components, field weights obtained and nitrogen content and moisture determined from subsamples. Grain yields were obtained by either hand harvesting or machine harvesting known areas from each plot and then determination of the nitrogen content (protein) by Kjeldahl analysis for calculation of nitrogen removal.

General Results

Positive yield responses were obtained at three of the four locations tested in 1979. Nitrogen response was, however, limited to the first level (Medium) of nitrogen application on two out of four locations. Only the Waseca location gave significant yield responses to the high level of nitrogen fertilization.

Yield responses in relationship to timing of nitrogen application were significant in two out of four locations. In general, early fall applications were inferior to later fall or spring application.

The use of N-Serve had relatively little influence on nitrogen utilization and grain yields at these four locations in 1979. The three locations in the western part of the state reflected essentially no advantage to the use of N-Serve. Although not significant at the 95% level of confidence, trends for yield increases due to N-Serve were found when applied with the nigh nitrogen rate with early fall nitrogen application and at the lower nitrogen rate with spring application. N-Serve has been found to be effective in delaying the conversion of ammonium nitrogen to nitrate nitrogen. The yield responses which have been obtained are related to the climatic and soil conditions which might influence the amount of nitrate nitrogen that might be lost by leaching or denitrification.

Table 1. Experimental Treatments with Fall vs. Spring Nitrogen Application with and Without N-Serve.

Experimental Location	Nitrogen Rate	Date of Application		N-Serve Rate	Test Crop
	#/A	1978-79		#ai/A	
Waseca	0	9/25	10/10	0, ½	Corn
	75	10/31	5/7		(Pioneer 3732)
	150				
Lamberton	0	10/1	11/1	0, ½	Corn
	50	5/5			(Pioneer 3780)
	100				
Morris	0	8/25	9/25	0, ½	Corn
	40	10/24	5/21		(Dekalk XL 12)
	80				
Crookston	0	8/29	9/28	0, ½	Wheat
	40	10/26	5/14		(Era)
	80				

Table 2. Nitrogen content of the leaf opposite and below the ear at silking as influenced by nitrogen rate, timing of nitrogen application and use of N-Serve.

Treatments 1/			Leaf N Content		
Date of Appl.	N Rate	N-Serve	Waseca	Lamberton	Morris
		0.5#ai/A	----------	%	----------
Control	0	No	1.98	2.26	2.71
Early Fall	Med.	No	2.64		2.66
Early Fall	Med.	Yes	2.70		2.70
Early Fall	High	No	2.91		2.70
Early Fall	High	Yes	2.93		2.68
Mid Fall	Med.	No	3.03	2.82	2.80
Mid Fall	Med.	Yes	3.04	2.76	2.77
Mid Fall	High	No	2.92	2.84	2.78
Mid Fall	High	Yes	2.96	3.10	2.74
Late Fall	Med.	No	2.75	2.62	2.72
Late Fall	Med.	Yes	2.86	2.75	2.84
Late Fall	High	No	2.99	3.10	2.89
Late Fall	High	Yes	3.00	2.77	2.79
Spring	Med.	No	2.92	2.81	2.84
Spring	Med.	Yes	3.07	2.79	2.92
Spring	High	No	3.09	2.78	2.82
Spring	High	Yes	3.03	2.96	2.75
Significance			**	**	NS
BLSD(.05)			0.16	0.28	-
Factorial Arrangement					
Application Date					
Early Fall			2.80		2.68
Mid Fall			2.99	2.88	2.77
Late Fall			2.90	2.81	2.81
Spring			3.03	2.84	2.83
Significance			**	NS	*
BLSD(.05)			0.10	-	0.10
Nitrogen Rate					
Med.			2.88	2.76	2.78
High			2.98	2.92	2.77
Significance			**	**	NS
BLSD(.05)			0.07	0.12	
N-Serve					
No			2.91	2.83	2.76
Yes			2.95	2.85	2.77
Significance			NS	NS	NS
BLSD(.05)			-	-	-

[1]See table 1 for dates and rates of nitrogen application.

Table 3. Influence of nitrogen rate, timing of nitrogen application and N-Serve on grain yields - 1979.

Treatments 1/			Grain Yields			
Date of N Appl.	N Rate	N-Serve 0.5#ai/A	Waseca	Lamberton	Morris	Crookston
			bu/A			
Control	0	No	116.4	120.0	84.3	33.0
Early Fall	Med.	No	154.7		89.7	40.8
Early Fall	Med.	Yes	154.8		93.1	40.7
Early Fall	High	No	166.7		91.2	43.5
Early Fall	High	Yes	174.4		94.0	47.0
Mid Fall	Med.	No	173.6	128.2	100.0	41.2
Mid Fall	Med.	Yes	174.4	126.3	86.5	42.7
Mid Fall	High	No	172.9	125.4	96.6	41.5
Mid Fall	High	Yes	178.0	127.2	89.1	39.1
Late Fall	Med.	No	161.2	137.9	94.2	41.6
Late Fall	Med.	Yes	162.4	138.9	91.8	42.7
Late Fall	High	No	180.0	138.6	92.4	43.1
Late Fall	High	Yes	181.0	135.2	104.4	42.1
Spring	Med.	No	166.7	139.8	88.4	43.4
Spring	Med.	Yes	176.1	137.4	99.3	42.9
Spring	High	No	181.4	132.4	98.4	42.5
Spring	High	Yes	180.9	138.2	89.6	39.1
Significance			**	*	NS	**
BLSD(.05)			10.2	16.1	-	5.5
Factorial Arrangement						
Application date						
Early Fall			162.6		92.0	43.0
Mid Fall			174.7	126.8	93.1	41.1
Late Fall			171.1	137.6	95.7	42.4
Spring			176.3	136.9	93.9	42.0
Significance			**	**	NS	NS
BLSD(.05)			6.5	6.2	-	-
Nitrogen Rate						
Med.			165.5	134.7	92.9	42.0
High			176.9	132.8	94.5	42.2
Significance			**	NS	NS	NS
BLSD(.05)			4.9	-	-	-
N-Serve						
No			169.6	133.7	93.8	76.5
Yes			172.7	133.9	93.5	73.7
Significance			NS	NS	NS	NS
BLSD(.05)			-	-	-	-

1/ See table 1 for dates and rates of application.

Table 4. Influence of nitrogen rate, timing of nitrogen application and N-Serve on nitrogen removal with the grain.

Treatments [1/]			Grain N Removal			
Date of N Appl.	N Rate	N-Serve 0.5#ai/A	Waseca	Lamberton	Morris	Crookston
Control	0	No	64.6	68.1	63.4	38.3
Early Fall	Med.	No	96.8		72.2	50.1
Early Fall	Med.	Yes	97.4		71.7	51.3
Early Fall	High	No	98.6		73.8	59.8
Early Fall	High	Yes	106.4		76.1	65.3
Mid Fall	Med.	No	104.4	84.4	78.8	49.3
Mid Fall	Med.	Yes	110.2	80.6	67.6	54.2
Mid Fall	High	No	113.5	81.4	79.0	56.7
Mid Fall	High	Yes	112.3	83.0	72.0	54.1
Late Fall	Med.	No	93.1	87.1	76.4	52.3
Late Fall	Med.	Yes	97.7	84.0	73.7	52.9
Late Fall	High	No	107.5	90.6	77.2	59.9
Late Fall	High	Yes	111.7	84.6	81.0	59.0
Spring	Med.	No	101.8	87.1	70.3	54.8
Spring	Med.	Yes	104.9	86.6	76.0	53.4
Spring	High	No	111.8	83.4	84.4	61.5
Spring	High	Yes	110.5	86.6	71.2	54.7
Significance			**	+	NS	**
BLSD(.05)			9.5	12.6	-	7.1
Factorial Arrangement						
Application Date						
Early Fall			99.8		73.5	56.2
Mid Fall			110.1	82.2	74.4	53.6
Late Fall			102.5	86.6	77.1	56.0
Spring			107.2	85.9	75.5	56.1
Significance			**	NS	NS	NS
BLSD(.05)			6.0	-	-	-
Nitrogen Rate						
Med.			100.8	84.9	73.3	52.3
High			109.0	85.0	76.9	56.1
Significance			**	NS	NS	NS
BLSD(.05)			4.4	-	-	-
N-Serve						
No			103.4	85.6	93.8	76.5
Yes			106.4	84.2	93.5	73.7
Significance			NS	NS	NS	NS
BLSD(.05)			-	-	-	-

[1/] See table 1 for dates and rates of nitrogen application.

GRASS SEED PRODUCTION AS INFLUENCED BY FERTILIZATION

A PROGRESS REPORT
December 31, 1979

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Research during 1979 included: (a) nitrogen source comparison on mineral soils, (b) nitrogen rate study on peat, and (c) copper study on peat. Six trials with timothy and Kentucky bluegrass were conducted on growers' fields in Roseau and Lake of the Woods counties. Fertilizer effects were determined by yield measurement, chemical analysis of grass tissue and visual estimation of severity of lodging.

A. WEATHER CONDITIONS DURING 1978/79 GROWING SEASON

Comments on weather conditions are based on climatological data reported by the U. S. Weather Station at Roseau (Table 1).

Generally, during the period from August 1978 to July 1979, 22.5 inches of precipitation (1.5 inch above normal amount) was received at Roseau, while the average air temperature was 4.2°F below normal. During August and September, over 6.5 inches of rainfall was received, while October was very dry. From November to April, the temperature was about 7.3°F below normal and the precipitation was over 3 inches above normal. May was cool and somewhat drier than normal. During June, relatively cool weather prevailed and nearly 2 inches of rainfall was received, about 1.5 inch below the normal amount. Nearly 4 inches of rainfall was received during July with the average air temperature being 1.8°F below normal.

B. NITROGEN SOURCE COMPARISON

1. Anhydrous Ammonia vs. Urea vs. Ammonium Nitrate

Two field experiments were conducted with Heidemij timothy and Park Kentucky bluegrass on mineral soils. The soils contained 13-17 lb/A of nitrate-N in the top two feet (Table 2). This amount of nitrate is relatively low when compared to the levels commonly found after some cultivated crops or fallow. The main root zone (0-3 inches) contained only 1.5-1.7 pp2m nitrate-N. The soils were calcareous, with pH values near 8 (Table 3).

Table 1. Precipitation and temperature data for the 1978/79 growing season as measured at Roseau Weather Station (KRWB Radio)*.

Period	Precipitation (inches) Total	Precipitation (inches) Departure from Normal	Air Temperature (°F) Average	Air Temperature (°F) Departure from Normal	GDD T_b=40°F
1978 Aug.	3.25	.03	65.2	.3	781
Sept.	3.44	.83	58.7	4.1	561
Oct.	.23	-.99	45.0	.5	155
1978 Nov. to 1979 Apr.	8.07	3.14	9.5	-7.3	46
1979 May	1.89	-.56	45.9M	-6.0	183
June	1.91	-1.51	58.5	-3.3	555
July	3.70	.25	65.4	-1.8	787
Total	22.49	1.50			3068
Average			33.0	-4.2	
Normal (1941-1970)	20.99		37.2		3329

*Calculated from Climatological Data, Minnesota, Vol. 84 and 85, 1978 and 1979, U.S. Dept. of Commerce.

Note: Data for December, January, February and March represent averages for the Northwest Division because precipitation at Roseau was not recorded.

Table 2. Amount of nitrate-N in the soil collected from 0-3, 3-6 and 6-24 inch depths.+

Location	Soil Texture	Sampling depth, inches 0-3	3-6	6-24	Total Nitrate-N in 0-24"
		----Nitrate-N pp2m----			
Kveen Heidemij timothy	CL	1.7	1.6	13.2	16.5
Helmstetter Bros. Park K. bluegrass	SL	1.5	1.6	9.6	12.7
Hedlund Timfor timothy	SICL	1.8	1.9	9.8	13.5
Kveen Park K. bluegrass	P	2.2	1.3	6.6	10.1

+ samples collected on October 9-11, 1978.

The objectives of this investigation were:

1) To determine effectiveness of nitrogen source,

2) To determine sod injury from anhydrous ammonia injection as measured in yield.

All fertilizer materials were applied during the first half of October 1978. Urea (46-0-0) and ammonium nitrate (34-0-0) were applied to 10 x 40 ft. plot areas with a 5-foot Gandy spreader. Anhydrous ammonia, AA (82-0-0) was applied with commercial applicators with the knives set 15 inches apart to 24 x 40 ft. plot areas. A 0+40+40 fertilizer treatment was made across all plots. Nitrogen treatments were replicated six times.

Heidemij Timothy showed good response to fertilization with nitrogen. Seed yield, N content of grass tissue and the lodging score all were increased by the application of 110 lb. N/acre (Table 4). All three nitrogen sources were equally effective. The knives of AA applicator caused some damage to timothy sod by ripping it. The damage, however, was not sufficiently serious as it did not affect the yield.

Park Kentucky Bluegrass produced high seed yield and showed remarkable response to the application of 120 lbs. of nitrogen per acre (Table 5). Vegetative growth had been stimulated by nitrogen to such an extent that considerable lodging was observed on June 27. Some lodging was noted for the AA treatment; urea showed very little to no lodging; grass receiving ammonium nitrate had lodged moderately to heavily. Ammonium nitrate also produced the highest yield, significantly higher than obtained with the two other nitrogen sources. Knifing did not significantly decrease the yield, as shown by the ammonium nitrate vs. ammonium nitrate + knife treatments (600 vs. 552 lb/acre).

2. Urea vs. Ammonium Nitrate

Several field trials were established in the fall of 1975 to compare the effectiveness of these two N sources when applied at two different times (fall vs. spring) and two different rates (50 vs. 100 lb. N/A). Only one of these experiments could be continued in 1979.

Timfor Timothy produced moderate seed yield, and therefore, the response to nitrogen fertilization was not spectacular. Extra plots receiving no nitrogen yielded 164 lb/acre of seed and produced grass tissue with 1.90% N. The N100 treatment increased N concentration of grass tissue and the seed yield above those produced with the N50 treatment (Table 6). Neither the N source nor the time of fertilization produced differences in yield or N concentration of grass.

Table 3. Soil test results of samples collected from 0-3, 3-6 and 6-24 inch depths.+

Location	Sampling Depth (inches)	Texture	pH	Extractable P pp2m	Exchangeable K pp2m	DTPA Extractable Cu+ ppm
Kveen	0-3	CL	8.2	23	167	
Heidemij Timothy	3-6	SL	8.4	7#	124	
	6-24	CL	8.6	3#	85	
Helmstetter Bros.	0-3	SL	8.1	22	101	
Park K. bluegrass	3-6	SL	8.3	10#	51	
	6-24	SL	8.5	8#	35	
Hedlund	0-3	SICL	8.4	27#	123	
Timfor timothy	3-6	SICL	8.5	11#	80	
	6-24	SICL	8.7	1#	35	
Kveen	0-3	P	8.3	24	90	
Park K. bluegrass	3-6	P	8.2	5#	29	
(N-Rate trial)	6-24	P	8.0	7#	31	
Kveen	0-3	P	8.2	45	129	1.45
Park K. bluegrass	3-6	P	8.0	8#	25	1.26
(copper trial)						
Kveen	0-3	P	6.6	19	176	1.18
Newport K.	3-6	P	6.6	30	53	1.02
bluegrass						
(copper trial)						

+ samples collected on October 9-11, 1978.

1:50 soil/solution ratio.

Table 4. Effect of four nitrogen treatments on seed yield, N concentration in tissue and lodging of Heidemij timothy, Gus Kveen farm, Roseau County, 1979.

Treatment	Seed Yield lb/acre	N Percent in Dry Matter	Lodging Score #
Check	321a	2.88a	1.3
Ammonium Nitrate + Knife	458b	3.79b	3.5
Ammonium Nitrate	467b	3.78b	2.8
Anhydrous Ammonia	485b	4.05b	3.3
Urea	454b	3.92b	3.7
Significance	**	**	
BLSD (0.05)	66	0.31	
C.V.	14	8	

Values followed by different letters are significantly different (5% level); all results are averages of six replications.

Nitrogen materials were applied at a rate of 110 lb. N/acre; all plots received 0+40+40 lb/acre of P_2O_5 and K_2O.

Observations made on 8/21/79; 1 = standing erect, 5 = flat.

Table 5. Effect of four nitrogen treatments on seed yield, N concentration in tissue of Park Kentucky bluegrass, Helmstetter Bros. farm, Lake of the Woods County, 1979.

Treatment	Seed Yield lb/acre	N Percent in Dry Matter
Check	166a	1.10a
Ammonium Nitrate + Knife	552cd	1.50b
Ammonium Nitrate	600d	1.56b
Anhydrous Ammonia	458b	1.95c
Urea	476bc	1.42b
Significance	**	**
BLSD (0.05)	83	0.18
C.V.	17	11

Values followed by different letters are significantly different (5% level); all results are averages of six replications.

Nitrogen materials were applied at a rate of 120 lb. N/acre; all plots received 0+40+40 lb/acre of P_2O_5 and K_2O.

Table 6. Effects of nitrogen source, rate, and time of application on seed yield and N concentration in tissue of Timfor timothy (1973 seeding), Dell Hedlund farm, Roseau County, 1979.

Treatment	Seed Yield lb/acre	N Percent in Dry Matter
Source		
Urea	269	2.63
Ammonium Nitrate	287	2.68
Significance	ns	ns
BLSD (0.05)	-	-
Rate		
50 lb/acre N	229a	2.35a
100 lb/acre N	326b	2.96b
Significance	*	**
BLSD (0.05)	67	0.23
Date		
Fall	299	2.68
Spring	257	2.62
Significance	ns	ns
BLSD (0.05)	-	-
C.V.	17	5

Values followed by different letters are significantly different (5% level).

All plots received 0+40+40 lb/acre of P_2O_5 and K_2O.

C. NITROGEN RATE STUDY ON PEAT

A field experiment with Park Kentucky bluegrass on peat was established in the fall of 1975 to investigate the effectiveness of different N rates. Five nitrogen rates were used: 0, 20, 40, 60, and 80 lbs/acre and the treatments were replicated four times. All plots received uniform 0+40+40 lbs/acre phosphate and potash treatments. Fertilizer materials were applied with a Gandy spreader on October 11.

Very high seed yield was produced at this location (Table 7). While nitrogen, applied at rates of 40 lb/acre and above, increased the N concentration of grass tissue, it had no beneficial effect on the yield.

Table 7. Effect of fertilization on seed yield and N concentration in tissue of Park Kentucky bluegrass on peat, Gus Kveen farm, Roseau County, 1979.

N Rate lb/acre	Seed Yield lb/acre	N Percent in Dry Matter
0	570	2.04a
20	639	2.02a
40	614	2.16ab
60	526	2.29b
80	638	2.14ab
Significance	ns	*
BLSD (0.05)	-	0.20
C.V.	11	5

Values followed by different letters are significantly different (5% level).

All plots received 0+40+40 lbs/acre of P_2O_5 and K_2O.

D. COPPER STUDY ON PEAT

Two field experiments with Kentucky bluegrass on peat were established in the fall of 1978. The objectives of this study are:

1. To determine the need for copper by Kentucky bluegrass grown for seed production on peat.

2. To determine the effectiveness of copper sulfate and copper chelate as Cu source.

3. To determine the effectiveness of fall vs. spring application.

4. To evaluate the effectiveness of a single application (residual) vs. repeated annual applications of copper.

The soils contained 1.18 and 1.45 ppm DTPA extractable copper in the top 3 inches (Table 3), indicating a relatively low availability of this nutrient. Copper sulfate and copper chelate were dissolved in water and sprayed on 10 x 20 ft. plots on October 12 and May 8. The treatments were arranged in a split plot design with the time of application as main plots and the subplots consisting of residual and annual treatments. All treatments were replicated four times. During the first year of establishment, both residual and annual treatments actually represented an annual treatment. Therefore, results of treatments receiving copper applications represent averages of 8 subplots. The entire experimental area received 20+40+40 lb/acre of N, P_2O_5 and K_2O on October 12.

Park Kentucky bluegrass yield was not affected by fertilization with copper (Table 8). Copper concentration in tissue of bluegrass collected from check plots was 1.39 ppm, considered a very low level. Copper sulfate (12.75 lb. Cu/A) applied at 50 lb/acre rate, increased Cu concentration of tissue to nearly 11.0 ppm, with both fall and spring applications being equally effective. The application of 6 lb/acre of copper chelate (0.78 lb. Cu/A) did not significantly increase the copper concentration of grass tissue.

Newport Kentucky bluegrass yield was increased 48 lb/acre over the check by fall application of 50 lb/acre of copper sulfate. Copper concentration of grass tissue was increased by fertilization with copper sulfate to nearly 7 ppm, compared to 1.24 ppm Cu for tissue from check plots.

Table 8. Seed yield and Cu concentration of Park Kentucky bluegrass tissue as affected by fertilization with copper, Gus Kveen, Roseau Co., 1979.

Copper Treatment		Time of Application	Seed Yield lb/acre	Copper, ppm in Dry Matter
	None		593	1.39a
50 lb/acre	Copper Sulfate	Fall	600	11.57b
"	" "	Spring	617	10.45b
6 lb/acre	Copper Chelate	Fall	598	5.18a
"	" "	Spring	664	5.13a
Significance			ns	**
BLSD (0.05)			-	4.74
C.V.			14	70

Values followed by different letters are significantly different at 5% level.

Table 9. Seed yield and Cu concentration of Newport Kentucky bluegrass tissue as affected by fertilization with copper, Gus Kveen, Roseau Co., 1979.

Copper Treatment		Time of Application	Seed Yield lb/acre	Copper, ppm in Dry Matter
	None		254a	1.24a
50 lb/acre	Copper Sulfate	Fall	302b	7.66c
"	" "	Spring	256a	6.32bc
6 lb/acre	Copper Chelate	Fall	257a	4.07ab
"	" "	Spring	291ab	4.33abc
Significance			*	**
BLSD (0.05)			38	3.51
C.V.			13	70

Values followed by different letters are significantly different at 5% level.

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Navy Bean Inoculation Trials - 1979

S.D. Sparrow and G.E. Ham

Peat is generally used as a carrier of Rhizobium (or nodule bacteria) used for inoculation of legume crops. However, the properties of peat are highly variable (even if obtained from the same deposit) and survivability of Rhizobium in peat can therefore vary. Also, peat is not readily available in many parts of the world. In order to test the effectiveness, under field conditions, of several materials as carriers of Rhizobium phaseoli, Upland navy beans at Becker and Rosemount were inoculated at planting with nodule bacteria in the following carriers: mineral salts liquid media, milled peat and finely ground peanut hulls, corn cobs, vermiculite, and charcoal. Three R. phaseoli strains, 3644, CIAT 75, and 650 R, which were previously shown to be effective nitrogen fixers were used in the study.

Nodule bacteria were added, using either a concentrated (high rate) or a dilute (low rate) cell suspension, to the carriers two days before planting. Carriers were refrigerated until time of use. Plate counts of suspensions were done to determine cell numbers. Average cell numbers for the three strains are presented in Table 1.

Seed yields for each carrier and rate are presented in Table 1 for Becker and Table 2 for Rosemount. Yields are averaged over the three R. phaseoli strains. Yields at Rosemount (average yield 1729 lbs/ac) were considerably higher than at Becker (average yield, 789 lbs/ac). At Rosemount, inoculation did not result in significant yield increases over the control. At Becker on the other hand, liquid media and vermiculite at the high rate and peat and charcoal at both rates resulted in significant yield increases over the uninoculated control. Peanut hulls and corn cobs at either rate did not result in significant yield increases.

Studies are currently being done in the laboratory to determine the long-term effectiveness of these materials as carriers of nodule bacteria.

Table 1. Navy bean yield for various Rhizobium phaseoli carriers at Becker.

Carrier	Rate	Seed yield (lbs/ac)
Control	0	569[c+]
liquid	low*	683[bc]
liquid	high*	896[ab]
peat	low	1031[a]
peat	high	953[a]
peanut hulls	low	658[bc]
peanut hulls	high	670[bc]
corn cobs	low	653[bc]
corn cobs	high	564[c]
vermiculite	low	786[abc]
vermiculite	high	958[a]
charcoal	low	857[ab]
charcoal	high	981[a]

Average # cells for low rate = 2.5×10^4 cells per cm row
Average # cells for high rate = 5.0×10^6 cells per cm row
[+] yields followed by the same letter(s) are not significantly different at the 95% level.

Table 2. Navy bean yield for various Rhizobium phaseoli carriers at Rosemount

Carrier	Rate	Seed yield (lbs/ac)
Control	0	1768
liquid	low	1750
liquid	high	1589
peat	low	1645
peat	high	1724
peanut hulls	low	1799
peanut hulls	high	1773
corn cobs	low	1730
corn cobs	high	1824
vermiculite	low	1770
vermiculite	high	1778
charcoal	low	1601
charcoal	high	1721

PASTURE FERTILIZATION TRIALS

Washington Co., 1978 & 1979

Morris Station, 1979

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

A pasture trial was initiated at the Kelly farms in Washington County, managed by Morris Grogan. The objective of one trial was to document magnesium levels which might be related to grass tetany in cattle. Magnesium content and relationship to potash treatments, to added dolomitic lime and to magnesium sulfate applications were studied. A nitrogen trial was also conducted at this site and was adjacent to the magnesium plot. This plot had varying nitrogen treatments to 120 pounds and is a continuation of the nitrogen trials in Goodhue County. Plots were fenced to prevent grazing.

A bromegrass plot was established at the Morris Station in 1979 in cooperation with Dr. Sam Evans to observe urea benefits topdressed on a high pH soil. Urea and ammonium were applied to split plots.

Discussion and summary

Kelly farms

1. Applications of dolomitic lime in the spring of 1978 did not increase magnesium content of grass that year, but in 1979 magnesium significantly increased from the topdressed application in 2 of the 4 cuttings. Epsom salts also increased magnesium.

2. Potassium, at very high rates, decreased magnesium content but at recommended rates no apparent reduction occurred.

3. There were no grass yield benefits from liming, only magnesium quality benefits that could offset potential problems of grass tetany in cattle.

4. Soil pH, on the surface 3 inches, has increased from 5.2 to 6.4 from 4 tons of lime from April 1978 to October 1979.

This project was financed through support by Cenex Foundation funds.

Table 1a. The effect of potash, magnesium (Epsom salts), and dolomitic limestone on dry matter yield of grass pasture. Kelly farms, 1978.

	pounds dry grass/acre				
	Cuttings				
	1	2	3	4	Total
Lime 4 T/A*	1690	2772	1226	939	6627
No lime	1803	2362	1336	1026	6527
Significance	ns	*	ns	ns	ns
BLSD (05)	-	353			
Lbs K_2O/A					
0	1850	2528	1230	911	6518
160	1716	2473	1113	886	6187
320	1767	2677	1228	928	6800
640	1624	2512	1545	1284	6964
1000	1803	2537	1313	942	6595
1000+100# Mg/A	1719	2674	1256	948	6596
Significance	ns	ns	ns	*	ns
BLSD (05)	-	-	-	184	-

Table 1b. The effect of potash, magnesium (Epsom salts), and dolomitic limestone on dry matter yield of grass pasture. Kelly farms, 1979.

	pounds dry grass/acre				
	Cuttings				
	1	2	3	4	Total
Lime 4 T/A*	1210	3164	386	930	5690
No lime	1448	3126	326	742	5642
Significance	ns	ns	ns	ns	ns
Lbs K_2O/A**					
0	1000	3380	358	712	5450
160	1238	3394	404	884	5918
320	1409	2779	385	881	5454
640	1427	2340	394	915	5676
1000	1434	3240	283	885	5842
1000+100# Mg/A	1465	3138	311	739	5652
Significance	ns	ns	ns	ns	ns

* Lime added early spring of 1978 + all plots received 120# N/A and 40# P_2O_5/A in 1978 and 1979.

** No potassium added in 1979; 100# Mg was applied both in 1978 and 1979.

Table 2a. Emission spectrograph analysis 1st cutting, Kelly farm, Washington Co. 1978.

Treatment	% P	% K	% Ca	% Mg	ppm Fe	ppm Mn	ppm Zn	ppm Cu	ppm B
No lime	.31	4.10	.30	.16	155	137	34	8	5
Lime 4 T/A	.31	4.48	.27	.14	155	149	35	8	5
Significance	ns	ns	+	*	ns	ns	ns	ns	ns
BLSD (5%)	-	-	.02	.01	-	-	-	-	-
lbs K_2O/A									
0	.35	4.16	.30	.16	153	133	36	8	5
160	.28	3.87	.29	.14	143	129	33	8	6
320	.33	4.47	.29	.14	162	153	35	8	6
640	.30	4.38	.29	.15	158	145	34	8	4
1000	.32	4.56	.28	.16	154	152	35	8	5
1000 + 100# Mg	.28	4.30	.28	.15	159	147	34	8	7
Significance	*	*	ns	ns	ns	+	ns	ns	ns
BLSD (5%)	.04	.44	-	-	-	18	-	-	-

Table 2b. 2nd Cutting

No lime	.32	3.32	.30	.16	71	159	30	8	5
Lime 4 T/A	.34	3.56	.27	.15	70	204	30	8	6
Significance	ns	*	ns	ns	ns	ns	ns	ns	ns
BLSD (5%)	-	.23	-	-	-	-	-	-	-
lbs K_2O/A									
0	.34	3.20	.29	.16	66	169	30	8	6
160	.33	3.42	.30	.15	72	161	31	8	5
320	.31	3.41	.26	.13	66	190	30	8	5
640	.33	3.57	.28	.16	71	189	30	8	5
1000	.35	3.43	.32	.17	78	202	30	8	6
1000 + 100# Mg	.32	3.62	.27	.16	71	176	31	9	5
Significance	ns	ns	ns	+	ns	ns	ns	ns	ns
BLSD (5%)	-	-	-	.02	-	-	-	-	-

Table 2c. Emission Spectrograph analysis 3rd cutting, Kelly farm, Washington Co. 1978.

Treatment	%				ppm				
	P	K	CA	Mg	Fe	Mn	Zn	Cu	B
No lime	.36	3.47	.34	.19	71	163	29	8	6
Lime 4 T/A	.38	3.88	.29	.17	72	183	28	9	6
Significance	+	+	+	*	ns	ns	ns	ns	ns
BLSD (5%)	.02	.24	.04	.01	-	-	-	-	-
Lbs K_2O/A									
0	.39	3.77	.34	.17	73	179	31	8	6
160	.37	3.57	.32	.18	70	140	28	8	6
320	.38	3.53	.29	.15	72	181	27	8	6
640	.36	3.63	.32	.19	74	175	27	8	6
1000	.37	3.73	.31	.19	66	207	28	8	6
1000 + 100# Mg	.37	3.82	.32	.19	75	158	30	9	6
Significance	ns	ns	+	*	ns	**	+	ns	ns
BLSD (5%)	-	-	.03	.02	-	25	3	-	-

Table 2d. 4th cutting.

No lime	.37	3.04	.42	.23	124	185	28	7	4
Lime 4 T/a	.39	3.10	.38	.20	124	214	26	8	5
Significance	*	ns	ns	+	ns	ns	ns	ns	ns
BLSD (5%)	.01	-	-	.02	-	-	-	-	-
Lbs K_2O/A									
0	.38	2.98	.44	.21	129	233	30	8	5
160	.38	2.99	.41	.22	126	146	28	8	5
320	.39	2.95	.40	.18	115	220	27	8	5
640	.37	3.07	.38	.24	123	170	26	7	5
1000	.39	3.25	.37	.22	122	268	27	8	5
1000 + 100# Mg	.37	3.15	.39	.23	131	160	27	8	5
Significance	ns	ns	ns	**	ns	ns	ns	ns	ns
BLSD (5%)	-	-	-	.02	-	43	-	-	-

Table 3a. Emission spectrograph analysis of pasture, Kelly farms, Washington Co., 1979. 1st cutting.

Trt.	% P	% K	% Ca	% Mg	ppm Al	ppm Fe	ppm Mn	ppm Zn	ppm Cu	ppm B
No lime	.31	3.67	.24	.14	21	89	117	33	7	5
Lime	.28	3.64	.25	.17	33	94	72	31	7	5
Significance	ns	ns	+	ns	**	ns	*	ns	ns	+
BLSD	-	-	.01	-	1	-	34	-	-	1
Lbs K_2O/A										
0	.28	3.10	.28	.16	22	88	83	32	8	6
160	.28	3.61	.26	.17	21	90	91	32	6	5
320	.27	3.58	.26	.16	24	87	100	33	7	5
640	.30	3.76	.23	.14	23	90	94	32	7	5
1000	.30	3.77	.21	.13	34	85	94	31	7	5
1000+100# Mg	.31	4.12	.20	.18	37	109	109	33	8	5
Significance	ns	**	**	**	ns	ns	ns	ns	*	*
BLSD	-	.27	.02	.02	-	-	-	-	1	1

Table 3b. Emission spectrograph analysis of pastures, Kelly farms, Washington Co., 1979. 2nd cutting.

Trt.	% P	% K	% Ca	% Mg	ppm Al	ppm Fe	ppm Mn	ppm Zn	ppm Cu	ppm B
No lime	.26	2.94	.22	.14	25	61	128	32	8	4
Lime	.24	2.97	.22	.16	21	60	72	31	7	3
Significance	**	ns	ns	+	ns	ns	**	+	ns	ns
BLSD	.13	-	-	.01	-	-	1	1	-	-
Lbs K_2O/A										
0	.25	2.46	.26	.17	18	58	84	34	8	4
160	.23	2.46	.26	.17	23	59	86	31	7	4
320	.23	2.86	.25	.15	23	64	111	32	7	4
640	.27	3.28	.20	.13	34	65	102	32	7	4
1000	.27	3.30	.19	.11	19	58	95	30	7	4
1000+100# Mg	.26	3.41	.16	.16	19	60	126	31	7	3
Significance	**	**	**	*	ns	ns	*	ns	+	ns
BLSD	.02	.38	.03	.03	-	-	28	-	.7	-

Table 3c. Emmission spectrograph analysis of pasture, Kelly farms, Washington Co., 1979. 3rd cutting.

Trt.	% P	% K	% Ca	% Mg	ppm Al	ppm Fe	ppm Mn	ppm Zn	ppm Cu	ppm B
No lime	.28	2.88	.33	.20	30	81	148	25	6	7
Lime	.29	2.97	.34	.24	26	81	74	25	6	6
Significance	ns	ns	ns	ns	ns	ns	*	ns	ns	ns
BLSD	-	-	-	-	-	-	3	-	-	-
Lb K_2O/A										
0	.29	2.52	.39	.23	30	86	98	90	7	8
160	.27	2.80	.35	.22	24	74	100	99	6	6
320	.27	2.68	.37	.25	35	80	125	87	6	6
640	.29	3.19	.32	.20	24	84	108	101	6	6
1000	.28	3.00	.28	.18	26	79	105	104	6	6
1000+100# Mg	.31	3.34	.27	.24	23	82	132	100	7	6
Significance	ns	+	*	+	+	ns	+	ns	ns	+
BLSD	-	.58	.07	.05	8	-	25	-	-	1

Table 3d. Emission spectrograph analysis of pasture grasses, Kelly farms, Washington Co., 1979. 4th cutting.

Trt.	% P	% K	% Ca	% Mg	ppm Al	ppm Fe	ppm Mn	ppm Zn	ppm Cu	ppm B
No lime	.21	1.75	.47	.21	60	99	292	21	4	7
Lime	.22	1.87	.45	.26	62	94	121	21	4	6
Significance	ns	*	ns	**	ns	ns	**	ns	ns	+
BLSD	-	.06	-	.01	-	-	17	-	-	1
Lbs K_2O/A										
0	.22	1.50	.54	.26	52	90	192	24	4	7
160	.21	1.69	.47	.24	63	99	200	20	5	6
320	.21	1.95	.48	.24	54	87	200	21	5	6
640	.21	1.89	.44	.21	63	101	204	20	5	6
1000	.22	1.87	.42	.20	65	104	193	19	4	7
1000+100# Mg	.22	1.94	.39	.27	67	100	251	22	5	7
Significance	ns	*	*	**	ns	ns	+	ns	ns	ns
BLSD	-	.26	.09	.03	-	-	40	-	-	-

Table 4a. The effect of varying nitrogen treatments on grass yield (dry matter) and percent nitrogen, Kelly farm, 1978.

Treatment N	P_2O_5	K_2O	lbs D.M./A 1	2	3	4	Total	%N 1	2	3	4
0	0	0	969	2066	1040	871	4946	2.75	2.32	2.73	3.20
0	40	40	1098	2129	1093	1018	5340	2.96	2.07	2.68	3.23
30	40	40	1314	2364	1038	1042	5759	3.05	2.29	2.69	3.11
60	40	40	1750	1978	1145	890	5763	3.70	2.71	2.66	3.39
*120(60+60)	40	40	1567	2295	1756	950	6568	3.72	2.48	3.37	3.43
Significance			**	ns	**	ns	**	**	**	**	ns
BLSD (05)			174	-	246	-	.796	.41	.27	.35	-
C.V.			9.1	12.6	13.7	25.5	8.9	8.5	7.2	8.0	6.7

*60# N/A spring + 60# N/A after second cutting

Table 4b. The effect of varying nitrogen treatments on grass yield (dry matter) and percent nitrogen, Kelly farm, 1979.

Treatment N	P_2O_5	K_2O	lbs D.M./A 1	2	3	4	Total	%N 1	2	3	4
0	0	0	572	1734	489	946	3740	2.60	1.63	2.34	2.03
0	40	40	524	1616	532	854	3526	2.59	1.95	2.28	2.10
30	40	40	935	1898	494	818	4145	2.88	1.61	2.14	2.02
60	40	40	1357	2638	475	883	5347	3.57	1.90	2.48	2.13
120(60+60)	40	40	1074	2198	1434	1281	5986	3.74	1.94	3.26	2.07
Significance			**	*	**	+	**	**	+	**	ns
BLSD (.05)			215	630	247	319	739	.37	.29	.37	-
C.V.			16.8	19.1	25.1	23.2	11.2	8.2	11.1	9.9	5.0

Table 5a. Pounds of nitrogen removed per acre and yield of protein. Kelly farms. 1978.

Treatment N	P_2O_5	K_2O	lbs N removed 1	2	3	4	Total	yield lbs protein/ acre
0	0	0	26.7	47.9	28.4	28.0	131.0	819
0	40	40	32.4	43.9	29.1	32.4	137.8	863
30	40	40	40.1	54.0	27.8	32.2	154.1	963
60	40	40	64.6	53.6	30.6	29.9	178.7	1119
120(60+60)	40	40	58.4	57.0	58.4	32.1	205.4	1281
Significance			**	ns	**	ns	**	
BLSD (05)			7.3	-	4.8	-	19.0	
C.V.			11.7	11.7	9.9	21.6	9.0	

Table 5b. Pounds of nitrogen removed per acre and yield of protein. Kelly farms. 1979.

Treatment N	P_2O_5	K_2O	lbs N removed/A 1	2	3	4	Total	yield lbs protein/ acre
0	0	0	14.9	28.6	11.4	19.1	74.0	460
0	40	40	13.5	31.7	12.0	18.0	75.2	459
30	40	40	26.7	30.3	10.6	16.6	84.2	529
60	40	40	48.2	49.9	11.7	18.6	128.4	800
120(60+60)	40	40	40.0	42.6	45.6	26.5	154.7	2652
Significance			**	*	**	*	**	
BLSD (.05)			5.9	12.8	4.0	7.2	10.9	
C.V.			14.6	21.9	15.5	21.4	7.5	

Table 6. Soil tests average of 2 samples per plot at 0 to 3 and 3 to 6 inch depths, according to lime and potash treatments. Kelly farms, Washington Co., 1978 & 1979.

	Potash treatment per acre																	
	0			160			320			640			1000			1000 + Mg		
	pH	P	K	pH	P	K	pH	P	K	pH	P	K	pH	P	K	pH	P	K
0 to 3 inch depth 1978																		
No lime	5.2	24	192	5.2	39	270	5.2	21	314	5.4	42	548	5.4	26	580	5.4	31	600+
Lime	6.2	28	263	6.3	28	207	6.1	28	340	6.2	23	490	6.0	27	555	6.2	23	600+
3 to 6 inch depth 1978																		
No lime	5.4	16	155	5.4	26	195	5.4	13	160	5.4	28	314	5.4	18	426	5.3	16	360
Lime	5.6	22	201	5.6	15	129	5.4	16	236	5.5	15	264	5.5	21	375	5.5	16	479
Avg. P & K 0-6"		23	203		27	200		20	263		27	404		23	484		22	510
0 to 3 inch depth 1979																		
No lime	5.2	11	65	5.1	16	212	5.2	9	135	5.2	19	308	5.2	16	371	5.3	16	294
4 T/A	6.4	17	139	6.5	17	122	6.5	19	205	6.4	24	328	6.4	24	420	6.5	16	328
3 to 6 inch depth 1979																		
No lime	5.6	9	44	5.3	15	152	5.5	8	96	5.3	17	252	5.5	14	271	5.4	13	323
4 T/A	5.6	15	110	5.7	12	75	5.7	15	137	5.6	14	267	5.6	19	308	5.6	13	297
Avg. P & K 0-6"		13	89		15	140		13	143		19	289		18	343		15	311

Avg. pH	1978		1979	
	0-3"	3-6"	0-3"	3-6"
No lime	5.2	5.4	5.2	5.4
4 T/A	6.2	5.6	6.4	5.6

Table 7. Yield comparisons of bromegrass comparing effects of urea vs ammonium nitrate topdressing on high pH soil. 1979.

Nitrogen lbs/A	form	time	*1st cutting	2nd cutting	1979 total
			lbs/A dry matter		
0	-	-	6968	3668	10636
50	urea	1	6742	3723	10465
50	"	2	7120	3698	10818
50	"	3	7648	2620	10268
50	AN	1	5455	2937	8092
50	"	2	6596	3389	9985
50	"	3	6438	3435	9873
100	urea	1	6217	3748	9965
100	"	2	6406	3742	10148
100	"	3	6886	3556	10442
100	AN	1	6158	3487	9644
100	"	2	6422	4018	10440
100	"	3	6794	3564	10358

	urea	AN	none
		lbs/A (DM)	
Total 2 cuts	10394	9580	10270

* Time 1= April, 2=at 1st cut, 3=at 2nd cut

INFLUENCE OF APPLICATION OF LIQUID CATTLE MANURE ON THE NUTRIENT LEVEL OF AGRICULTURAL SOILS IN JACKSON COUNTY, MINNESOTA - 1979

Mike O'Leary, Tim Wagar, and Charles Simkins

Wilder Farms of Jackson County, Minnesota is a cattle feeder operation that annually produces approximately 10,000 animals for processing.

The capacity of the feed lot is 5,000 animals. A majority of the livestock is raised in a slatted floor confinement area. Approximately 4 million gallons of manure is collected yearly.

The manure is normally applied on cropland for disposal. A large tank wagon with an injection system is utilized to apply the liquid manure. Nearly 80 percent of the land area of the farm (850 acres) receives an application of manure either in the spring or fall. The liquid manure is applied at the rate of 15-18 tons per acre. Most of the crop area on the farm is used to produce corn which is harvested as silage and fed to the beef animals. In recent years the only commercial fertilizer used has been 100 lbs/A of K_2O broadcast and 100 lbs/A of 5-12-10 starter.

This cattle feeding operation has been in operation for many years. The specific quantity of manure applied to each field during this time is unknown.

Soils

The soils of the farm are largely Clarion, Nicollet and Webster. Most of the land is nearly level to gently tolling. Clay loam is the main soil texture. These soils have a high nutrient and water holding capacity.

The depressional lands, mainly Webster and Glencoe soils, have been tiled in order to improve the drainage of the lands.

Soil tests prior to manure applications were not made. The level of available phosphorus and potassium prior to the time that cattle feeding operations were initiated is not known.

Methods of Study

The Wilder Farm which consists of 850 acres was divided into 24 soil sampling areas. Each area was approximately 35 acres in size. (See Annex 2).

Soil samples were taken at random in each area. 20 cores were obtained from the area. Cores were taken from a depth of 0-6 inches and from 0 to 24 inches.

The composite samples were analyzed for pH, O.M., P, K and conductivity from a saturated extract. Only NO_3N determinations were made on the samples taken from a depth of 0 to 24 inches. The areas sampled were relatively uniform in respect to soil type.

Results

The results of the soil tests from the various areas are given in Annex 1.

Nitrate-Nitrogen

The nitrate-nitrogen accumulation to a depth of 2 feet ranged from 112 to 900 pounds per acre. Normally a test of 150 lbs. of nitrate-nitrogen in the 0 to 2 feet of soil indicates sufficient nitrogen for optimum yields of corn. The areas tested indicated the following levels.

	Level of NO_3N lbs/acre	Number of areas
Very low	0 - 30	0
Low	30 - 50	0
Medium	51 - 90	0
High	91 - 150	3
Very High	151 - 200	5
Excessive	201 - 500	8
Excessive	500 +	2

Based on the nitrate-nitrogen levels present in most areas, there is good evidence that past manure treatments have resulted in a rather high level of nitrogen for crop production. Since it is the intention of the producer to put additional manure on those fields which had less than 200 pounds of nitrate-nitrogen, it is unlikely that any nitrogen fertilizer would be needed for this years corn crop.

Phosphorus

Phosphorus test levels were determined by the Bray No. 1 method using a soil to extract ratio of 1 to 10. The soil test values for all areas tested are shown in Annex 1. Phosphorus soil test levels ranged from 34 to 175 lbs. of P per acre. A test of more than 30 lbs. per acre of phosphorus is considered to be a relatively high test and little or no crop yield response is obtained by use of additional phosphorus fertilizer. Research results have shown that the use of a small amount of phosphorus and potassium fertilizer at planting time can give economical increases in yields in 5 out of 7 years. This so called "starter effect" can result in yield increases from 5 to 10 bushels per acre.

A summary of the phosphorus level from the various areas are as follows.

		Number of areas
Very low	0 - 5	0
Low	6 - 10	0
Medium	11 - 20	0
High	21 - 30	0
Very high	31 - 50	6
Extremely high	50 +	18

Potassium

The exchangeably potassium was extracted from the soil sample with normal ammonium acetate. A test level of 200 lbs. per acre K is considered high. Tests of over 300 are considered very high. The soil test values and the relative levels in respect to good corn production are as follows.

		Number of tests
Very low	0 - 50	0
Low	51 - 100	0
Medium	101 - 200	3
High	201 - 300	16
Very High	300 +	5

These tests are relatively high when one considers that each year the entire corn crop is removed for corn silage. It is unlikely that additional potassium fertilizer would result in economical increases in crop yield.

Organic Matter

The organic matter level of the 0-6 inch sample taken from each area was determined by a modified Walkley - Black method. These determinations were made to assist the producer in applying herbicides. In general these analyses indicate a rather high level of organic matter. These levels of organic matter probably contribute greatly to the annual soil nitrogen level. There would appear, however, to be little correlation between the percent organic matter and the quantity of nitrate-nitrogen found in the top 2 feet of soil. Soils with organic matter levels of 5 to 6 percent displayed higher nitrate-nitrogen levels than those of 7 percent or above. This illustrates the fallacy of using the organic matter level of a soil as a measure of annual nitrogen availability. It stresses the need for an annual test to determine the nitrate-nitrogen level of each individual field.

Conductivity

Conductivity measurements were made on each area to determine the relative quantity of possible soluble salts which might be injurious to crop growth and soil degeneration. The level of conductivity and the possible depression in crop yields is often expressed as follows.

Conductivity mmhos/cm	Effect on crop
0 - 2	None
2 - 4	Sensitive crops effected
4 - 8	Many crops effected
Over 8	Most crops effected

Only two areas sampled displayed conductivity levels which might have a deleterious effect on crop yields. Those areas which had a high conductivity level also displayed a high level of nitrate-nitrogen. No more manure should be applied on these areas until the conductivity level is below 1.0 mmhos/cm.

Summary and Recommendations

Soil samples taken from 24 areas of the Wilder Farm in Jackson County indicate relatively high levels of nitrate-nitrogen, available phosphorus and exchangeable potassium. Except for the application of starter fertilizer at planting time, the need for additional fertilizer for corn production is probably not warranted.

1. For the 1980 cropping year, each area should be sampled and tested for nitrate-nitrogen. (Preferably in the fall, 1979).

2. It will not be essential to sample the areas for phosphorus and potassium in 1980.

3. Those areas with a conductivity level above 2.0 mmhos/cm should be re-sampled in the fall of 1979.

4. During the 1979 cropping season it is suggested that comparisons of manure and no manure be carried out on several fields by use of strips. Yield determinations should be made from the treated and non-treated areas at harvest time.

5. Soil and plant analysis for zinc might be carried out in the near future. The soils of this area may be deficient in zinc, especially when phosphorus levels are high.

6. It is unlikely in this case since cattle manure contains considerable zinc. The analysis of the manure is shown in Annex 3. It is evident that the amount of heavy metals in the manure would not pose any problems in a land application program.

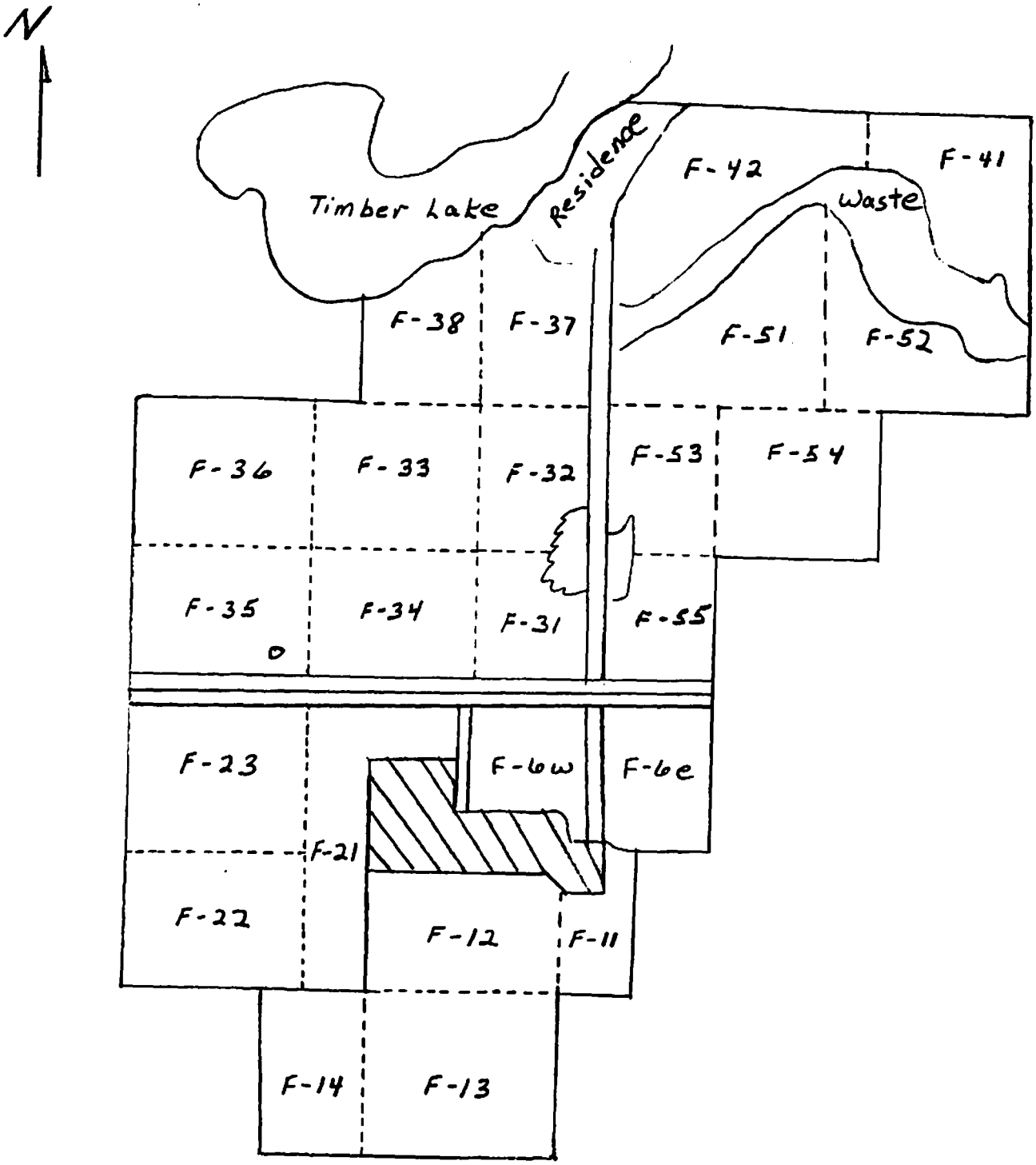
7. Soil and plant analyses could be helpful in avoiding any future problems.

ANNEX 1

Results Soil Analysis - Wilder Farms
Wilder, Minnesota

Field F_1	NO_3N Lbs/A	P Lbs/A	K Lbs/A	OM %	COND. mmhos
Area 1	Alfalfa	119	343	5.2	.8
Area 2	900	96	600+	9.9	3.0
Area 3	480	42	341	9.9	2.3
Area 4	215	36	265	7.8	.8
Field F_2					
Area 1	Oats	118	460	6.0	.8
Area 2	282	68	252	7.0	.9
Area 3	218	44	253	9.2	.7
Field F_3					
Area 1	360	59	206	4.9	.9
Area 2	350	50	195	5.2	1.0
Area 3	---	56	220	6.2	.9
Area 4	---	46	210	6.7	.7
Area 5	172	45	212	6.3	.6
Area 6	130	51	224	6.6	.7
Area 7	152	70	240	7.3	.8
Area 8	112	52	190	7.6	1.0
Field F_4					
Area 1	140	53	195	5.0	.6
Area 2	244	66	278	5.6	.6
Field F_5					
Area 1	182	85	248	5.3	.6
Area 2	175	54	247	5.2	.8
Area 3	---	34	213	8.0	.7
Area 4	---	68	264	5.2	1.0
Area 5	530	175	600+	5.7	1.3
Field F_6					
Area E	200	70	264	4.4	.8
Area W	500	60	224	5.9	.8

WILDER FARMS- WEIMER & DELAFIELD TWP.



ANNEX 3

Manure Analysis - Wilder Farms

	Percent - Wet Weight
Kjeldahl - Nitrogen	0.6
NH_3-N	0.5
PO_4-P	0.1
K	0.3

	Mg/Kg - Wet Weight
Cu	1.5
Ni	< 2.09
Pb	< 2.6
Zn	14.1
Cd	< 0.5
Cr	< 2.6

TOTAL SOLIDS	14.0%
CALCIUM CARBONATE EQUIVALENT	1.25%

YIELDS AND QUALITY OF SUNFLOWER AND WHEAT CROPS AS INFLUENCED BY FERTILIZER RECOMMENDATIONS FROM SEVERAL SOIL TESTING SERVICES*

Charles Simkins and Michael O'Leary

Farmers in Minnesota have an opportunity to utilize soil test services from a rather large number of independent as well as land-grant college laboratories. The value of these services to the agriculturist should ultimately be measured in the resulting returns of increased crop yield and or quality of the crop for the amount of investment in fertilizer.

Soil test services should supply to the farmer a fertilizer program which will result in the highest economical yield with the least cost of fertilizer.

It is nearly impossible to predict with absolute certainty the ability of a soil to supply a given nutrient for crop use. However, the use of a soil testing service which has carefully researched the soil test values against the response of the crop in the field usually provides an economical and effective fertilizer recommendation.

Most soil testing services can do a precise, reproducible test on a soil sample and obtain an index of the nutrient level in the soil. If, however, the nutrient index is not correlated and calibrated with field response the test is of doubtful value.

Minnesota soil specialists have recognized for some time that there is considerable difference in the fertilizer recommendations furnished farmers by various laboratories providing these services. Farmers in several instances have voiced a concern and have indicated that they have lost faith in soil testing because of the wide variation in recommendations they have obtained from different laboratories.

In order to develop educational information which would assist the University of Minnesota soil specialists in re-establishing farmers confidence in soil testing, experiments were established on two crops (wheat and sunflowers).

These trials were carried out on farmers fields in W. Polk and Marshall County, Minnesota. A large composite sample of soil was taken at each location in the spring of 1979. The samples were dried thoroughly, mixed and sub-divided for testing at 5 different laboratories.

Sub-divided samples were sent by the farmer to these laboratories with an indication of the desired crop and yield goal. After receiving the recommendations for the 5 different laboratories, fertilizer treatments were formulated from dry fertilizer materials. The fertilizer materials were applied broadcast and incorporated by disking prior to planting. The weed control, tillage and planting were done by the farmer cooperators.

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

The samples were sent to 3 commercial laboratories and 2 land-grant college laboratories.

Results and Discussion of Sunflower Trials

The sunflower trial was established on a Bearden silty clay loam near Crookston, Minnesota. The field was well drained and soil test indexes indicate a rather high state of residual fertility. It had been in sugarbeets the previous year. Soil test values obtained from the University of Minnesota Soil Testing Laboratory were the following: pH 7.8, P - 103 lbs/acre, K - 481 lbs/acre, NO_3-N 2 feet 62 lbs/acre.

The recommended fertilizer useage by each laboratory for a yield goal of 2400 lbs/acre are shown in Table 1. Each fertilizer treatment and check plot was replicated 4 times in a randomized complete block design. Each individual plot consisted of six - thirty six inch rows forty feet in length.

Table 1. Comparison of Fertilizer Recommendations for Sunflowers (Yield Goal 2400 lbs/acre) from Various Soil Testing Laboratories - 1979

Laboratory	Recommendations lbs/acre							
	N	P_2O_5	K_2O	S	Zn	Fe	Mg	Mn
A	121	--	30	-	4	3	5	2
B	95	45	40	8	-	-	-	-
C	105	--	35	6	3	-	-	-
D	60	--	--	-	-	-	-	-
E	60	--	--	-	-	-	-	-

A summary of fertilizer costs based on average price of materials in April, 1979 is shown in Table 2.

In the case of iron the price of iron sulfate was used. An application of 3 pounds per acre of chelate iron would have greatly increased the cost of this nutrient.

Table 2. Fertilizer Costs ($/acre) from Fertilizer Recommendations for Sunflowers. Crookston - 1979

Laboratory	Total Fertilizer Costs/Acre
A	28.40
B	25.20
C	18.20
D	7.20
E	7.20

The final plant population of sunflowers was approximately 15,100 plants/acre. During the growing season there was a rather ample supply of precipitation. There were essentially no weeds in the field and little or no problems were associated with insect damage.

A number of pathological diseases were observed during the growing season and at harvest time. The most prevalent were Sclerotinia, Rhizopus and Fusarium. It is estimated that yields were reduced approximately 15 percent by the presence of these organisms.

Seed yields and oil yields were determined from samples harvested from the middle two rows of each plot.

Harvested sunflower heads were cut, bagged and dried to eight percent moisture. Threshing and cleaning of seed was accomplished with a Volgel thresher and dockage cleaning equipment.

The yields and percent oil were obtained from seed samples of areas treated as recommended by the various soil testing laboratories are compared with non-treated areas in Table 3.

Table 3. Seed and Oil Yields of Sunflowers from Fertilizer Recommendations from Various Soil Testing Laboratories. Crookston, Minnesota - 1979

Laboratory	Seed Yields Lbs/Acre	Oil Percent	Oil Yield Lbs/Acre
A	2224	38.6	858
B	2221	39.0	866
C	2292	39.0	894
D	2138	38.0	812
E	2108	37.7	795
No Treatment	2081	40.0	834
Significance	NS	NS	NS

No significant increase or decrease in seed yields, percent oil, or oil yields were observed as a result of the fertilizer treatments recommended.

The yields although somewhat reduced by disease were considered good yields for the crop year 1979. Farmers yields in the same area ranged from 1000 to 1500 lbs seed/acre.

The data indicated a slight reduction in oil percentage as a result of fertilizer applications. This reduction was not significant at the 5% level.

Results and Discussion of Wheat Trials

Wheat trials were established on a Fargo silty clay loam soil near Warren, Minnesota. The previous crop was wheat. The recommended fertilizer usage by each laboratory for a yield goal of 60 bushels of wheat per acre was applied and disked in prior to the planting of wheat. Each fertilizer treatment and check plot was replicated 4 times in a randomized complete block design. Each individual plot consisted of an area fourteen x thirty feet. The recommended fertilizer use by the various laboratories is shown in Table 4.

Table 4. Fertilizer Recommendations for Wheat (Yield Goal 60 bu/acre) from Various Soil Testing Laboratories - 1979.

Laboratory	Recommendations lbs/acre						
	N	P_2O_5	K_2O	S	Zn	Fe	Mg
A	85	--	30	--	-	3	5
B	50	30	--	24	-	-	-
C	60	--	50	5	2	-	-
D	60	--	--	--	-	-	-
E	65	--	--	--	-	-	-

The wheat crop was seeded on May 18, 1979, using 90 lbs. of Era wheat seed per acre.

The soil test value obtained from tests at the University of Minnesota Soil Testing Laboratory were as follows: pH 7.7, P - 139 lbs/acre, K - 600+ lbs/acre, NO_3-N 2 feet 81 lbs/acre.

A summary of fertilizer costs based on the average price of fertilizer materials in April, 1979 is shown in Table 5.

Table 5. Comparison of Fertilizer Costs ($/acre) Based on Fertilizer Recommendations from Various Laboratories - Wheat Trials, Warren, Minnesota - 1979

Laboratory	Total Fertilizer Costs/Acre
A	21.10
B	12.90
C	13.70
D	7.20
E	7.80

Weed control for the crop was accomplished by 2 spray applications of herbicide. During the growing season excessive rain was obtained on several occasions. Additionally, during the latter part of the growing season the crop was subjected to several weeks of continuous cloudy weather. Despite these handicaps the yield and quality of the grain was above normal whem compared to other fields in the area.

The yields, protein and test weight of the wheat obtained from the various treatments are shown in Table 6.

Table 6. Yields, Protein Percent and Test Weight of Era Wheat from Various Fertilizer Recommendations. Warren, Minnesota - 1979

Laboratory	Bu/A	Protein %	Test Weight Lbs/Bu
A	53.3	14.3	59.9
B	52.0	14.3	60.7
C	51.6	14.6	60.8
D	54.2	14.4	60.4
E	51.9	14.6	60.0
No Treatment	55.2	14.1	60.1
Significance	NS	NS	NS

No significant differences in yield, protein content or test weight of wheat were observed as a result of the various fertilizer treatments.

These trials illustrate the need for farmers to consider and select carefully the laboratory which they use to develop their fertilizer program.

1979 Soybean Foliar Fertilizer Studies**

G.E. Ham, G.W. Randall and S.D. Evans

During the 1979 growing season, Folian was applied at the rate of 100 pounds of material per acre (12-4-4-1/2 S analysis) and Eco-Gro was applied at the rate of one quart per acre (8-4-4). Hodgson '78 soybeans were planted in 14 inch rows at Rosemount and Waseca and in 30 inch rows at Morris. Foliar fertilizer treatments were not applied at Lamberton due to very frequent rainfalls during flowering and pod-filling. Soil tests indicated that no soil fertilizer was needed.

The only seed yield increase occured at Rosemount when Folian was applied. Folian did not increase seed yields at the other locations while Eco-Gro did not increase seed yields at any location.

Table 1. Influence of commercial foliar fertilizer on soybean seed yields.

	Location		
Treatment	Morris	Rosemount	Waseca
	bu/acre		
Control	37	43	36
Eco-Gro	36	44	36
Folian	38	48*	36

*Seed yield significantly greater than unfertilized control at the same location.

**This project was financed through support by Minnesota Soybean and Promotion Board.

NITROGEN FERTILIZATION OF SUGARBEETS IN WEST-CENTRAL MINNESOTA - 1979

G. L. Malzer, J. N. Lensing, and O. M. Gunderson

Nitrogen management continues to be a prime economic consideration that sugarbeet growers not only in West-Central Minnesota, but also in other sugarbeet production areas should be concerned with if they are to attain maximum sugar production per acre. Nitrogen management involves many aspects of nitrogen fertilization, including not only rates of application but also nitrogen forms, methods of application and time of application. The need for nitrogen in sugarbeet production is well documented, but it has also been demonstrated that excess nitrogen fertilizer may decrease the sugar percentage and purity thereby lowering the recoverable sugar per acre. An accurate prediction of nitrogen needs is therefore essential in the overall nitrogen management system. The measurement of residual nitrates in the soil to a depth of two feet has aided a great deal in estimating the nitrogen needs for sugarbeets, but depending on the year (weather), soil type, soil organic matter, soil drainage and previous cropping history, the nitrogen fertilizer requirement may vary from one location to another. The sugarbeet variety planted and the plant population utilized could also influence the yield, quality and the nitrogen needs of the crop.

Research was initiated in 1976 to study the problem of predicting fertilizer nitrogen requirements for sugarbeets in West-Central Minnesota. One of the major concerns of the research in 1976 was to determine the adequacy of the two foot nitrate-nitrogen test in making fertilizer recommendations. Since many soils outside of the Red River Valley have better drainage characteristics, large accumulations of nitrate-nitrogen below a depth of two feet have been encountered. If sugarbeets are capable of utilizing large quantities of nitrate-nitrogen below a depth of two feet this will influence the fertilizer nitrogen needs and the soil test should be altered to make a more accurate prediction. The objectives of the studies in 1979 were to look at various aspects of nitrogen management and to: 1) evaluate the importance of deep subsoil nitrates, and to determine the optimum soil sampling depth; 2) to correlate and calibrate soil nitrate-nitrogen levels to fertilizer nitrogen rates; 3) to investigate the importance of nitrogen rate, and timing of nitrogen application on soil nitrates and various yield components; 4) to evaluate the importance of nitrogen forms and rates; and 5) to determine the responses of different varieties of sugarbeets to rates of nitrogen application.

Materials and Methods: Eleven locations were selected in West-Central Minnesota for nitrogen management studies in 1979. Seven locations were established for fertilizer nitrogen correlation-calibration information, two locations to evaluate time, rate and form of nitrogen application, and two locations to investigate the response of different sugarbeet varieties to increasing rate of nitrogen.

The correlation-calibration experiments consisted of two locations with nitrogen rates of 0, 40, 80, and 120 pounds of nitrogen per acre applied in the fall as urea. These trials were established with four replications and

arranged in a randomized complete block. Five additional locations consisting of four paired comparisons of nitrogen fertilizer versus a no nitrogen control were also conducted. These 200-400 foot strips were established by farmers utilizing the nitrogen fertilizer rate and form which was used on the remainder of the field. Two different experiments were established to investigate the importance of time, rate, and form of nitrogen application. One location was on the Earl Davison farm which consisted of two dates of fall applied nitrogen (Aug. 15 and Nov. 5) and one spring application (May 17). Nitrogen was applied as urea at rates of 40, 80 and 120 pounds per acre. An ammonium nitrate comparison was included on the Nov. 1 application date. A second trial was established on the West-Central Experiment Station at Morris, Minnesota. The trial consisted of two dates of nitrogen application (Nov. 1 and May 15), with three rates of nitrogen (0, 40, 80 lbs. N/A), and four nitrogen sources (anhydrous ammonia, urea, ammonium nitrate, and urea-ammonium nitrate (28%) solution). All treatments were replicated four times. Trials to investigate the importance of nitrogen rates and sugarbeet varieties were established at the West-Central Experiment Station at Morris, Minnesota and the LeRoy Stamer farm in Renville County. These trials were conducted in cooperation with Dr. Larry Smith at the Crookston station and results from the Morris station along with the overall summary of the project has been prepared by Dr. Smith. Both trials were conducted in the same manner with six varieties, three nitrogen levels and four replications in a split block arrangement. Nitrogen levels were established at soil nitrate (two feet) plus fertilizer nitrogen of 150, 250, and 350 lbs N/A. The six varieties utilized were: Beta 1443, G.W. R-1, ACH-30, Beta 1345, Bush Monofort, and H 309.

Soil cores were taken to a depth of five feet prior to fertilization in all experiments. The soil cores were separated into increments of 0-½', ½-1', 1-2', 2-3', 3-4', and 4-5' and analyzed for nitrate-nitrogen. In addition soil analysis were made on a composite sample of the 0-½' depth for pH, organic matter, available phosphorus, exchangeable potassium and zinc. Young-mature petioles were sampled from all experiments three times in four week intervals beginning on July 31 to monitor nitrate-nitrogen levels in the sugarbeet tissue.

Plots were harvested during the first two weeks of October utilizing either a four row farmhand lifter or a modified one row plot harvester supplied by Dr. Smith at the Crookston Experiment Station. Subsamples were collected and processed through the tare lab either at the Minn-Dak Farmers Cooperative and American Crystal lab at Moorhead or the American Crystal lab at East Grand Forks.

Results and Discussion: Of the eleven experimental locations established in 1979 only five locations produced favorable responses to the addition of fertilizer nitrogen. The residual nitrates in the top two feet of the experimental locations were high (>150#/N) at only three locations, and this coincided very well with the lack of a nitrogen response from these areas. From the eight locations which were low to medium in nitrate-nitrogen (less than 150) in the top two feet, five locations responded to nitrogen fertilization, two locations did not appear to respond because of high subsoil nitrates (below two feet) and one was severely influenced by poor drainage.

The experiments which compared different nitrogen forms suggested that their was no difference between materials. Although there was no overall response

to nitrogen at the Earl Davison location, timing of application did directly influence yield, gross sugar and recoverable sugar. Early fall application of nitrogen was in general inferior to a later fall application. This would suggest that the position of nitrate-nitrogen in the soil profile may be an important parameter to consider when evaluating nitrogen responses and its relationship to sugar production.

Responses of different sugarbeet varieties to increasing nitrogen fertilization can be very important when evaluating sugar production. Please refer to the report by Dr. Larry Smith in the 1979 Sugarbeet Research and Extension Reports for the long term summary of this topic.

General Comments: The present two foot soil sample for nitrate-nitrogen is a very valuable tool in predicting the nitrogen needs for sugarbeets. When the nitrate test is high (greater than 150# N/A) response to fertilizer nitrogen are minimal. When the nitrate test (2') is less than 150 lbs. N/A responses and calibration are less clear cut. In several situations an estimate of the nitrate-nitrogen below a depth of two feet was useful in predicting the type of response which would be expected. The positioning of the nitrates in the soil profile may also be important and a 0-3' or 0-4' may not be as good as a 0-2' and 2-4' sample.

Minnesota soils have a tremendous ability to release nitrogen from organic matter when the moisture and growing season are adequate. The sugarbeet grower should, therefore, not be misled into believing he needs to apply large amounts of nitrogen to obtain high tonnage. These excessive rates of nitrogen fertilization can decrease sugar and purity and not necessarily increase tonnage.

Acknowledgements: Sincere appreciation is extended to the Sugarbeet Research and Education Board and to the University of Minnesota Experiment Station for financing and supporting this research project. Recognition should be given to our farmer-cooperators for their interest and assistance and to Wayne Schwitter for his special assistance during harvest. Special appreciation is also extended to Jerome Lensing and the Department of Soil Science field crew for their attention to the field phases of the project and to Dr. Larry Smith and Mr. Gordon Rudolph for their assistance with the experiments.

Table 1. Soil nitrate-nitrogen at the experimental locations for the 1979 studies.

Soil Depth	H. Peterson, P. Frieborg ----- Calibration ------		E. Davison N Rate x Time Aug. 15, Nov. 5, May 17			W.C. Station N Form	L. Stamer N Variety
Feet	---------- lbs NO_3-N/A ----------						
0-½	34	45	17	23	24	24	17
½-1	43	17	9	18	17	20	7
1-2	66	20	9	17	18	23	15
2-3	40	13	9	9	10	44	8
3-4	97	18	9	9	10	43	
4-5	34	16	9	8	7	33	

Table 2. Effect of various rates of nitrogen on sugarbeet root yield, percentage sugar, gross sugar, purity, and recoverable sugar. Harold Peterson farm, Chippewa County - 1979.

Nitrogen Rate	Yield	Sugar	Gross Sugar	Purity	Recoverable Sugar
lbs/A	T/A	%	lbs/A	%	lbs/A
0	19.8	16.8	6636	87.7	5814
40	21.2	16.4	6960	87.1	6080
80	20.4	15.6	6360	83.5	5324
120	19.4	15.9	6184	85.4	5285
Significance	NS	NS	NS	**	NS
BLSD (.05)	--			0.2	

Table 3. Effect of various rates of nitrogen on sugarbeet root yield, percentage sugar, gross sugar, purity, and recoverable sugar. Pete Frieborg farm, Renville Co. - 1979.

Nitrogen Rate	Yield	Sugar	Gross Sugar	Purity	Recoverable Sugar
lbs/A	T/A	%	lbs/A	%	lbs/A
0	24.7	15.7	7760	86.4	6708
40	26.2	15.4	8072	87.5	7060
80	24.9	15.7	7809	87.3	6816
120	25.1	15.2	7640	86.5	6607
Significance	NS	NS	NS	NS	NS
BLSD (.05)	--	--	--	--	--

Table 4. Effect of nitrogen rate, timing of nitrogen application and nitrogen form on sugarbeet root yield, percentage sugar, gross sugar, purity, and recoverable sugar. Earl Davison farm, Grant County - 1979.

Treatments					Gross		Recoverable
N Rate	Date	Form	Yield	Sugar	Sugar	Purity	Sugar
lbs/A			T/A	%	lbs/A	%	lbs/A
40	8/15	Urea	14.0	18.4	5152	87.0	4481
40	11/1	Urea	16.6	19.0	6299	88.9	5598
40	11/1	A.N.	15.6	18.6	5811	88.2	5126
40	5/17	Urea	14.3	17.7	5083	85.5	4363
80	8/15	Urea	14.9	18.5	5499	85.3	4691
80	11/1	Urea	15.8	18.6	5876	86.9	5102
80	11/1	A.N.	15.5	18.5	5769	87.4	5043
80	5/17	Urea	15.5	17.9	5568	86.5	4823
120	8/15	Urea	14.9	18.4	5483	84.7	4650
120	11/1	Urea	15.6	19.0	5908	85.6	5056
120	11/1	A.N.	17.3	19.0	6564	86.4	5678
120	5/17	Urea	16.0	17.6	5606	83.0	4660
Nitrogen Rates - lbs/A							
40			15.1	18.4	5586	87.4	4892
80			15.4	18.4	5678	86.5	4915
120			15.9	18.5	5890	84.9	5011
Significance			NS	NS	NS	**	NS
BLSD (.05)			--	--	--	0.8	--
Time of N Application							
	8/15	Urea	14.6	18.4	5378	85.7	4607
	11/1	Urea	16.0	18.8	6028	87.1	5252
	5/16	Urea	15.2	17.7	5419	85.0	4616
Significance			+	*	*	+	**
BLSD (.05)			1.0	0.8	482	1.5	439
Nitrogen Form (Nov. 1)							
		Urea	16.0	18.8	6028	87.1	5252
		A.N.	16.1	18.7	6048	87.3	5282
Significance			NS	NS	NS	NS	NS
BLSD (.05)			--	--	--	--	--
N Rate x Time x Form							
Significance			NS	NS	NS	NS	NS
BLSD (.05)			--	--	--	--	--

Table 6. Effect of nitrogen rate and sugarbeet variety on root yield, sugar content, gross sugar, purity and recoverable sugar. LeRoy Stamer farm, Renville County - 1979.

N Rate	Variety	Yield	Sugar	Gross Sugar	Purity	Recoverable Sugar
lbs/A		T/A	%	lbs/A	%	lbs/A
150	Beta 1443	18.2	16.0	5840	89.8	5244
150	G.W. R-1	17.2	16.6	5714	90.9	5200
150	ACH-30	15.9	16.8	5351	91.5	4899
150	Beta 1345	15.1	17.0	5149	91.5	4711
150	Bush Mono	11.9	17.3	4108	91.7	3767
150	H 309	14.6	16.4	4790	90.5	4333
250	Beta 1443	16.5	16.6	5490	89.3	4908
250	G.W. R-1	17.2	16.4	5645	91.3	5151
250	ACH-30	18.6	17.1	6344	90.6	5746
250	Beta 1345	16.3	16.6	5446	90.4	4930
250	Bush Mono	15.8	17.0	5351	90.2	4827
250	H 309	18.4	16.3	5986	90.0	5390
350	Beta 1443	18.8	16.0	6008	89.7	5384
350	G.W. R-1	20.0	15.9	6332	88.5	5608
350	ACH-30	18.4	16.8	6174	89.9	5553
350	Beta 1345	16.4	16.2	5356	90.1	4818
350	Bush Mono	17.4	16.2	5659	89.5	5067
350	H 309	17.6	15.6	5560	88.8	4942
N Rate lbs/A						
150		15.5	16.7	5159	91.0	4692
250		17.1	16.7	5710	90.3	5159
350		18.1	16.1	5848	89.4	5229
Significance		*	NS	NS	**	NS
BLSD (.05)		2.0	--	--	0.1	--
Variety						
	Beta 1443	17.8	16.2	5779	89.6	5179
	G.W. R-1	18.1	16.3	5897	90.2	5320
	ACH-30	17.6	16.9	5956	90.7	5399
	Beta 1345	16.0	16.6	5317	90.7	4820
	Bush Mono	15.0	16.8	5039	90.5	4554
	H 309	16.9	16.1	5445	89.8	4888
Significance		**	**	**	NS	**
BLSD (.05)		1.3	0.6	527	--	482
N x Variety						
Significance		*	NS	NS	NS	NS
BLSD (.05)		2.8	--	--	--	--

Table 7. Effect of nitrogen fertilization on sugarbeet root yield, sugar percentage, gross sugar, purity and recoverable sugar - 1979.

Cooperator	Nitrate-Nitrogen 0-2'	0-3'	0-4'	0-5'	N Treatment	Yield	Sugar	Gross Sugar	Purity	Recoverable Sugar
	lbs				#/A	T/A	%	lbs/A	%	lbs/A
B. Skalbeck	47	63	77	90	0	16.0	14.7	4708	86.4	4070
Renville Co.					100	17.9	15.6	5605	88.3	4947
N. Bosch	159	230	331	366	0	18.8	15.7	5884	86.9	5120
Chippewa Co.					90	19.0	14.7	5598	84.8	4768
C. Morrow	102	144	178	205	0	13.9	19.1	5326	85.6	4564
Grant Co.					70	16.9	18.9	6418	85.2	5471
J. Berger (North)	174	261	359	397	0	14.6	18.0	5290	81.6	4340
Grant Co.					80	15.0	17.3	5192	80.2	4163
J. Berger (South)	130	176	196	208	0	9.1	18.4	3363	82.6	2771
Grant Co.					80	12.9	19.4	5006	85.7	4296

Table 5. Effect of nitrogen rate, timing of nitrogen application and nitrogen form on sugarbeet root yield, percentage sugar, gross sugar, purity and recoverable sugar. West-Central Experiment Station, Stevens County - 1979.

Treatments Time of Appl.	N Rate	N Form	Yield	Sugar	Gross Sugar	Purity	Recoverable Sugar
	lbs/A		T/A	%	lbs/A	%	lbs/A
----	0	------	19.8	17.0	6725	84.3	5766
11/1	40	A. Amm	21.0	17.4	7288	85.2	6211
11/1	40	Urea	20.2	17.0	6839	85.7	5859
11/1	40	A.N.	20.8	17.5	7290	87.7	6392
11/1	40	UAN	21.2	18.0	7628	87.3	6667
11/1	80	A. Amm	20.5	17.2	7019	85.5	6000
11/1	80	Urea	20.5	17.8	7301	85.8	6269
11/1	80	A.N.	20.8	17.0	7044	84.9	5985
11/1	80	UAN	20.5	17.4	7115	86.2	6131
5/15	40	A. Amm	20.0	17.3	6890	85.8	5918
5/15	40	Urea	21.2	17.6	7435	86.6	6439
5/15	40	A.N.	20.1	17.4	6978	85.9	5992
5/15	40	UAN	21.3	16.9	7182	82.2	5909
5/15	80	A. Amm	21.2	17.2	7340	84.3	6192
5/15	80	Urea	20.4	17.3	7027	86.2	6058
5/15	80	A.N.	20.8	16.2	6763	84.9	5742
5/15	80	UAN	20.8	16.6	6911	83.0	5750
Significance			NS	*	NS	NS	NS
BLSD (.05)			--	1.0	--	--	--
Time of Application							
Nov. 1			20.7	17.4	7191	86.0	6189
May 15			20.7	17.1	7066	84.9	6000
Significance			NS	*	NS	*	NS
BLSD (.05)			--	0.3	--	1.0	--
N Rates lbs/A							
40			20.7	17.4	7191	85.8	6173
80			20.7	17.1	7065	85.1	6016
Significance			NS	*	NS	NS	NS
BLSD (.05)			--	0.3	--	--	--
N Form							
		A. Amm	20.7	17.3	7134	85.2	6080
		Urea	20.6	17.4	7150	86.0	6156
		A.N.	20.6	17.0	7019	85.8	6028
		UAN	21.0	17.2	7209	84.7	6114
Significance			NS	NS	NS	NS	NS
BLSD (.05)			--	--	--	--	--
Time x Rate x Form							
Significance			NS	NS	NS	NS	NS
BLSD (.05)			--	--	--	--	--

Fertilizer Trials on sunflowers - 1979

S.D. Evans, G.W. Randall, C.J. Overdahl

Field trials on sunflowers were started in 1978 and continued in 1979.

Plots were located at Waseca, Morris, and Becker, Minnesota. Additional trials were conducted by Dr. Varvel in the Crookston area and his data are in the Crookston reports; and by Dr. Simkins, also reported elsewhere in the annual report. Tables 1 through 4 show results from nitroten treatments.

Table 1. Yields of sunflowers at 3 locations according to nitrogen treatments - 1979.

Treatment N lbs/A	Morris	Waseca	Becker
		lbs seed/acre	
0	1524	1930	1013
30	1992	1849	-
60	2092	1776	1746
90	2331	1619	1824
120	2426	1572	1866
150	2317	1581	1940
180	-	-	1940
Significance	**	*	**
BLSD (.05)	180	282	249
C.V.	6.8	9.8	10.2
Soil tests 1979 (early)			
Nitrate 0-2	31	56	10
P	H	M-H*	75
K	H	M-H*	60*

* 0+120+200 applied at Waseca, 0+0+120 applied at Becker.

Table 2. Effect of N treatments on leaf N, percent oil and oil yield. 1979.

N Lbs/A	Morris % N 5th leaf	Morris % oil	Morris oil lbs/A	Waseca % N 5th leaf	Waseca % oil	Waseca oil lbs/A	Becker % N 5th leaf	Becker % soil	Becker oil lbs/A
0	2.43	44.3	676	3.39	44.2	854	3.48	44.8	454
30	2.82	43.8	873	3.41	43.5	806	-	-	-
60	3.16	44.0	943	3.40	41.4	736	3.80	44.6	777
90	3.13	43.1	1009	3.48	42.2	685	3.76	45.2	801
120	3.39	43.6	1058	3.87	41.0	645	4.28	43.4	812
150	3.66	42.3	982	3.77	40.8	645	3.99	42.8	830
180	-	-	-	-	-	-	4.32	42.4	823
Significance	**	*	**	ns	**	*	**	+	**
BLSD (.05)	.35	1.0	88	-	1.1	129	.14	1.9	113
C.V.	9.1	1.7	7.8	9.7	1.8	11.2	2.6	3.1	10.6

Table 3. Soil nitrates in profile at Waseca & Morris, 1979.

Depth feet	Morris	Waseca 1st sampling May	Waseca 2nd sampling July
0-1	19	40	38
1-2	12	18	16
2-3	8	17	16
3-4	8	40	32
4-5	11	61	58

Table 4. Head size, percent lodged, population. Waseca, 1979/

	Head size cm	Head size inches	% lodged	Population plants/acre
0	15.0	6.0	2.5	23,810
30	14.7	5.8	12.0	24,540
60	15.0	6.0	17.0	24,530
90	13.6	5.4	28.2	25,840
120	13.8	5.5	27.5	24,100
150	14.1	5.6	30.0	25,700

Nitrogen summary -

Highly significant response to nitrogen was obtained at Morris and Becker. The 60 pounds per acre treatment at Becker appeared optimum and 90 pounds per acre appeared best at Morris. There was no significant response from nitroten at Waseca. High nitrates below 3 feet at Waseca appeared to be the reason for no response. Nitrates were low at Becker and Morris all the way to 5 feet. Oil content dropped as nitrogen rates were increased.

Results from potassium treatments at Becker are shown in Tables 5 and 6.

Table 5. Sunflower yield, soil test K, percent K in leaves, and percent oil related to 6 levels of potassium.

K_2O lbs/A	Yield lbs seed/A	Soil test K	% K, 5th leaf Aug. 20	% oil	Oil yield lbs/A
0	1277	63	2.60	41.2	527
60	1965	69	2.77	44.2	870
120	2017	76	2.90	44.3	914
180	2082	86	3.01	44.8	932
240	2172	87	3.27	44.7	971
300	2033	91	3.28	45.1	916
Significance	**		**	**	**
BLSD (.05)	220		.30	1.6	86

Potassium summary

The 60 pounds of K_2O treatment appeared nearly optimum, although the 240 pound treatment was significantly higher than 60 pounds. Oil content increased with treatment. The failure of the soil test to increase above a "low" level even with 300 pounds of K_2O is difficult to explain.

Table 6. The effect of potassium treatments on 9 elements in the 5th leaf - Becker, 1979.

K-Trt	---------%----------				---------ppm----------				
lbs K_2O/A	P	K	Ca	Mg	Fe	Mn	Zn	Ca	B
0	.44	2.60	2.17	1.30	68	132	47	19	30
60	.45	2.77	2.13	1.17	68	126	49	19	28
120	.45	2.90	1.96	1.02	69	124	44	19	30
180	.43	3.01	2.00	1.04	68	132	44	20	30
240	.43	3.27	1.82	.94	67	131	45	19	32
300	.44	3.28	1.88	.94	70	122	45	19	28
Significance	ns	**	*	**	ns	ns	+	ns	ns
BLSD (.05)	-	.30	.23	.10	-	-	4	-	
C.V.	3.8	6.8	7.1	6.6	3.7	16.2	5.8	7.4	14.4

NITROGEN, PHOSPHORUS AND POTASSIUM FERTILIZER RATE STUDIES ON SUNFLOWER - 1979

G.E. Varvel and R.K. Severson

The objective of this study was to gather data on the fertilizer needs of sunflower over a range of soil types and fertility levels. This data will be used for improving fertilizer recommendations on sunflower. Leaf samples were also taken during the growing season to investigate the effect of applied fertilizer on nutrient levels in the leaf and to determine if critical levels could be established for these nutrients.

Experimental Procedures:

Five potassium, 4 phosphorus and 1 nitrogen experiments were conducted in northwestern Minnesota over a range of soil types and textures. The fertilizer treatments and soil test information for each location are shown in Tables 1-10. Yield and oil content were determined for each location and leaf samples (5th leaf) at approximately 10% bloom were taken at 4 of the locations.

All treatments were spring applied. A randomized complete block design was used at all locations.

Results:

Yield, oil content and oil yield are shown in Tables 1-10 for all locations. Information on nutrient content of the 5th leaf is presented in Tables 1-4.

Significant yield responses were obtained in 3 of the experiments, 2 from phosphorus and 1 from potassium, at the Fosston and McIntosh locations (Tables 1-4). Visual responses and an increasing yield trend indicate that responses to both P and K may have been obtained at the Crookston location (Tables 5-6), but were nonsignificant due to uneven stands. The experiments at Blackduck were highly variable due to many complicating factors and no conclusions were apparent (Tables 7-10).

Oil content was not affected by the fertilizer treatments at any location.

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

Treatment K_2O Rate	Yield	Oil	Oil Yield	Population at Harvest	Leaf Analyses N	P	K	Ca	Mg	Fe	Na	Mn	Zn	Cu	B
lb/A	lb/A	%	lb/A	Plants/A	%					ppm					
0	2087	42.6	888	21,586	4.6	0.54	2.52	1.81	1.08	74	13	65	54	16	98
50	2082	42.7	888	20,522	4.3	0.51	2.56	1.78	1.14	80	10	61	49	14	98
100	2147	42.7	917	22,458	4.6	0.52	2.68	2.02	1.07	77	7	69	51	13	103
150	2115	42.9	908	21,780	4.4	0.52	2.83	1.88	0.98	76	11	60	51	13	103
200	1997	42.7	852	21,393	4.5	0.53	2.90	1.98	1.00	78	8	67	51	14	103
250	2097	42.1	882	19,360	4.4	0.51	3.04	1.98	1.01	72	9	63	48	16	106
Significance	NS	NS	NS	NS	NS	NS	**	NS	NS	NS	NS	NS	NS	NS	NS
B.L.S.D.(.05)							0.22								
C.V. (%)	7.7	1.7	8.6	10.1	4.2	4.8	5.3	10.8	8.1	11.5	42.4	14.5	7.7	12.3	6.5

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

Treatment P_2O_5 Rate	Yield	Oil	Oil Yield	Population at Harvest	Leaf Analyses N	P	K	Ca	Mg	Fe	Na	Mn	Zn	Cu	B
lb/A	lb/A	%	lb/A	Plants/A	%					ppm					
0	1937	42.5	823	19,457	4.6	0.45	3.34	2.12	0.89	73	8	69	62	19	92
40	1991	42.7	851	19,941	4.8	0.53	3.29	1.98	0.91	76	10	57	55	14	102
80	1951	41.6	811	16,069	4.6	0.54	3.23	2.03	0.99	70	8	60	54	14	102
120	2006	42.0	842	18,682	4.5	0.56	3.22	2.03	0.99	72	8	61	56	13	107
160	2157	42.4	915	19,263	4.3	0.49	3.28	2.09	1.09	63	7	61	46	14	103
200	2345	42.1	987	20,812	4.6	0.61	3.09	2.09	0.96	70	9	62	51	12	97
Significance	**	NS	**	NS	NS	**	NS	NS	NS	NS	NS	NS	*	*	NS
B.L.S.D.(.05)	232		108			0.08							11.4	4.9	
C.V. (%)	7.0	2.1	7.6	13.7	5.7	9.7	9.3	11.0	14.3	12.3	22.5	12.1	12.1	19.6	8.9

Soil Test P = 20 lb/A K = 227 lb/A Broadcast 100 K_2O over P Study.

Farmer applied 85 N as anhydrous ammonia. Broadcast 40 P_2O_5 over K Study.

Table 3. Effects of different rates of potassium fertilizer on sunflower at McIntosh.

Treatment					Leaf Analyses										
K_2O Rate	Yield	Oil	Oil Yield	Population at Harvest	N	P	K	Ca	Mg	Fe	Na	Mn	Zn	Cu	B
lb/A	lb/A	%	lb/A	Plants/A	%					ppm					
0	1628	43.7	712	22,167	4.3	0.35	2.65	1.96	1.09	59	8	64	50	22	84
50	1631	43.5	709	22,070	4.2	0.33	2.96	2.01	1.03	59	8	63	51	24	87
100	1768	43.8	775	22,651	4.0	0.33	3.15	2.24	1.05	60	10	65	48	23	95
150	1840	44.2	813	22,651	4.4	0.40	3.28	2.11	0.96	61	7	57	45	19	93
200	1900	44.1	838	22,651	4.2	0.35	3.47	2.19	0.89	62	8	62	45	24	96
250	1921	44.1	847	23,135	4.1	0.33	3.53	2.14	0.93	63	11	64	43	22	95
Significance	**	NS	**	NS	NS	NS	**	NS	NS	NS	NS	NS	*	NS	NS
B.L.S.D.(.05)	170						0.54						5.8		
C.V. (%)	6.1	1.1	6.1	8.3	4.0	13.5	10.4	11.7	13.0	8.9	27.3	15.4	7.3	14.1	9.1

Table 4. Effects of different rates of phosphorus fertilizer on sunflower at McIntosh.

Treatment					Leaf Analyses										
P_2O_5 Rate	Yield	Oil	Oil Yield	Population at Harvest	N	P	K	Ca	Mg	Fe	Na	Mn	Zn	Cu	B
lb/A	lb/A	%	lb/A	Plants/A	%					ppm					
0	1684	43.8	736	23,038	4.2	0.31	2.61	1.96	1.19	60	7	56	46	20	81
40	1613	43.5	701	23,038	4.1	0.34	2.66	2.13	1.21	59	6	62	42	21	88
80	1876	42.5	799	22,070	4.4	0.39	2.55	2.18	1.29	59	6	68	38	19	91
120	1997	43.0	859	22,458	4.4	0.43	2.48	2.25	1.39	67	7	77	36	17	99
160	1963	42.6	836	21,006	4.4	0.42	2.45	2.16	1.39	63	6	63	35	17	89
200	2032	43.2	878	22,941	4.4	0.46	2.40	2.44	1.48	61	8	76	37	16	93
Significance	**	NS	*	NS	NS	**	NS	NS	*	NS	NS	NS	**	**	NS
B.L.S.D.(.05)	262		126		0.09								5.3	2.8	
C.V. (%)	8.8	2.1	9.4	7.7	7.1	14.9	7.4	11.5	9.0	10.6	29.2	23.0	8.7	9.4	10.3

Soil Test P = 11 lb/A K = 196 lb/A Broadcast 50 lb/A K_2O over P Study.

Farmer applied 90 N as anhydrous ammonia. Broadcast 40 lb/A P_2O_5 over K Study.

Table 5. Effects of different rates of phosphorus fertilizer on sunflower - Crookston.

P_2O_5 Rate	Yield	Oil	Oil Yield
lb/A	lb/A	%	lb/A
0	1463	42.9	621
40	1601	43.5	696
80	1814	43.2	782
120	1770	40.4	713
160	1575	41.3	653
200	1627	42.2	686
Significance	NS	NS	NS
C.V. (%)	14.2	3.7	13.4

Soil Test P = 13 lb/A K = 103 lb/A Broadcast 60 lb/A N over both studies, 120 lb/A K_2O on P Study and 40 lb/A P_2O_5 on K Study.

Table 6. Effects of different rates of potassium fertilizer on sunflower - Crookston.

K_2O Rate	Yield	Oil	Oil Yield
lb/A	lb/A	%	lb/A
0	1492	40.3	600
50	1585	42.8	676
100	1461	42.3	617
150	1798	41.9	756
200	1740	42.3	736
250	1792	41.4	742
Significance	NS	NS	NS
C.V. (%)	18.7	3.1	19.0

Soil Test P = 13 lb/A K = 103 lb/A Broadcast 60 lb/A N over both studies, 120 lb/A K_2O on P Study and 40 lb/A P_2O_5 on K Study.

Table 7. Effects of different rates of nitrogen fertilizer on sunflower - Blackduck.

NO_3-N Rate	Yield	Oil	Oil Yield
lb/A	lb/A	%	lb/A
0	1246	47.5	590
30	908	46.7	428
60	1220	47.2	579
90	1370	46.4	640
120	1185	47.1	559
150	1200	45.8	548
Significance	NS	NS	NS
C.V. (%)	29.4	2.9	30.1

Soil Test P = 150 lb/A K = 154 lb/A.
Farmer had applied 100 lb/A on field.

Table 8. Effects of different rates of phosphorus fertilizer on sunflower - Blackduck.

P_2O_5 Rate	Yield	Oil	Oil Yield
lb/A	lb/A	%	lb/A
0	1463	43.5	638
40	1418	42.6	604
80	1506	42.7	641
120	1359	41.3	564
160	1703	42.6	728
200	1474	44.0	651
Significance	NS	NS	NS
C.V. (%)	10.7	4.7	12.5

Soil Test P = 11 lb/A K = 157 lb/A.
Farmer had applied 100 lb/A N on field.

Table 9. Effects of different rates of potassium fertilizer on sunflower - Blackduck.

K_2O Rate	Yield	Oil	Oil Yield
lb/A	lb/A	%	lb/A
0	1838	44.6	824
50	1711	42.3	725
150	1533	43.4	665
250	1428	43.5	619
Significance	NS	NS	NS
C.V. (%)	17.9	2.8	19.2

Soil Test P = 17 lb/A K = 95 lb/A.
Farmer had applied 100 lb/A N on field.

Table 10. Effects of different rates of potassium fertilizer on sunflower - Blackduck.

K_2O Rate	Yield	Oil	Oil Yield
lb/A	lb/A	%	lb/A
0	876	47.7	418
50	1074	46.4	498
100	938	47.3	445
150	857	46.9	405
250	858	46.9	405
Significance	NS	NS	NS
C.V. (%)	23.2	3.9	25.3

Soil Test P = 150 lb/A K = 154 lb/A.
Farmer had applied 100 lb/A N on field.

NITROGEN AND POTASSIUM STUDIES ON SUNFLOWERS IN PENNINGTON COUNTY, MINNESOTA - 1979

Charles Simkins and Michael O'Leary

The limited sunflower fertility studies in Minnesota have been conducted largely on the medium to fine textured soils of western and northern Minnesota.

In general the response to fertilizer has been relatively small and limited to nitrogen. Currently sunflower production in Minnesota has spread so that many of the coarse textured soils are being utilized for production.

These studies were conducted on a sandy loam soil overlying poorly drained sand, probably a Toppleton series. This soil represents a large acreage in Red Lake, Pennington and other counties on the beach areas of the Red River Basin.

Soil test data from the field indicated a rather low nitrate-nitrogen content (0-24 in.) of 58 to 71 lbs. The phosphorus test level at the 0-6 in. depth was 66 lbs. per acre and the K test indicated a range of 76-141 lbs. per acre.

Methods and Materials

Fertilizer materials were broadcast prior to planting and disked in. Sunflowers of the variety Sun Bred NK254 were seeded with a 6 row planter. Each plot was 15 feet by 40 feet.

Four replications of each treatment in a randomized complete block design were established in the trials. The nitrogen trials included rates of 0,30,60,90, 120, and 150 lbs. of N per acre on land which a broadcast application of 120 lbs. of K_2O has been applied.

In the potassium experiment 120 lbs. of nitrogen and 40 lbs. of P_2O_5 were applied to the experimental area with the exception of control treatments. The potassium treatments consisted of 90 lbs. of K_2O applied as KCl, K_2SO_4 and KCl plus sulfur. Remaining treatments were a non fertilized check, a nitrogen and phosphorus treatment and a nitrogen, phosphorus and sulfur treatment.

The potassium sulfate and sulfur treatments were included since the farmer had indicated that his crops often suffered from sulfur deficiency. The soil test subsequently indicated a rather high sulfur content (15 ppm).

Leaf samples were collected and analyzed for nitrogen content on the nitrogen rate study and for nitrogen, phosphorus and potassium content on the potassium study. The fifth leaf down from the blossom was utilized. The plants were sampled in the early bloom stage (Aug. 11, 1979). Weed and insect control for the trials was carried out by the cooperator. This control included a pre-plant herbicide application, one cultivation and one application of insecticide for control of sunflower leaf beetles.

Results and Discussion

The seed yields, oil percentage and pounds of oil per acre obtained as a result of the various potassium and sulfur fertilizer treatments are shown in Table 1.

Table 1. Influence of Various Fertilizer Treatments on the Seed and Oil Yields of Sunflowers - Fleshe Farm - Pennington County, Minnesota - 1979

Treatment Lbs/Acre N	P_2O_5	K_2O	Seed Yield Lbs/Acre	% Oil	Lbs Oil/Acre
0	0	0	657	39.7	263
120	40	0	888	37.2	335
120	40	90 (KCl)	1323	41.5	549
120	40	90 (K_2SO_4)	1366	41.6	566
120	40	90 (KCl+S)	1365	41.6	568
120	40	0 + S	682	37.6	256
		Significance	**	**	**
		BLSD (.05)	210	2.0	81

*Sulfur at 32 lbs/acre

Seed yields as well as oil yields were increased by nitrogen-phosphorus fertilizer treatments as well as nitrogen-phorphorus-potassium treatments. It is rather obvious that the addition of 90 lbs. of K_2O in combination with nitrogen and phosphorus resulted in striking increases in yield. The addition of sulfur either as calcium sulfate or in potassium sulfate did not result in significant increases in seed or oil yields. The inclusion of potassium in the fertilizer treatments significantly increased the percentage of oil in the sunflower crops.

Leaf analysis of the plant tissue from the various fertilizer treatments at the time of early bloom are shown in Table 2.

Table 2. Influence of Various Fertilizer Treatments on the N, P and K Content of Sunflower Leaves. Fleshe Farm - Pennington County, Minnesota - 1979

Treatment Lbs/Acre			% in Fifth Leaf		
N	P_2O_5	K_2O	N	P	K
0	0	0	3.4	.34	1.7
120	40	0	4.2	.39	1.3
120	40	90 (KCl)	4.1	.40	1.4
120	40	90 (K_2SO_4)	4.1	.41	1.9
120	40	90 (KCl+S)	4.1	.51	1.5
120	40	0+S	4.2	.42	1.4
		Significance	**	+	**
		BLSD (.05)	.4	.06	.2

*Sulfur at 32 lbs/acre

As indicated in Table 2 the application of nitrogen and phosphorus with or without the addition of potassium fertilizer increased the nitrogen and phosphorus content of the sunflower leaves. There was a significant reduction in the percent potassium in the leaves when nitrogen and phosphorus were applied alone. The percent potassium in the leaves, range (1.3 - 1.9 percent) is quite low in comparison to the level generally encountered when sunflowers are grown on soil high in potassium (normally 3.0 to 4.0 percent). The nitrogen and phorphorus levels in the fifth leaf are similar to those obtained on more fertile soils.

A nitrogen rate study conducted in the same field did not result in statistically significant increases in seed or oil yields. The seed and oil yields as well as nitrogen content of the fifth leaf as influenced by the various nitrogen treatments is shown in Table 3.

Table 3. The Influence of Various Nitrogen Fertilizer Rates on Seed and Oil Yield and Leaf Nitrogen Content of Sunflowers

Nitrogen Lbs/Acre	Seed Yield Lbs/Acre	Oil %	Lbs Oil/Acre	% N In Fifth Leaf
0	1304	43.7	567	3.5
30	1490	42.7	636	4.2
60	1421	42.0	601	3.9
90	1448	42.6	616	4.1
120	1495	43.0	643	4.2
150	1568	42.4	664	4.7
Significance	NS	NS	NS	+
BLSD (.05)	--	--	--	.7

As indicated by the data in Table 3, nitrogen fertilizer treatments did not result in significant increases in seed or oil yields. There was however, a general trend towards increasing yields as a result of nitrogen treatments. The lack of significance may have been influenced by the rather mediocre plant population (15,000 per acre).

The nitrogen content of the sunflower leaves was significantly increased by the application of nitrogen fertilizer. This would further suggest a need for higher plant population to utilize the higher nitrogen level.

NITROGEN FERTILIZATION OF IRRIGATED SWEET CORN

J.N. Lensing, G.L. Malzer, O.M. Gunderson, and S.L. Johnson.

In 1979 a trial was conducted at Westport, MN to evaluate the influence of nitrogen on the production of irrigated sweet corn. Two Green Giant varieties of sweet corn; Code 7 as early planting and Code 47 planted approximately two weeks later were evaluated with ten treatments replicated four times. Treatments included a control, 4 nitrogen rates (60, 120, 180, 240 #N/A), 2 methods of application (single preplant), split application (1/4-preplant, 1/4-8 leaf stage, 1/3-12 leaf stage, 1/6-16 leaf stage) and one treatment of 180 #N/A coated with 1/2 #a.i./A Terrazole (nitrification inhibitor). Experimental area was irrigated as needed with a one tower center pivot system. Weeds were controlled with an application of atrazine.

Dry matter and nitrogen uptake were determined by harvesting 2 rows 20 ft. long from each plot. Ears were separated from stalks, field weights obtained and samples removed for moisture determination and nitrogen analysis. Wet ear T/A were recorded because farmer payments are based on wet ear weights delivered to factory. Quality factors were analyzed on samples taken to Green Giant plant at Glencoe, Minnesota.

Results

Early planted (Code 7) sweet corn (Table 1) ear dry matter production responded to 60 #N/A with 240 #N/A significantly better than check. Stover and total dry matter production were increased significantly up to 180 #N/A in a single application compared to 60 #N/A applied as split application, however, 240 #N/A applied as a split application and 180 #N/A with terrazole were significantly better than 60 #N/A. Ear and stover %N were signficantly increased with 60 #N/A. Ear, stover and total N-removal showed similar trends as the dry matter yields. Wet ear T/A were significantly increased from 5.6 T/A without N to 10.4 T/A with 240 #N/A. Split applications of N did not significantly increase yields of wet ear T/A.

Late planted (Code 47) sweet corn (Table 2) ear dry matter yields, nitrogen removal, and wet ear T/A responded significantly to 60 #N/A. Quality factors were not significantly affect by application or rate of nitrogen for either planting dates.

Table 1. Influence of nitrogen on dry matter, % N, N-removal, and wet ear T/A of Code 7 sweet corn. Westport, MN. 1979

Treatments # N/A	# of Appl.	Ears	Stover	Total	Ears	Stover	Ear	Stover	Total	Wet Ear T/A
		----------# D.M./A----------			-------%N--------		--N-Removal-#/A----------			
0	-	2088	3004	5092	1.37	1.06	28.5	31.7	60.3	5.6
60	1	3342	3314	6656	1.55	1.84	51.5	60.7	112.2	8.3
120	1	3096	3106	6202	1.51	1.61	46.8	49.6	96.4	8.3
180	1	3510	4166	7676	1.61	1.97	56.5	82.3	138.8	9.3
240	1	4062	4262	8324	1.59	2.08	64.7	88.7	153.4	10.4
60	4	3536	3444	6980	1.53	1.64	54.4	57.0	111.4	8.8
120	4	3424	3662	7086	1.57	1.96	53.5	71.4	124.9	9.0
180	4	3744	3784	7526	1.60	2.00	59.7	74.8	134.5	9.5
240	4	3928	4056	7984	1.63	2.06	64.0	83.3	147.3	10.4
180 + Dwell		3710	4298	8008	1.65	2.08	61.3	89.1	150.4	9.9
Signif.		**	**	**	NS	*	**	**	**	**
BLSD(.05)		787	498	873	-	.52	14.5	16.0	20.9	1.7
C.V.		12.8	8.0	7.4	5.8	15.3	15.5	14.3	10.6	11.0

Table 2. Influence of nitrogen on dry matter, % N, N-removal and wet ear T/A of Code 47 sweet corn. Westport, MN. 1979.

Treatments		Ears	Stover	Total	Ears	Stover	Ear	Stover	Total	Wet Ear
# N/A	# of Appl.	----------#D.M./A----------			--------%N----------		---N-Removal----#/A----------			T/A
0	-	2622	5916	8538	1.26	1.35	32.9	79.9	112.8	6.1
60	1	3656	7150	10808	1.30	1.40	47.3	99.3	146.6	8.5
120	1	3232	7424	10656	1.41	1.59	45.5	118.2	163.6	7.4
180	1	3424	7518	10942	1.36	1.59	46.4	121.4	167.5	7.9
240	1	3162	6496	9658	1.41	1.66	44.7	107.6	152.1	7.4
60	4	3502	7298	10798	1.41	1.43	49.3	104.0	153.2	8.3
120	4	3466	6614	10080	1.32	1.48	45.7	98.4	144.1	7.8
180	4	3126	7288	10416	1.45	1.60	44.9	117.3	162.2	7.3
240	4	3204	7038	10244	1.40	1.61	45.0	113.0	158.0	7.6
180 + Dwell		3304	6582	9886	1.40	1.54	46.3	101.3	147.7	7.5
Signif.		+	NS	NS	NS	NS	+	NS	NS	*
BLSD		613	-	-	-	-	9.4	-	-	1.4
C.V.		12.2	14.1	11.7	8.0	10.3	13.7	17.7	14.1	10.9

N Rate, Source, and Incorporation Study - Wheat

W. Nelson, S. Evans, G. Varvel, J. Lensing, and H. Meredith

Objective of Study: Determine wheat yield differences when broadcast forms of nitrogen are incorporated into the surface soil or left on the soil surface unincorporated. A secondary objective of the study is to utilize the nitrate soil test to correlate soil nitrate levels and wheat grain yields.

Locations: Crookston, Morris and Lamberton experimentation stations. Site selection based on nitrate tests where probability of response to N is high.

N Sources: Urea, ammonium nitrate and 28 percent urea-ammonium nitrate solution are compared.

N Rate: At Lamberton and Morris 40 and 80 pounds N per acre were applied. At Crookston 50 and 100 pounds N per acre were applied. Zero N plots serve to delineate an N response.

In general rainfall was adequate to slightly excessive in 1979. High yields in 1977 and 1978 have tended to lower residual N levels which have increased probability of a crop response to applied N.

There were little or no yield differences between the sources or incorporation, Table 1. Most, if not all of the response to applied N was achieved from the lower N addition.

Table 1. Yield of Era Wheat at Morris, Lamberton and Morris Experiment Stations as a Response to N Rates, Incorporated vs. Non-incorporation, 1979.

Lbs N/A	Am. Nitrate		Urea		28% N Soln.	
	I	N	I	N	I	N
Morris - check: 13.4 - Yield - Bu/A						
40	23.6	25.3	27.7	21.6	25.0	24.1
80	24.4	25.4	26.5	28.4	26.6	25.0
Lamberton - check: 15.3						
40	20.4	18.7	19.3	19.6	19.8	17.8
80	21.9	21.8	19.8	20.6	22.3	21.6
Crookston - check: 31.5						
50	47.5	49.7	44.9	47.2	47.5	46.5
100	49.6	47.3	46.1	48.2	47.5	48.2

I - Incorporated N - Nonincorporated

Table 2. Nitrate Soil Tests, pH and Available Water, at Lamberton.

Depth, In.	NO_3-N Lbs/A	pH	Available Water In/ft.
0-12	29	6.0	1.69
12-24	13	6.3	1.38
24-36	21	6.9	1.55
36-48	44	7.9	1.88
48-60	39	7.9	1.85
	146		8.35

Sampled May 1979
Ave. of 4 reps.

Table 3. Nitrate Soil Tests at Morris.

Depth, In.	NO_3-N (Lbs/A)
0-12	31
12-24	17
24-36	11
36-48	25
48-60	14
0-24	48
0-36	59
0-48	84
0-60	98

THE YIELD AND PROTEIN CONTENT OF ERA WHEAT AS INFLUENCED BY STARTER FERTILIZER AT SEVERAL FARM LOCATIONS IN RED RIVER BASIN OF MINNESOTA - 1979*

Charles Simkins, Michael O'Leary, and Terrance Courneya

The application of fertilizer at seeding time with an attachment on the grain drill is a common practice in the Red River Basin of Minnesota and North Dakota. Early investigators have shown that the application of phosphorus fertilizer in this manner, particularly on soils low in available phosphorus, was an efficient means of meeting the phosphorus needs of the crop. As a general guide for low testing soils it was recommended that 40 lbs. of P_2O_5 per acre be applied with the seed at planting time. Doubling these rates was required for the same response when the fertilizer was broadcast and worked into the soil.

With time, the phosphorus reserves of most soils producing wheat have reached rather high levels in the Red River Basin. Agriculturists question the need for applying phosphorus fertilizer with the grain drill at planting time. It is generally agreed that if fertilizer could be omitted at planting time without loss of yield or quality, there would be several opportunities for economic savings.

Methods and Materials

Trials were established at 8 locations in the Red River Basin of Minnesota. Wheat producers prepared seed beds, applied nitrogen fertilizer and seeded wheat with grain drills in their customary manner. The starter fertilizer applied at seeding time with the grain drill varied from location to location. The quantity used by each producer is shown in Table 1.

During seeding the fertilizer attachment on the grain drill was shut down, so that strips the width of the grain drill were seeded without starter fertilizer.

Table 1. Starter Fertilizer Applied by Various Cooperators (Starter vs. No Starter Trials) - 1979

Cooperator	Starter Fertilizer Used	
Ross	10 gal/acre	10-34-0
Christensen	100#/acre	10-26-26
Sanders	160#/acre	10-26-26
Fleshe	100#/acre	18-46-0
Skaar	100#/acre	10-26-26

Previous to seeding soil samples were taken for chemical analysis. These chemical properties are shown in Table 2.

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

Table 2. Some Chemical Properties of Soils in Trials Comparing Starter Fertilizer with No Starter Fertilizer - 1979

Location	pH	NO_3-N (2 ft)	P lbs/a	K lbs/a
Skaar	8.3	---	27	251
Fleshe	8.1	---	38	160
Christensen	8.0	---	10	152
Sanders	8.1	---	25	98
Ross 1	8.2	79	54	385
Ross 2	8.1	113	21	435
Ross 3	8.1	208	51	380
Ross 4	8.1	208	51	380

At harvest time plant samples were harvested from those strips which received starter fertilizer and those strips which received no starter fertilizer. Four samples were collected from each treatment at each location. The samples consisted of 4 drill rows 30 feet in length. Yield and protein determination were made on threshed samples.

Results and Discussion

During the growing season there was little indication that the application of starter fertilizer produced a difference in plant growth which could be detected by observation. Yields in general were below normal for all the farmers or cooperators concerned. This perhaps was largely due to excessive rainfall and cloudy weather.

Comparison of yields between strips receiving starter fertilizer and no starter fertilizer are shown in Table 3.

Table 3. The Influence of Starter Fertilizer on Yield of Era Wheat - Red River Basin of Minnesota - 1979

Location	Yield Bu/A	
	Starter	No Starter
Christensen	53.9	50.9
Sanders	37.6	37.8
Fleshe	27.5	28.3
Skaar	45.2	44.5
Ross 1	50.1	47.4
Ross 2	48.4	38.1
Ross 3	56.4	53.3
Ross 4	52.7	55.0

The application of starter fertilizer failed to result in significant increases in yield at any of the locations. Further indication of the response of the wheat plants to application of starter fertilizer under the conditions of these trials is illustrated in the amount of phosphorus and or potassium in the wheat plants at heading stage in Table 4.

Table 4. Phosphorus and Potassium Content on Wheat Plants (Heading Stage) on Starter and No Starter Trials

	%P		%K	
Location	Starter	No Starter	Starter	No Starter
Fleshe	.31	.31	1.9	2.5
Christensen	.20	.20	2.1	1.9

The wheat plants from 4 replications at each location were not significantly different in percent phosphorus or potassium. The wheat plants at different locations were significantly different in levels of phosphorus in the plant. These differences can be readily explained due to the levels of available phorphorus in the soil.

The effect of starter fertilizer versus no starter on the protein content of the grain is shown in Table 5.

Table 5. Percentage Protein in Wheat Grain as Influenced by Starter Fertilizer Treatments - Red River Basin of Minnesota - 1979

	% Protein	
Location	Starter	No Starter
Christensen	14.1	13.6
Sanders	14.4	14.0
Fleshe	14.3	14.5
Skaar	11.2	11.8
Ross 1	14.3	14.3
Ross 2	12.5	12.4
Ross 3	14.1	13.8
Ross 4	14.2	14.4

Non-Significant

Summary

Starter fertilizer applied with the grain drill at 8 locations in the Red River Basin did not significantly increase the yield or protein content of wheat grain under soil and weather conditions in 1979.

The soil test levels for phosphorus and potassium were relatively high except for the Christensen location.

Additionally, the late planting date at most of the locations may have influenced the response to starter fertilizer. Starter fertilizer normally gives best responses when soil test levels are low and when cold weather conditions exist after seeding.

YIELDS OF WINTER WHEAT ON FINE-TEXTURED SOIL IN NORTHERN MINNESOTA - 1979*

C. Simkins, M. O'Leary, M. Johnson, and H. Shurson

Winter wheat is grown on a very limited acreage in northern Minnesota. Due to the possibility of winter kill yields have been inconsistent and in general have been lower than spring wheat yields. With several new winter wheat varieties there is a renewed interest in the possibility of winter wheat production in Minnesota. If winter wheat could be grown successfully it would be of value to farmers in helping distribute their labor. Additionally, the crop seeded in the fall could provide winter cover to assist in reducing soil erosion by wind in the winter months.

In cooperation with the County Extension Director and Mr. Bachholz, a farmer near McIntosh, Minnesota, wheat trials were established in the fall of 1978.

Methods and Materials

The trial was established on a fine textured soil of the McIntosh-Winger complex probably a Waukon silty clay loam. The fertility level of the soil was relatively high - P test 38 lbs/acre, K test 250 lbs/acre, and 220 lbs. of NO_3-N in the top 2 feet. Wheat was seeded at the rate of 90 lbs. per acre in strips 8 feet wide. Each variety was seeded in 3 replications. The strips were 50 feet long.

Fertilizer was applied with the grain drill at planting time at the rate of 100 pounds per acre of 16-24-24. Seeding was made on Sept. 13, 1978. In May, 1979, 50 pounds/acre of nitrogen as urea was topdressed on the growing wheat.

Wheat was harvested on August 14, 1979. Samples were harvested with a binder, and threshed in a Vogel thresher.

Results and Discussion

The yield and protein content of the various winter wheat varieties used in the trials are shown in Table 1. These yields and protein percentages are the average of 3 replications.

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

Table 1. Yields and Percent Protein of Various Winter Wheat Varieties, McIntosh, Minnesota, 1979

Variety	Bu/A	% Protein
Centurk	56.2	15.7
Eklund	37.8	16.1
Froid	37.7	17.1
Gent	43.2	17.7
Minter	32.0	16.4
Roughrider	38.9	16.0
Winoka	44.0	16.7
Significance	**	NS
BLSD (.05)	9.6	--

As a result of good stand survival and adequate moisture, relatively good yields were obtained. Yields of various varieties showed a significant difference.

The percent protein in the various varieties was non significant. This one year trial indicates that under favorable winter weather conditions satisfactory wheat yields can be obtained. Further studies are needed to determine the feasibility of winter wheat production under less favorable conditions.

WILD RICE FERTILIZATION RESEARCH - 1979

A PROGRESS REPORT
December 27, 1979

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Research was continued during 1979 on fertilization, nutrient requirement and water quality. Soil, water and air temperatures, and quality of paddy water were monitored during the growing season to obtain information on the environment in which wild rice grows. A nitrogen rate study was conducted on a mineral soil at Grand Rapids with the Netum variety in first production year. Three fertilization experiments were conducted with a second year stand of K2 variety on peat in Aitkin County to study N, P, K rates, and the effectiveness of foliar fertilization. Tissue samples were collected for plant analysis to learn more about nutrient uptake by the plant.

A. WEATHER AND PLANT DEVELOPMENT

The average air temperature (Table 1) was slightly below normal during April, May and August, and nearly normal during June and July. Generally, weather conditions during the 1979 growing season were more "normal" than those of 1976 and 1977 seasons which were exceptionally early and warm.

Soil, water and air temperatures were measured at three locations by 3-point automatic sensing and recording thermographs (see Fig. 1, 2, 3). Instrument malfunctions caused interruptions in temperature measurements.

The air and water temperatures fluctuated much more than the soil temperatures. The mineral soil at Grand Rapids also showed greater temperature fluctuations than the two organic soils. The temperature of both organic soils was in the low 40's during the plant emergence in early May. The temperature of organic soils measured about 50°F by mid-May, gradually increased to 65°F by mid-July and then gradually decreased towards harvest time.

Plants emerged on May 8 in Aitkin County and on May 11 at Grand Rapids (Fig. 4, 5). The jointing stage was reached by Netum at Grand Rapids on July 6, 55 days after emergence, and by K2 in Aitkin County on July 9. Netum was harvested on August 27, 108 days after emergence. The K2 wild rice was harvested on August 28, 112 days after emergence.

Table 1. Average air temperature as measured at three U.S. weather stations.[1/]

Station Year	Month April	May	June	July	August	5 Month Average	GDD T_b=40
	----------average air temperature, °F----------						
Fosston, Polk Co.							
Normal[2/]	41.0	54.6	63.6	69.4	67.5	59.2	2955
1974	41.0	50.5	63.4	71.6	62.8	57.9	2744
1975	34.8	55.7	61.9	70.5	64.6	57.5	2852
1976	46.6	54.9	66.8	68.8	70.9	61.6	3315
1977	49.1	66.4	64.6	70.3	60.6	62.2	3446
1978	41.7	59.2	63.4	67.8	67.7	60.0	3060
1979	36.0	48.7	63.6	69.6	63.6	56.3	2627
Grand Rapids, N.C. School							
Normal	39.9	52.7	62.0	67.4	65.1	57.4	2681
1974	41.6	49.4	62.7	70.7	62.8	57.4	2670
1975	34.7	57.0	62.2	71.5	65.2	58.1	2951
1976	47.1	54.4	66.1	68.2	67.4	60.6	3166
1977	48.2	63.8	64.0	69.2	60.2	61.1	3284
1978	41.3	57.9	62.8	66.5	66.0	58.9	2892
1979	37.1	49.5	61.5	68.1	62.6	55.8	2511
Aitkin							
1974	42.9	49.8	63.1	71.1	63.3	58.0	2770
1975	39.0M[3/]	59.4M	64.4M	72.1	66.2M	60.2	3141
1976	47.5	54.8	66.8	69.3M	68.1	61.3	3267
1977	48.3M	64.4M	65.4M	70.3M	61.0	61.9	3446
1978	40.7M	57.5M	64.1M	67.0M	66.9	59.2	2938
1979	37.7	50.6M	62.0	68.1M	63.4	56.4	2585.1

1/ Source: Climatological Data, Minnesota, Vol. 80, 81, 82, 83, 84, 85 (1974-79), U.S. Dept. of Commerce.

2/ Normals for the period 1931-60.

3/ M = less than 10 days record missing.

Fig. 1

MEAN AIR, WATER AND SOIL TEMPERATURES

GRAND RAPIDS – 1979

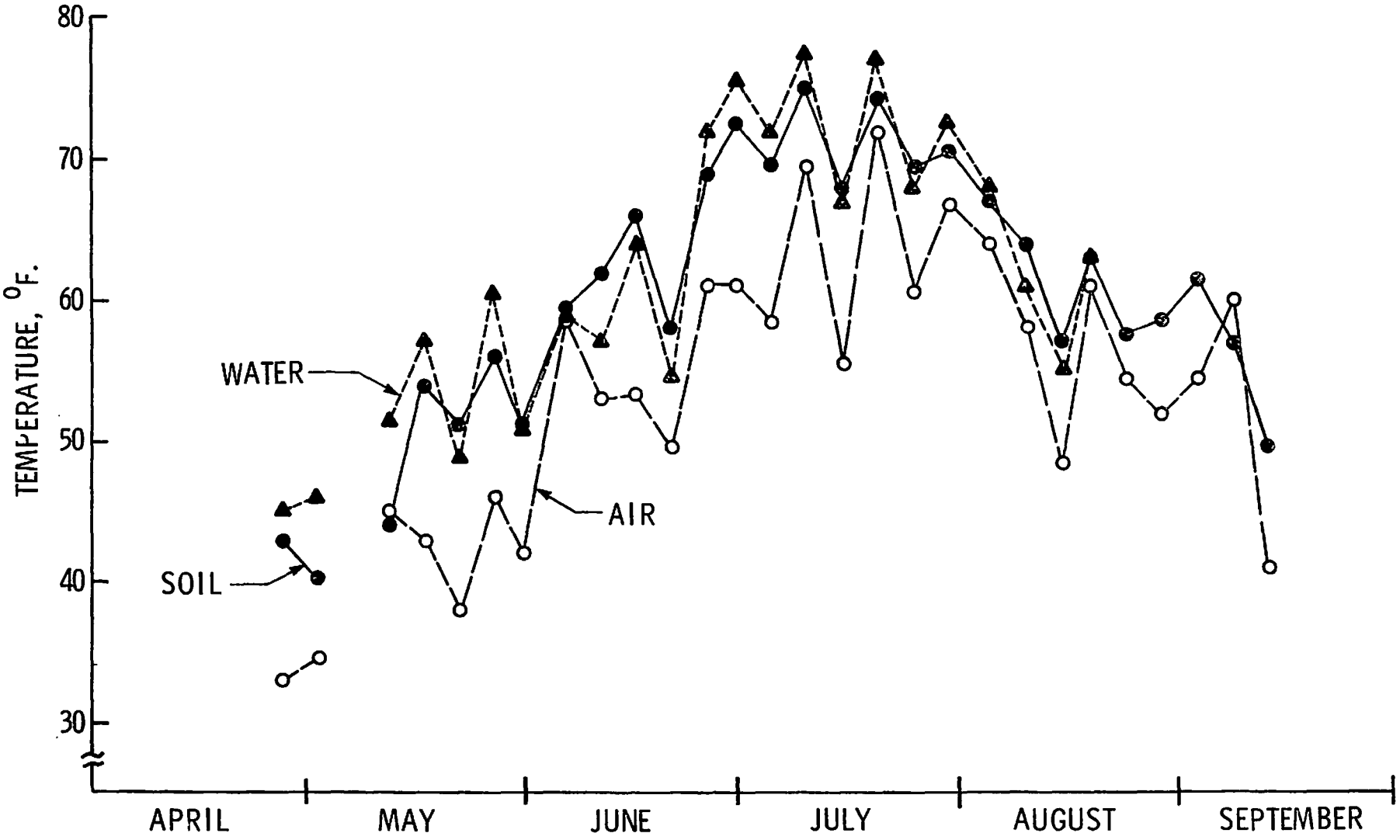

Fig. 2

MEAN AIR, WATER AND SOIL TEMPERATURES

KOSBAU BROS., AITKIN – 1979

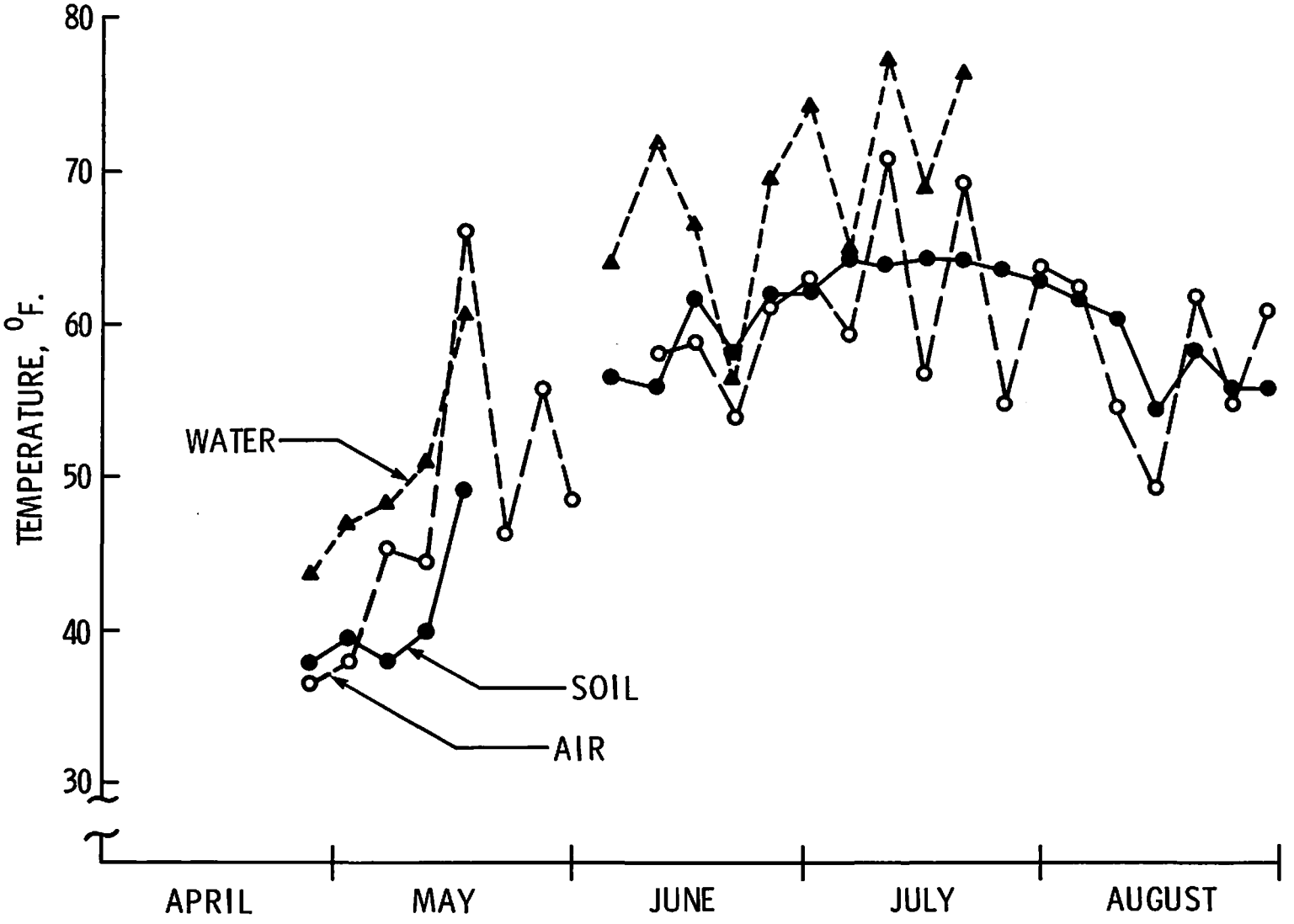

Fig. 3

MEAN AIR, WATER AND SOIL TEMPERATURES

GULLY – 1979

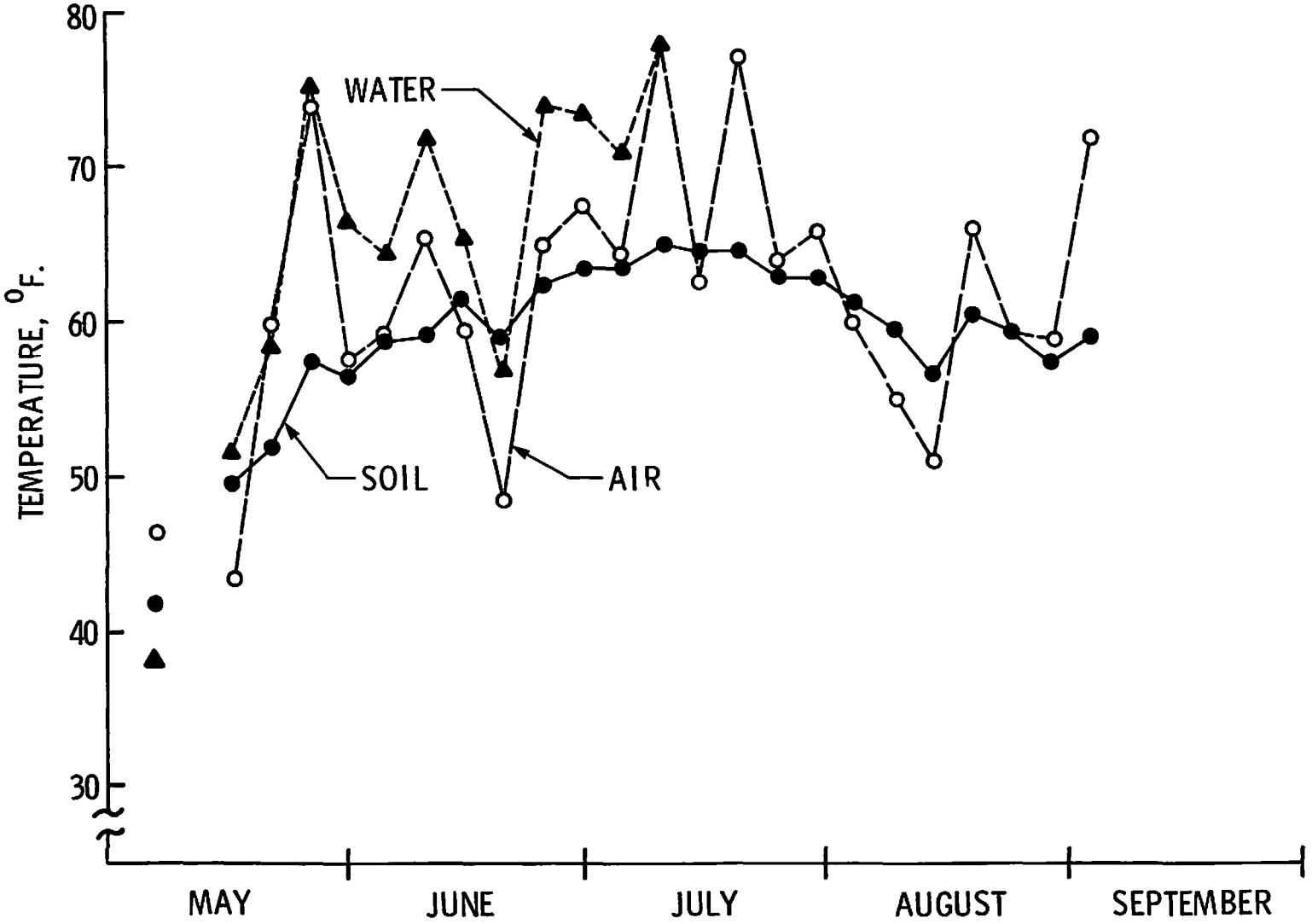

Fig. 4

WILD RICE DEVELOPMENT
NETUM VARIETY, GRAND RAPIDS, 1979

	STAGES OF DEVELOPMENT	DAYS	DATE
VEGETATIVE GROWTH PHASE	EMERGENCE	0	MAY
	FLOATING LEAF	21	JUNE
	AERIAL LEAF	26	
	TILLERING	40	
REPRODUCTIVE GROWTH PHASE	JOINTING	55	JULY
	BOOT	60	
	MID-FLOWERING	71	
	MATURITY	108	AUGUST

Fig. 5

WILD RICE DEVELOPMENT
K2 VARIETY, KOSBAU BROS., AITKIN CO., 1979

	STAGES OF DEVELOPMENT	DAYS	DATE
VEGETATIVE GROWTH PHASE	EMERGENCE	0	MAY
	FLOATING LEAF	27	JUNE
	AERIAL LEAF	44	
	TILLERING	52	
REPRODUCTIVE GROWTH PHASE	JOINTING	62	JULY
	BOOT	72	
	MID-FLOWERING	84	
	EARLY GRAIN FORMATION	97	AUGUST
	MATURITY	112	

B. CHEMICAL CHARACTERISTICS OF PADDY WATER

The quality of paddy water is of interest to the grower as well as to state and federal agencies. The grower may be concerned, for example, with the concentration of sulfate in the water. Plant response to fertilization may be related to nutrient levels found in the water. Public control agencies may want to know levels of nitrogen and phosphorus present in the water when it is released during draining of paddies.

Water samples were collected from several sites at three different paddy locations during the 1979 growing season. At Washkish, water samples were collected from two sites on May 22 for general reference. At Grand Rapids, samples were collected from an experimental paddy used for a nitrogen rate study on mineral soil. Source of water is the Prairie River. Water was also sampled at two sites in Kosbau Bros. paddies in Aitkin County. Paddies at this site derived water from the Little Willow River via a diversion ditch. One sampling site was located at the beginning of the diversion ditch, just above a bridge; the other site was within a paddy in which three fertilization trials were conducted. The third sampling location was in the Imle and Gunvalson paddies near Gully. These paddies derived water from the Clearwater River.

Water samples were collected and stored in 250 ml polyethylene bottles. After the determination of pH and conductivity, a preservative was added (2 ml mercuric chloride solution, made by dissolving 40 mg $HgCl_2$/L, to 250 ml of sample). Chemical analyses were made by the Research Analytical Laboratory, University of Minnesota. Information on location, sampling dates, and chemical composition data of water are given in Table 2.

The pH of water is the measurement of hydrogen-ion activity. Water samples from the rivers showed some differences. Greatest differences in pH, however, were found in the water from different paddies. There was a certain relationship found between the pH and hardness of the water from different sampling sites. The hardness of water is calculated by multiplying calcium and magnesium concentrations by specific factors, adding up and is expressed as $CaCO_3$, mg/liter. Water from the Clearwater River was very hard (314 mg/L) and strongly alkaline with pH of 8.0 or above. The water from the Prairie River and the Little Willow River is moderately hard, with values of 96 and 89 mg/L, respectively, and had a pH value of 7.3, indicating slight alkalinity. At Gully and Grand Rapids, the levels of hardness and pH of paddy water were nearly the same as those found in the river water. In Aitkin County on peat, however, the paddy water showed 18 to 23% lower calcium and 30 to 43% lower magnesium content than the river water, and 4-fold decrease in hardness. Consequently, the water within the Kosbau paddy was acid (pH 5.0-6.6) and was relatively soft, having a hardness value of 22 mg/liter.

At Grand Rapids, concentrations of total N and P in paddy and river water were nearly the same, and remained relatively constant throughout the growing season. Total concentration in the water ranged from 0.2 to 0.9 ppm N, and 0.04 to 0.2 ppm P. The K concentration of paddy water was only slightly higher than that found in river water, except for the June 21 sampling date when the paddy water had three times more K than river water (17.5 vs. 5.9 ppm K).

At Gully, nutrient concentrations in the river and paddy water were inconsistent and showed considerable variation.

Paddy water at the Aitkin County location had considerably higher concentration of total N, P and K than found in the river water. Total N concentration of paddy water ranged from 1.9 to 4.3 ppm compared to 0.4-0.8 ppm found in samples collected from the diversion ditch. Total P concentration in paddy water ranged from 1.45 to 1.93 as compared to 0.04-0.11 ppm in the water from the diversion ditch. Potassium levels of paddy water ranged from 7 to 11 ppm while the water from the diversion ditch had concentration of less than 1 ppm to 5 ppm K.

The sulfate concentration of water is reported in terms of parts per million of sulfate-sulfur. To convert results to the sulfate form, they would have to be multiplied by 3. For example, 20.5 ppm sulfate-S x 3 = 61.5 ppm sulfate (SO_4) in the water.

The water at Grand Rapids and in Aitkin County did not contain appreciable amounts of sulfate (4-9 ppm SO_4). The sulfate concentration in the water at Gully, however, was relatively high (62-79 ppm SO_4).

Table 2. Chemical composition of water collected from wild rice paddies during 1979 growing season.

Sample No.	Sampling Date	Location	pH	Conductivity milli-mhos/cm	Alkalinity as $CaCO_3$ mg/L	Hardness $CaCO_3$ mg/L	Total Kjeldahl N ppm	Ammonium N ppm	Nitrate & nitrite N ppm	Total P ppm	Soluble P ppm	Sulfate S ppm	Ca ppm	Mg ppm	K ppm
Location: Grand Rapids															
5.	5/22	EP	7.5	.12	44.5	63.8	0.3	0	0	0.04	0.03	1.4	17.8	4.4	3.3
6.	5/22	PR	7.3	.16	70.5	96.1	0.2	0	0	0.09	0.05	2.1	27.5	6.3	2.9
10.	6/21	EP	7.6	.12			0.4			0.04			34.5	8.4	17.5
11.	6/21	PR	7.3	.18			0.9			0.05			31.4	7.8	5.9
16.	7/6	EP	7.2	.14			0.6			0.05			18.7	4.3	<0.75
17.	7/6	PR	7.0	.17			0.6			0.04			23.0	5.3	<0.75
20.	7/11	EP		.14			0.7			0.05			17.5	4.3	<0.75
21.	7/11	PR	7.3	.15			0.6			0.06			19.8	4.5	<0.75
22.	7/19	EP	7.7	.13			0.8			0.08			19.7	4.7	<0.75
23.	7/19	PR	7.0	.13			0.6			0.20			19.9	4.4	<0.75
26.	7/31	EP	7.7	.12			0.6			0.08			16.1	6.6	1.27
27.	7/31	PR	7.5	.16			0.5			0.05			19.9	6.1	<0.75

Abbreviations and description of sampling sites at Grand Rapids: EP = Experimental Paddy #1E; PR = Prairie River

Location: Kosbau Bros., Aitkin Co.															
7.	5/15	EP	5.2	.05	3.5	18.9	1.9	0.5	0	1.45	1.33	2.4	3.9	1.6	8.1
8.	5/25	EP	5.0	.07	7.0	22.3	2.4	0.1	0	1.81	1.69	2.9	4.5	1.9	8.1
9.	5/25	DD	7.3	.17	69.0	88.9	0.4	0	0	0.09	0.08	1.7	24.4	6.3	2.1
12.	6/21	EP	6.6	.05			3.3			1.87			6.3	2.6	11.2
13.	6/21	DD	7.3	.18			0.4			0.04			27.8	6.0	5.0
18.	7/6	EP	5.7	.05			4.3			1.93			5.5	2.6	6.5
19.	7/6	DD	7.3	.19			0.8			0.11			26.9	7.1	<0.75
28.	7/31	D	5.1	.10			6.2			3.07			8.5	2.7	3.5

Abbreviations and description of sampling sites at Kosbau Bros.: EP = Experimental Paddy; DD = Diversion ditch at bridge near the Little Willow River; D = Ditch on the south side of experimental paddy.

Table 2. Chemical composition of water collected from wild rice paddies during 1979 growing season (continued).

Sample No.	Sampling Date	Location	pH	Conductivity milli-mhos/cm	Alkalinity as $CaCO_3$ mg/L	Hardness $CaCO_3$ mg/L	Total Kjeldahl N ppm	Ammonium N ppm	Nitrate & nitrite N ppm	Total P ppm	Soluble P ppm	Sulfate S ppm	Ca ppm	Mg ppm	K ppm
Location: Imle and Gunvalson, Gully															
1.	5/21	PP	8.1	.48	135.5	262.8	1.1	0	0	0.33	0.24	26.4	71.5	20.3	15.6
2.	5/21	CR	8.0	.51	194.5	314.3	0.5	0	0	0.05	0.05	20.5	85.9	24.0	4.1
14.	6/27	PP	8.3	.62			0.8			0.14			88.4	24.6	7.6
15.	6/27	CR	8.0	.53			2.0			1.15			99.5	26.5	18.3
24.	7/31	D	7.0	.43			0.9			0.11			57.6	17.4	1.4
25.	7/31	CR	7.4	.45			1.7			0.41			56.5	19.9	2.1

Abbreviations and description of sampling sites at Gully: PP = Production Paddy; CR = Clearwater River; D = Ditch on west side of paddy.

Location: Washkish															
3.	5/22	D	7.1	.21	40.5	88.1	1.6	0	0	0.68	0.58	4.1	22.1	7.7	20.7
4.	5/22	TR	6.9	.14	55.5	85.8	0.7	0	0	0.07	0.06	2.6	22.4	7.0	1.6

Abbreviations and description of sampling sites at Washkish: D = Ditch on east side of paddy complex; TR = Tamarac River.

C. NITROGEN RATE STUDY ON MINERAL SOIL

A field experiment was conducted with the Netum variety on a mineral soil at the North Central Experiment Station, Grand Rapids. The experimental paddy, No. 1 East, was in fallow during 1978 and was fumigated with methyl bromide in the fall. Soil tests indicated a very high level of extractable phosphorus, nearly a high level of exchangeable potassium (Table 3). The nitrate-N reading of 42 lb/A in the top 6 inches of soil (main rooting depth of wild rice) indicated that considerable amount of nitrate had been produced under fallow. Four rates of nitrogen were used in this experiment: 0, 20, 40 and 80 pounds per acre. Urea (46-0-0) was applied by hand and incorporated into the soil by rototilling. A randomized block design was used in this experiment. Each nitrogen treatment was replicated five times. Individual plots occupied a 14 x 16 ft. area and were separated from adjoining plots by 5 ft. wide alleys. Seed of Netum variety was broadcast-applied by hand on October 18 and rototilled into the soil. Plant density, at jointing, was about three plants per square foot. Water level was maintained at about 6 to 10 inches. Ten plants were collected at random from each plot at jointing, and five plants at late flowering for weight measurements and plant analysis. The jointing state was reached on July 6 (Fig. 4). Water was drained from the paddy on August 25. A 32 sq. ft. area from each plot was hand-harvested on August 27 for yield determination.

Netum wild rice produced 945 to 1049 pounds of grain per acre (Table 4). The yield, however, was not affected by N fertilization.

The second leaf at jointing contained 4.16 - 4.55% N, considered to be a relatively high concentration (Table 5). Total nitrogen uptake by wild rice at jointing or late flowering was not affected by the nitrogen treatments (Table 6).

Table 3. Soil test values of experimental paddy, No. 1 East, Grand Rapids.

Sampling Depth inches	pH	Extractable P pp2m	Exchangeable K pp2m	NO_3-N lb/A
0 - 6	5.5	84	196	42
6 - 12	5.6	83	197	42

Samples collected on 10/18/78.

Table 4. Effect of nitrogen application on the yield of Netum wild rice, Grand Rapids, 1st year stand, 1979.

N Rate lbs/acre	Grain Yield lbs/acre
0	1037[1)]
20	945
40	1049
80	999
Significance	ns
C.V., %	13

1) 7% moisture, average of 5 replications

Table 5. Effect of nitrogen application on N concentration in 2nd leaf of Netum wild rice at jointing, Grand Rapids, 1979.

N Rate lbs/acre	N % in Dry Matter
0	4.29
20	4.16
40	4.32
80	4.55
Significance	ns
C.V., %	25

Table 6. Effect of nitrogen application on total uptake of N by the wild rice plant at jointing and late flowering. Netum variety, Grand Rapids, 1979.

N Rate lbs/acre	Stage of Development	
	Jointing	Late Flowering
	---N in milligrams per plant---	
0	234	535
20	210	604
40	196	599
80	226	625
Significance	ns	ns
C.V., %	37	23

D. FERTILIZATION STUDIES ON PEAT

Three fertilizer experiments, carried out in a Kosbau Bros. paddy in Aitkin County during 1978, were continued in 1979. A second year stand of the K2 variety was used. Fertilizer was applied by hand to 12 x 12 foot plot areas on October 23, 1978 and incorporated into the soil by rototilling. Wild rice started to emerge on May 8 and by July 9 (62 days after emergence) had reached the jointing stage (Fig. 5). Rice was thinned once by airboat on June 4 when most plants were in the floating leaf stage. Average plant density was three plants per square foot. The stand, however, was spotty and thin in some areas. The paddy was drained on July 26. A 4 x 4 foot area was hand-harvested from each plot for yield measurement on August 28. No color or height differences were observed during growing season and the crop response to fertilization was modest and rather inconsistent. Soil tests, of samples collected on October 23, 1978 prior to fertilizer application, indicated medium to high extractable P levels, medium to high exchangeable K level, and low nitrate-N content (Table 7). The grain yield ranged from 250 to 550 lb/acre.

Table 7. Soil test values of experimental areas, Kosbau Bros., Aitkin Co.

Area		pH	Extractable P pp2m	Exchangeable K pp2m	NO_3-N lb/A
NK trial,	K0	4.3	18	124	0.5
	K60	4.3	20	154	
	K200	4.3	25	217	
NP trial,	P0	4.3	22	205	0.8
	P80	4.2	25	197	
Foliar Fertilization (check plots)		4.4	20	178	1.5

Samples collected on 10/23/78. Results are for 0-6 inch depth.

NK Rate Trial

Potassium treatments, made in the fall of 1977, had resulted in a gradual increase of K test levels. Exchangeable K test levels of 124, 154 and 217 pp2m corresponded with the potassium treatments of 0, 60, 200 lbs. K_2O per acre, respectively (Table 7). Nitrogen treatments consisted of the following rates: 0, 30, 90 pounds per acre. Potassium was applied at rates of 0, 60 and 200 pounds of K_2O per acre. All plots received phosphorus at 40 pounds P_2O_5 per acre. Fertilizer treatments, arranged in a randomized block design, were replicated six times. Urea, muriate of potash and concentrated superphosphate were applied by hand during the fall of 1978 and incorporated into the soil by rototilling.

The yield of wild rice ranged from 258 to 405 pounds per acre (Table 8). Neither nitrogen nor potassium treatments had any effect on the yield.

Table 8. Effect of nitrogen and potassium application on grain yield of wild rice, Kosbau Bros., 1979.

K Rate K_2O lb/acre	N Rate, lb/acre 0	30	90	Average (K Rate)
	----------Grain Yield, lb/acre----------			
0	265	280	405	317
60	333	269	291	298
200	258	367	309	311
Average (N Rate)	285	305	335	
Significance	ns			
C.V., %	35			

7% moisture, average of 6 replications.

NP Rate Trial

Average extractable phosphorus in the experimental area measured 22 and 25 pp2m, indicating high relative level (Table 7). Nitrogen was applied at rates of 0, 30, 60 lb/acre, and phosphorus treatments included 0, 40, 80 pounds of P_2O_5 per acre. All plots received potassium at 60 lbs/acre of K_2O. Fertilizer treatments were replicated six times. Urea, concentrated superphosphate and muriate of potash were applied by hand in the fall and incorporated into the soil by rototilling.

Grain yields ranged from 251 to 366 pounds per acre (Table 9). Although some yield differences were detected at the 10% level, crop response was inconsistent and not related to nitrogen and phosphorus treatments.

Table 9. Effect of nitrogen and phosphorus application on grain yield of wild rice, Kosbau Bros., 1979.

P Rate P_2O_5 lb/acre	N Rate, lb/acre 0	30	60	Average (P Rate)
	----------Grain Yield, lb/acre----------			
0	277	340	313	310
40	251	291	300	281
80	366	298	262	309
Average (N Rate)	298	310	292	
Significance	+			
BLSD (0.10)	79			
C.V., %	21			

7% moisture, average of 6 replications.

Foliar Fertilization Trial

Interest in foliar application of fertilizer was aroused in 1975-76 by publicity generated by spectacular soybean yield increases obtained in Iowa. Numerous field trials were initiated with soybeans and other crops and a full-scale sales program was launched by at least one major fertilizer company. Research in Minnesota and other states, mainly with soybeans, has not shown any substantial benefits from foliar fertilization.

Some wild rice growers also showed interest in foliar fertilization. Field trials were initiated in 1976, and continued in 1977, in Aitkin County to provide information on the effectiveness of foliar fertilization of wild rice.

In the fall of 1977, a new experiment was established on a new seeding of K2 variety in an area adjoining NK and NP trials. The experiment was continued in 1979. Soil tests indicated medium phosphorus and potassium availability, and the nitrate-N content of top 6 inches was relatively low (Table 7).

Soil application of fertilizer (30+40+60) was made during the fall of 1978 and incorporated into the soil. Fertilizer solution was sprayed on 12 x 12 foot plot areas with a backpack sprayer at a rate of 26.4 gallons per acre or 250 pounds per acre. Spraying pressure was maintained at 30 psi by using a carbon dioxide cylinder. The formulation, materials used and costs were reported, in detail, in the 1976 Wild Rice Research Report. At 1976 prices, the total cost of three foliar applications would be $48.15 per acre, consisting of $19.35 for fertilizer materials and $28.80 for aerial application. Currently the cost of such applications should be well over $50.00 per acre. Soil application of 30+40+60 pounds per acre of plant nutrients, at present prices, would cost about $22.00 per acre, including application costs.

In 1979, foliar fertilizer applications were made on the following dates:

1st spraying, 7/11 - jointing to early boot stage,
2nd spraying, 7/31 - mid-flowering,
3rd spraying, 8/14 - early grain formation.

No "leaf burn" damage to wild rice was observed in this trial.

The grain yield in this experiment ranged from 380 to 565 pounds per acre (Table 10). The yield of wild rice was increased significantly (at 10% level) by about 150 lb/acre over the control either by soil applied fertilizer or three foliar applications. There was no advantage, however, of combining these two types of fertilizer application. It must be pointed out that similar yield increases from fertilization were obtained at (a) $22.00 for soil application, and (b) over $50 per acre for three foliar applications. Consequently, foliar fertilization of wild rice is not recommended, at the present time, neither as a substitute of nor as a supplement to soil application. Topdressing of solid nitrogen fertilizers, urea and ammonium nitrate, at jointing (basically a soil application) is not included in this recommendation.

Table 10. Effect of foliar and soil application of fertilizer on grain yield of wild rice, Kosbau Bros., 1979.

Number	Foliar Application				Soil Application		Average
	Total Plant Nutrients Applied, lbs/acre						
	N	P_2O_5	K_2O	S	None	30+40+60	(Foliar)
					----Grain Yield, lbs/acre-----		
None		None			380a	523b	452
1x	15 +	6 +	9 +	1.3		427ab	427
2x	30 +	12 +	18 +	2.6		514ab	514
3x	45 +	18 +	27 +	3.9	565b	441ab	503
Average (soil)					473	476	
Significance					+		
BLSD (0.10)					142		
C.V., %					25		

7% moisture, average of 6 replications.

Values followed by different letters are significantly different (10% level).

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