SOIL SERIES 112

A REPORT ON FIELD RESEARCH IN SOIL SCIENCE

The 1982 edition of the "Bluebook" is a compilation of data collected and analyzed throughout Minnesota. Information was contributed by personnel of the Department of Soil Science including Extension Soil Specialists, Scientists at the branch stations of Crookston, Lamberton, Morris, and Waseca; Becker and Staples experimental site; and Soils and Crop area agents. Associated personnel from the Soil Conservation Service, and the Soil and Water Research group of the SEA-USDA, the Tennessee Valley Authority, The Departments of Agriculture and Natural Resources also contributed information.

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

Some of the results are from 1981 experiments only and should be regarded on this basis. Since most data are from only 1981 studies, conclusions are not conclusive and are thus not for further publication without the written consent of the individual researchers involved.

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

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Soil Moisture

by

D. G. Baker, W. W. Nelson, S. Evans,
G. Randall, G. Varvel, and D. L. Ruschy

Two relative unknowns in the hydrologic cycle have been evapotranspiration and soil moisture. Because it is so difficult to measure, evapotranspiration has usually been either estimated or calculated by empirical formula. The estimates are usually based upon the difference between income and outgo of water from a watershed. If calculated, then it is done by empirical formulas using a minimum of the necessary data, since only temperature and precipitation data are readily available. Soil moisture in turn has usually been omitted because (a) it seemed insignificant relative to the other elements of the hydrologic cycle, (b) the data are difficult to find, or (c) it is simply too difficult and time consuming to get the original data.

The part that soil moisture plays with respect to both our climate and the hydrologic cycle is seldom appreciated. First and foremost soil moisture provides a reservoir which the plants can draw upon between periods of precipitation. For example, over and above the growing season precipitation, the soils in the Lamberton area supply on the average nearly 4 inches of water received and stored outside the heart of the growing season. This is of particular importance, since the normal precipitation received during mid-June through August is ordinarily insufficient for the crop. This deficiency increases from east to west across the state.

Just how soil water affects our climate is even less well understood. Since solar energy is required to evaporate the water consumed in evapotranspiration - approximately 20 inches per year - there is little excess energy available for heating until water supplies are low. Thus as long as soil moisture supplies are plentiful the air temperature does not show great variation. High air temperatures in Minnesota occur as soil moisture supplies begin to be depleted, usually in July and August. This becomes most obvious in periods of drought.

In summary then, soils provide an all important water reservoir and the release of this water by evapotranspiration from the soil and plant surfaces to the atmosphere results in a modification and amelioration of the climate.

1982 Minnesota Spring Soil Moisture Situation

by

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Soil Moisture measurements were obtained from 51 sites in late October and early November 1981 by the Soil Monitoring Program directed by the University of Minnesota Soil Science Department and sponsored in part by State Climatology, Division of Waters, Minnesota Department of Natural Resources. Further, to obtain a more detailed analysis of the soil moisture amount, some 670 precipitation reports were used in conjunction with the soil moisture measurements. The soil measurements were made in the first five feet of medium to fine textured soils. Most sites were under corn, except for the northwest where the sites were under small grains (mostly wheat).

The potential plant available water content of the soils sampled averaged 8 to 12 inches. Thus, one should adjust the amount of plant available water held in lighter (sandy) or heavier (clay) soils.

The major feature found in the autumn 1981 soil moisture survey is the extensive areas of average to above average soil water across the state (see Figure 1). It is only in a relative small area adjacent to the South Dakota border extending from southern Big Stone county southward to Lac Qui Parle, western Yellow Medicine, Lincoln, southern Lyon, and northern Pipestone, Murray, and Cottonwood counties where soil moisture is about one to three inches below average.

Major areas of above average soil moisture (wet soils), where the soils contain 2-3 inches above average soil moisture include all of the southeastern and south-central counties west to central Martin, Watonwan, and Brown counties and north, through central McLeod, northern Carver and Scott and southern Dakota counties. Also, the "wet" areas include almost all of the northwestern and north-central counties. Other small "wet" areas are southeast Pope, southwest Stearns and northern Kandiyohi and Meeker counties; and a small area in southeast Crow Wing, southern Aitkin, northwest Pine, and northern Mille Lacs and Kanabec counties.

The spring 1982 soil moisture outlook is therefore in general one of adequate to excessive soil moisture except for the relatively small area in the extreme southwestern and west-central part of the state already mentioned. In the areas of average and higher soil moisture contents, most of the over-winter precipitation is expected to runoff this spring with little moisture entering the soil. An exception is the forested areas of north-central and northeastern Minnesota where most of the runoff will be retained. Even here, wherever the autumn soil moisture indicates above average water content, the spring runoff is expected to be greater than usual.

An interesting situation relative to the entry of spring snowmelt into the soil, or its loss as runoff, is the depth to which soils have frozen. Except for the forested areas of the state, the soil freezing depth has been determined essentially by the date of the first permanent snow cover. An area covering parts of 15 counties in the southeast, extending from Martin to Houston counties and a larger area extending from South Dakota eastward that includes the Twin Cities is where there has been a continous snow cover since December 1.

As of January 19, the frost depth in these areas was about 12-16 inches, 12 at Waseca, 14 at Lamberton, and 16 at St. Paul. These measurements are approximately 20 inches below normal for this time of year. Elsewhere, with a continous snow cover only since December 25 or later, the freezing depth is generally at least 30 inches. For example, at the Morris Agricultural Experiment Station and at the North Dakota Agricultural Experiment Station at Fargo, the soils are frozen to 38 and 39 inches, respectively. At the Crookston Agricultural Experiment Staion the depth is about 30 inches. This is near their average for this time of year. Maximum freezing depth is usually reached in early March in Minnesota.

Of real concern is the chance that soils currently below average in water content will remain below average this spring. Long term data indicate there is one chance in three that soil water will remain below average this spring - or two chances in three that soil water will be average or greater. For the major portion of the state, which has average to above average soil water content, the chances are almost 9 out of 10 that the wet soils will have an average or greater water content, and 7 chances out of 10 that the soils with an average content will have the same or better this spring.

As a result of this soil moisture outlook for Minnesota, the spring planting can be expected to be delayed this year. This situation will probably be most serious in the Red River Valley where the high moisture content soils in conjunction with the level terrain have the potential to delay operations considerably.

This report also contains a map of the precipitation for the agricultural year which runs from September 1, 1980 to August 31, 1981 and a set of graphs showing how the precipitation during that period varied from the normal at six Experiment Stations, (Figures 2 and 3 respectively).

The amount of precipitation and the time it occurred for the 1980-81 agricultural year as a whole was near ideal for most of the agricultural area of the state. The fall, 1980 recharge was above normal except in the west central and southwest. The winter and spring had less precipitation than normal. This worked in the favor of the farmers as they had good planting conditions. The wet summer (June, July, and August) with 2 to 6 inches above normal precipitation amounts was most ideal for crops. These above normal rains, coupled with the adequate soil moisture reserves over most of the state, resulted in record or near record yields for most agricultural districts, except for the southwest where the summer rains came in time to provide a fair crop in the dry areas.

The precipitation map shows that the driest areas were in the southwest and along the western edge of Minnesota as far north as Moorhead. The wettest area was the entire southeast and most of south central and central areas and smaller wet areas in all of the other districts. It was particularly wet in Red Lake and eastern Polk counties.

The graphs of precipitation for the six experiment stations show the variation of rainfall across the state and through the year. All the graphs show the dry winter (the dashed line representing the normal precipitation patterns rises faster than the solid line, which is the 1980-81 precipitation), from late October-early November to late February-early March. All the stations showed the effect of the above normal summer rainfall as the solid line then started climbing faster than the dashed (or normal) line. These summer rains allowed the season total to reach normal at all stations except Waseca, where the 1980-81 total was 7 inches above normal (36.91 for 1980-81 vs. 29.95 for the normal) and Lamberton which was about 6 inches below normal (18.62 for 1980-81 vs. 24.80 for the normal) Even though Lamberton was 6 inches below normal at the end of the agricultural year they were able to produce a fair crop as the summer rains were about three and one half inches above normal.

NOVEMBER, 1981

Date	Cooperator	Address	Crop	Avail..Water	Capacity
10/20	Viken	Roseau	Wheat	13.11 Inches	13.58 In.
10/21	Riopelle	Argyle	Wheat	6.07	13.34
10/21	Driscoll	E. Grand Forks	Wheat	9.44	13.58
10/22	Christenson	Thief River Falls	Wheat	9.92	10.30
10/22	Buchholtz	McIntosh	Wheat	6.80	10.30
10/22	Brendamuhl	Moorhead	Wheat	9.27	13.34
10/22	Lieseth	Moorhead	Wheat	9.62	13.58
10/23	Sethre	Carlisle	Wheat	7.19	12.75
10/23	Evenson	Fergus Falls	Wheat	1.96	12.75
10/28	Homan	Beardsley	Wheat	5.64	13.50
10/28	Dimberg	Ortonville	Corn	1.16	12.75
10/28	Nesvold	Madison	Corn	5.87	12.75
10/23	Pfau	Freeport	Corn	8.95	8.03
10/19	Powers	Hugo	Corn	7.35	8.03
10/27	Krause	Buffalo	Corn	6.51	13.34
10/27	Marklowitz	Litchfield	Corn	7.15	9.34
10/27	Rhoda	Raymond	Corn	7.18	12.23
10/27	Scheibel	Bird Island	Corn	14.27	13.50
10/30	Haubrich	New Ulm	Corn	7.49	14.50
10/29	Jeremiason	Minneota	Corn	6.93	12.23
10/29	Horton	Pipestone	Corn	6.69	13.99
10/29	Keller	Slayton	Corn	7.87	12.23
10/29	Turner	Bingham Lake	Corn	9.10	13.82
10/29	Ruschy	Sherburn	Corn	7.81	9.34
10/30	Van Sickle	Garden City	Corn	Not Available	
10/30	Seetin	Huntley	Corn	15.49	14.50
11/ 4	Hassing	Wells	Corn	7.07	14.50
11/ 4	Gniffke	Hayward	Corn	Not Available	
11/ 3	Goodsell	Spring Valley	Corn	9.95	10.30
11/ 3	Hoscheit	Caledonia	Corn	14.28	15.61
11/ 3	Carter	Eyota	Corn	11.38	15.61
11/ 4	Nordling	Lakeville	Corn	Not Available	
11/ 3	Olson	Welch	Corn	12.16	15.61
11/ 4	(Airport)	Fairbault	Soybeans	Not Available	
		S.C.S. SITES			
10/30	Hamann	Luverne	Corn	11.40	9.81
11/ 6	McNab	Brewster	Alfalfa	1.05	9.81
?	Nichols	Milaca	?	10.61	9.64
11/ 4	Sandbo	Odin	Soybeans	9.57	13.82
10/30	Zickrick	Kellogg	Corn	12.51	15.61
10/29	Woods	Winthrop	Corn	11.49	11.78
11/ 5	Sutherland	Hayfield	Corn	7.85	10.59
-	Hartung	Bertha	Alfalfa	No Data	
		EXPERIMENT STATIONS			
-	North West	Crookston	Corn	No Data	
11/10	West Central	Morris (DSL)	Corn	7.81	9.81
11/10	West Central	Morris (HCL)	Corn	6.31	11.60
10/15	South West	Lamberton	Corn	4.85	9.81
11/ 2	South Central	Waseca	Corn	10.14	-
11/18	Marcell Station (U.S. Forest Service)	Itasca Co.	Forested	11.63	-

Figure 1.

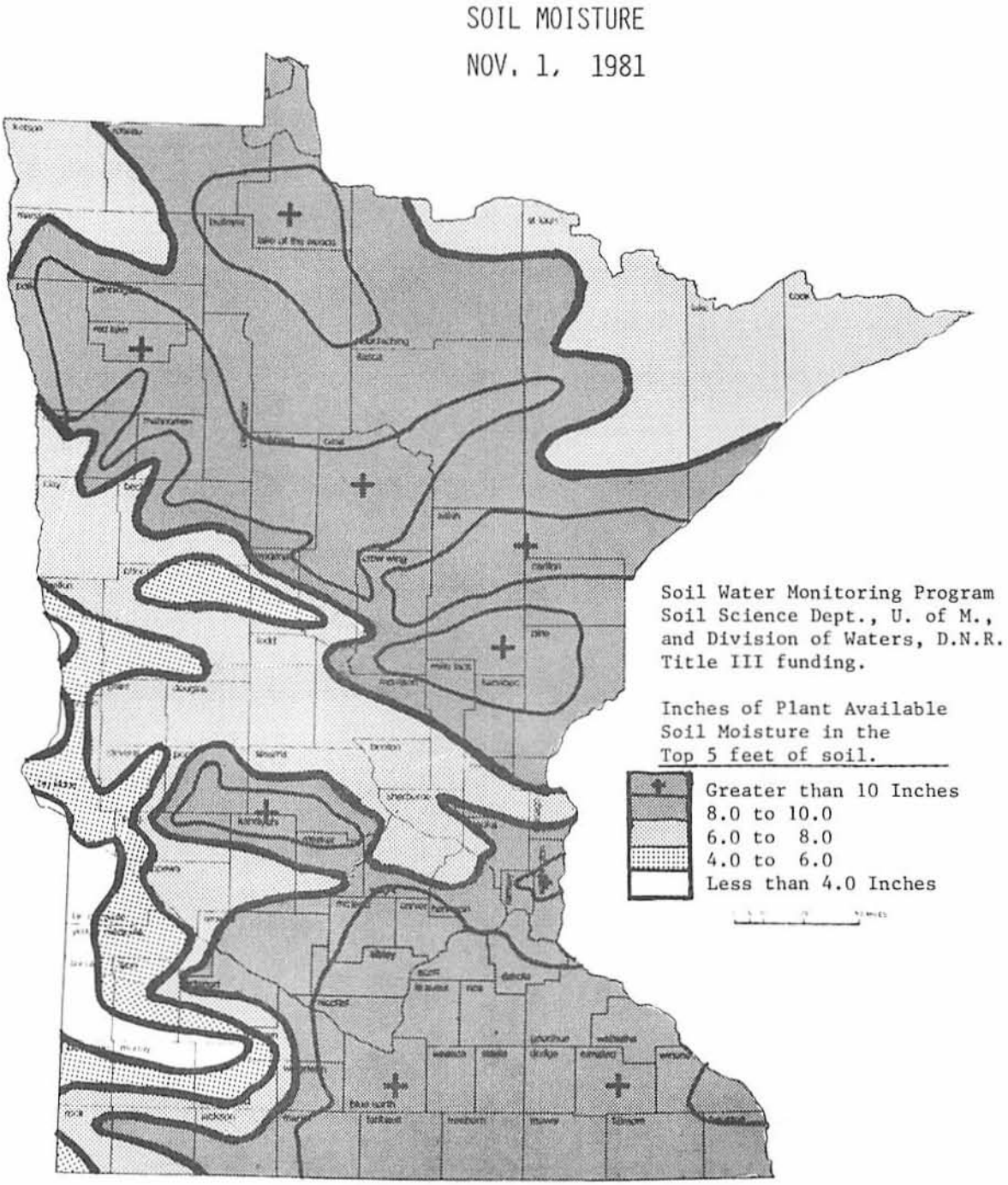

SOIL MOISTURE
NOV. 1, 1981
Soil Water Monitoring Program
Soil Science Dept., U. of M.,
and Division of Waters, D.N.R.
Title III funding.
Inches of Plant Available
Soil Moisture in the
Top 5 feet of soil.
Greater than 10 Inches
8.0 to 10.0
6.0 to 8.0
4.0 to 6.0
Less than 4.0 Inches

Figure 2.

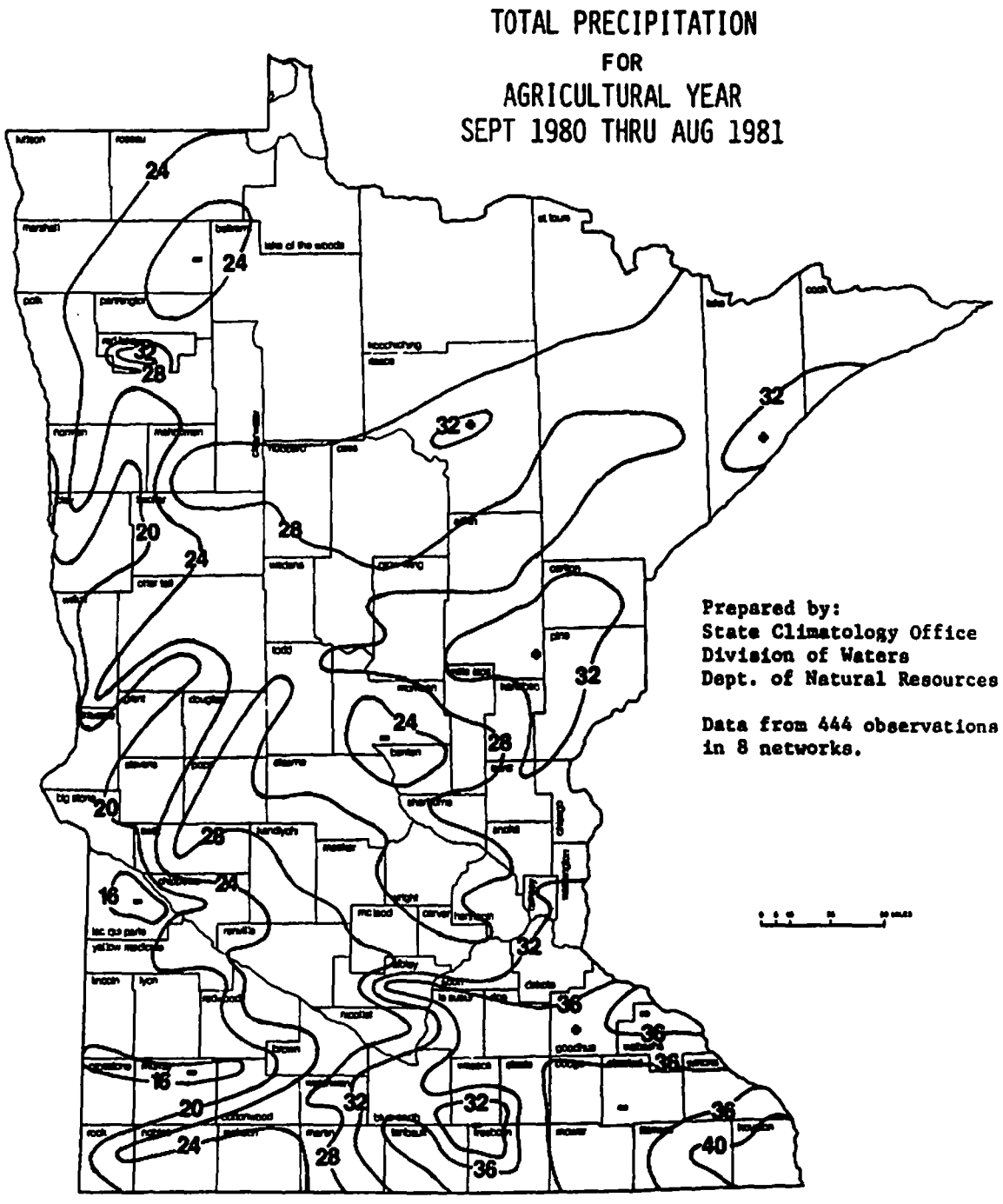
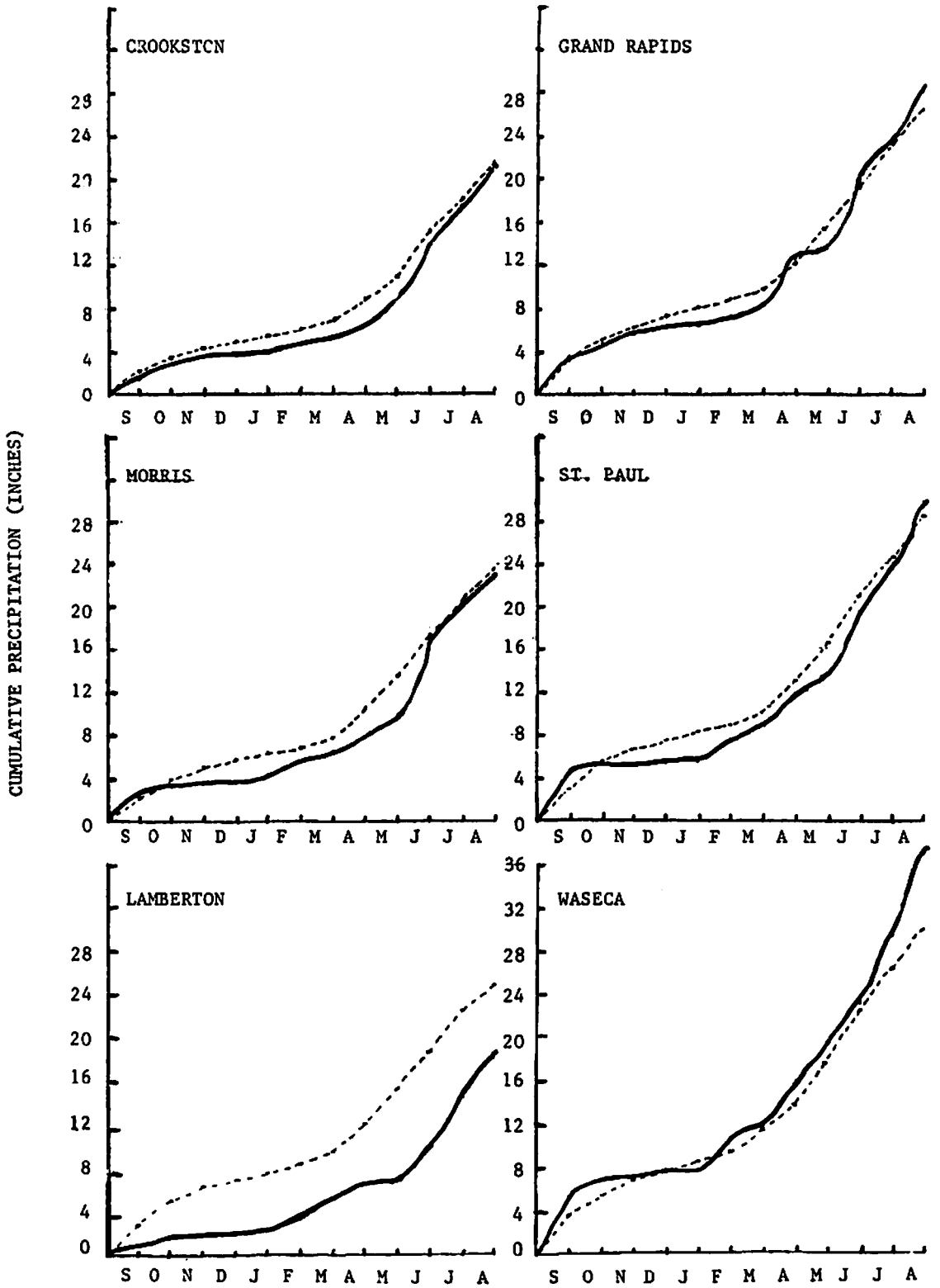

TOTAL PRECIPITATION
FOR
AGRICULTURAL YEAR
SEPT 1980 THRU AUG 1981
Prepared by:
State Climatology Office
Division of Waters
Dept. of Natural Resources
Data from 444 observations
in 8 networks.

Figure 3. AGRICULTURAL YEAR PRECIPITATION FOR SIX EXPERIMENT STATIONS

Sept., 1980 thru Aug., 1981 ————

Normals: (1931 - 1970) ———— (1961-80 at Lamberton and St. Paul)



Long Term Soil Moisture Record

by

D. G. Baker, Soil Science Dept.
W. W. Nelson, S. W. Exp. Station

The long-term historical record of soil moisture at the Southwest Agricultural Experiment Station is shown in Fig. 4. This represents the total amount of plant available water held in a 60 inch column of soil under corn. The line in Fig. 4 is the best-fit line of the weekly mean data. The data continue to support our view first expressed some years ago that there are four periods associated with soil moisture in Minnesota's agricultural soils:

1. The spring recharge period - extends from the soil thaw period until about June 10.
2. The grand consumption period - from about June 10 to the end of August. This is the grand plant growth period where stored soil moisture is drawn upon to make up for the insufficient amount of water supplied by precipitation.
3. The late summer-fall recharge period - from September until the soils are frozen. In the southern one-third of the state this is generally the first week of December. This recharge period is usually more important than the spring recharge period both in terms of the total amount of water added and the efficiency of its entry into the soil.
4. The fourth and final period is when the soils are frozen - about the first week in December to the first week in April in the southern one-quarter of the state. Normally very little of the over-winter precipitation enters the soil.

The timing of the reproductive period (silking and tasseling in the case of corn) relative to the soil moisture supply is all important. One good reason for early planting is to have the reproductive period occur when the soil moisture supplies are still high and before the usual late July period of low precipitation. Presently the average silking-tasseling date in south-central Minnesota is July 21.

Figure 5 shows the 22-year soil moisture record at Lamberton. The moisture profile of each year (the heavy line) is compared to the long-term mean (light line). Of particular interest is the 1973-1976 sequence. The soil moisture was progressively depleted earlier each season finally culminating in the 1976 drought. There was water in the soil but topsoil supplies ran out early and the roots simply could not reach the subsoil water supplies. The mean corn yield in Redwood and neighboring Cottonwood counties departed from the general yield trend by -4, -34, -40, and -53 bushels per acre in 1973-76, respectively.

Figure 4.

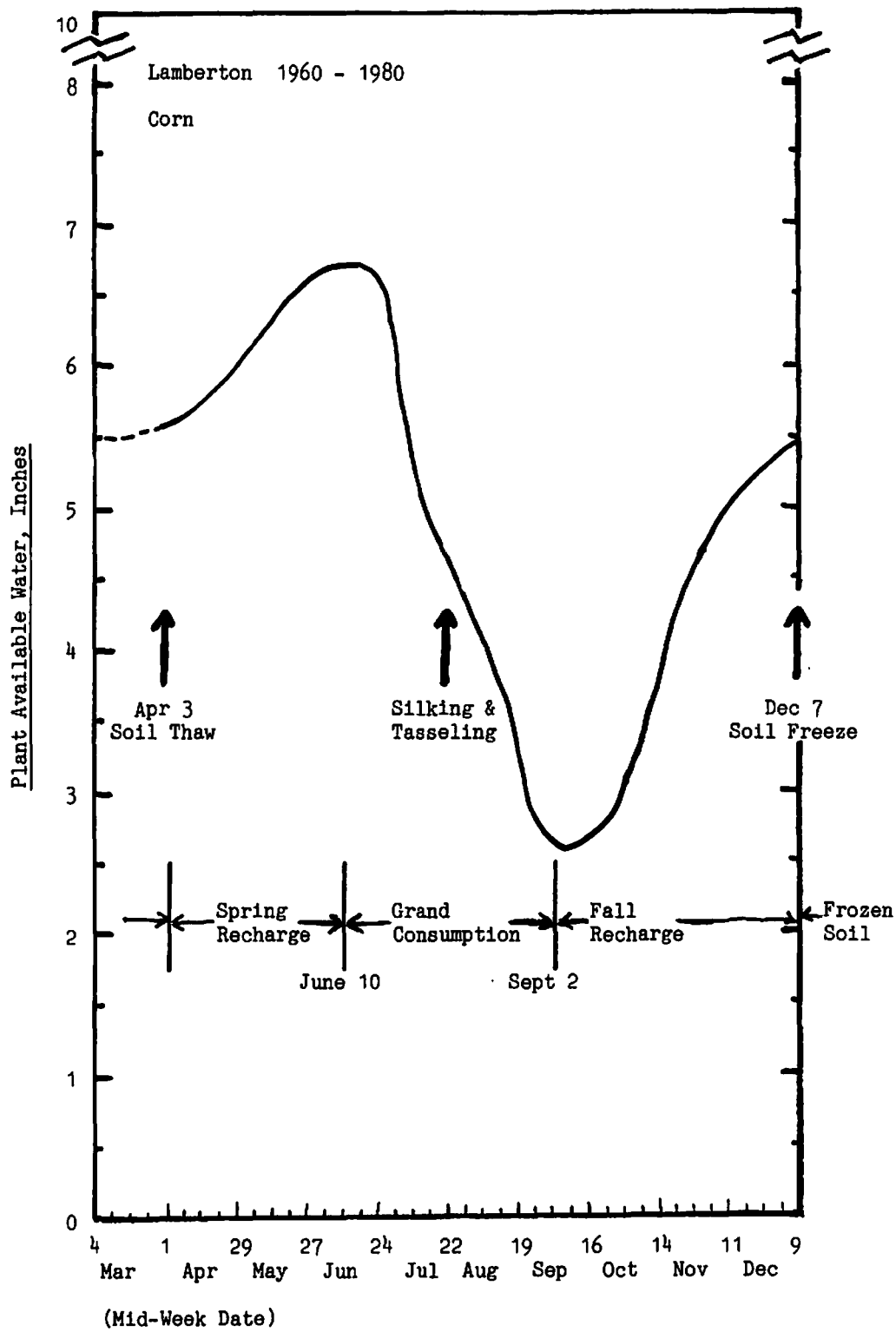
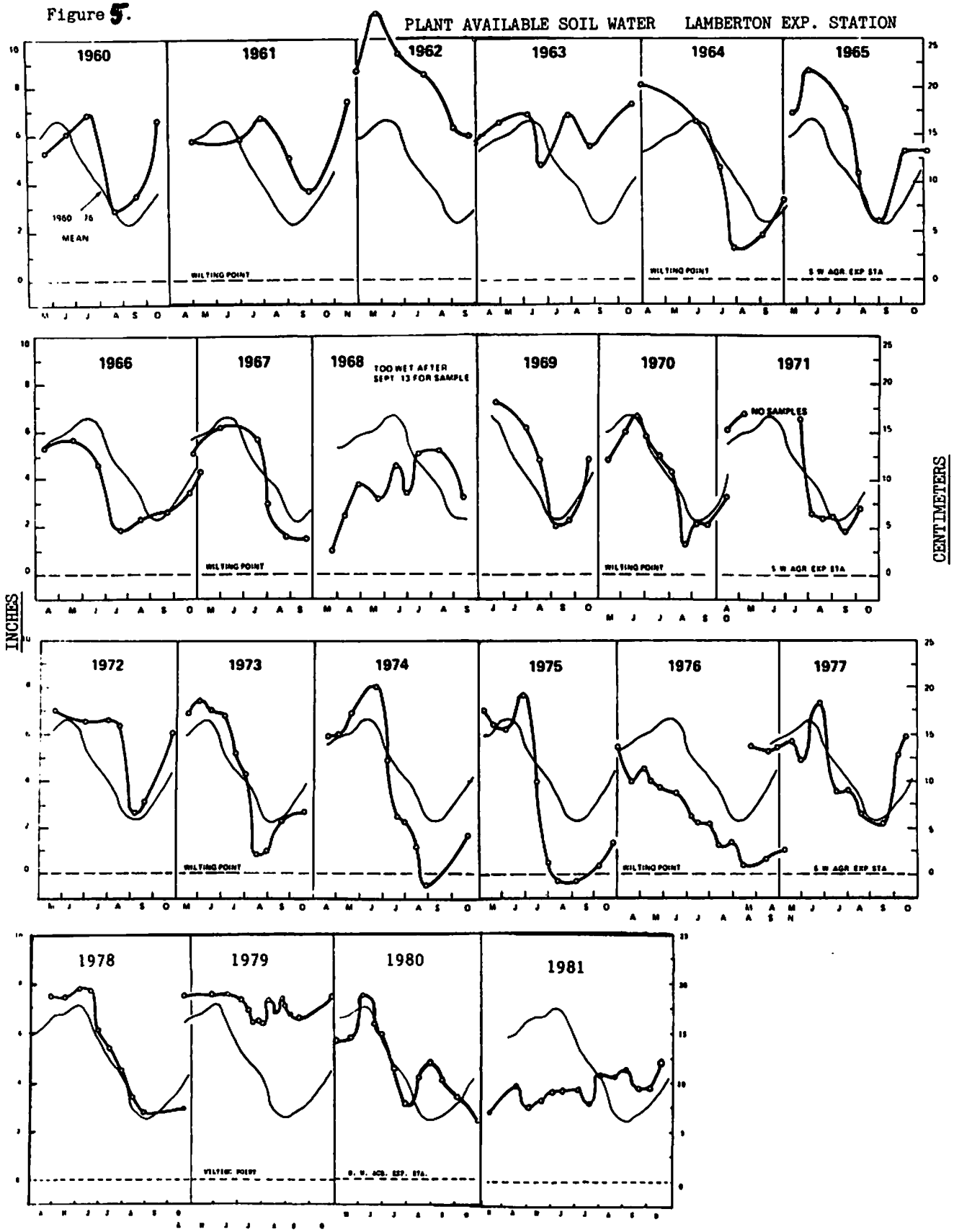

Lamberton 1960 - 1980
Corn
Plant Available Water, Inches
10
8
7
6
5
4
3
2
1
0
Apr 3
Soil Thaw
Silking &
Tasseling
Dec 7
Soil Freeze
Spring
Recharge
Grand
Consumption
Fall
Recharge
Frozen
Soil
June 10
Sept 2
4 Mar
1 Apr
29 May
27 Jun
24 Jul
22 Aug
19 Sep
16 Oct
14 Nov
11 Dec
9
(Mid-Week Date)

Figure 5.

PLANT AVAILABLE SOIL WATER LAMBERTON EXP. STATION



Soil Water Monitoring

D. G. Baker, E. L. Kuehnast, and D. L. Ruschy

(Mr. Kuehnast is with the State Climatology Office, D.N.R.)

A state-wide soil moisture monitoring program has been in progress for 3 years. The map shown in Fig. 1 is the result of the late fall, 1981, sampling and is an example of the detail possible. The soil moisture sites sampled totaled 51 with 36 from the monitoring project. Eight sites are sampled through courtesy of the Soil Conservation Service, U. S. D. A., 2 sites from the Forest Service, U. S. D. A., at Grand Rapids, and 5 Minnesota Agricultural Experiment Station sites. Although uniformity of the sites is not possible, it has been attempted. Sites have been selected with these features in mind: level to nearly level; medium to fine textured soil; continuous crop - corn in the southern part of the state, small grain in the northwest and forest in the north - central and northeast.

It is recognized that the variability of soils and, in particular, the variability of precipitation requires more than 51 sites for an accurate picture of soil moisture. As a result a very dense precipitation network is used in conjunction with the soil moisture network. Thus, a much more detailed picture of soil moisture is permitted. The soil moisture information, for example, shows the efficiency with which precipitation entered the soil and the precipitation data show how the water varied between soil sites. Figure 6 shows the locations of the two networks across the state.

1981 Precipitation

by

E. L. Kuehnast, State Climatologist, D. N. R.
J. A. Zandlo, Assistant State Climatologist, D. N. R.

The annual 1981 precipitation for the state as a whole was about 2 to 6 inches above normal except for the western border counties from Traverse south to the Iowa border which were 2 to 6 inches below normal.

The driest area, more than 6 inches below normal, was in northern Pipestone, Murray, and Cottonwood counties. The wettest areas of 6 to 9 inches above normal were located in Faribault, Red Lake, Fillmore - Houston and in northwestern Cook and northeastern Lake counties. The wetter than normal conditions have resulted in a record productive year for the state on the whole. Only some of the driest areas described above had somewhat below normal production. Further the overall wet conditions have resulted in above normal 1981-82 fall-winter field soil moisture conditions across the entire state except again in the described dry areas. (See Figure 7.)

Figure 6. 1981

Precipitation Observation

Locations (1258 Observers)

and Soil Moisture Sites

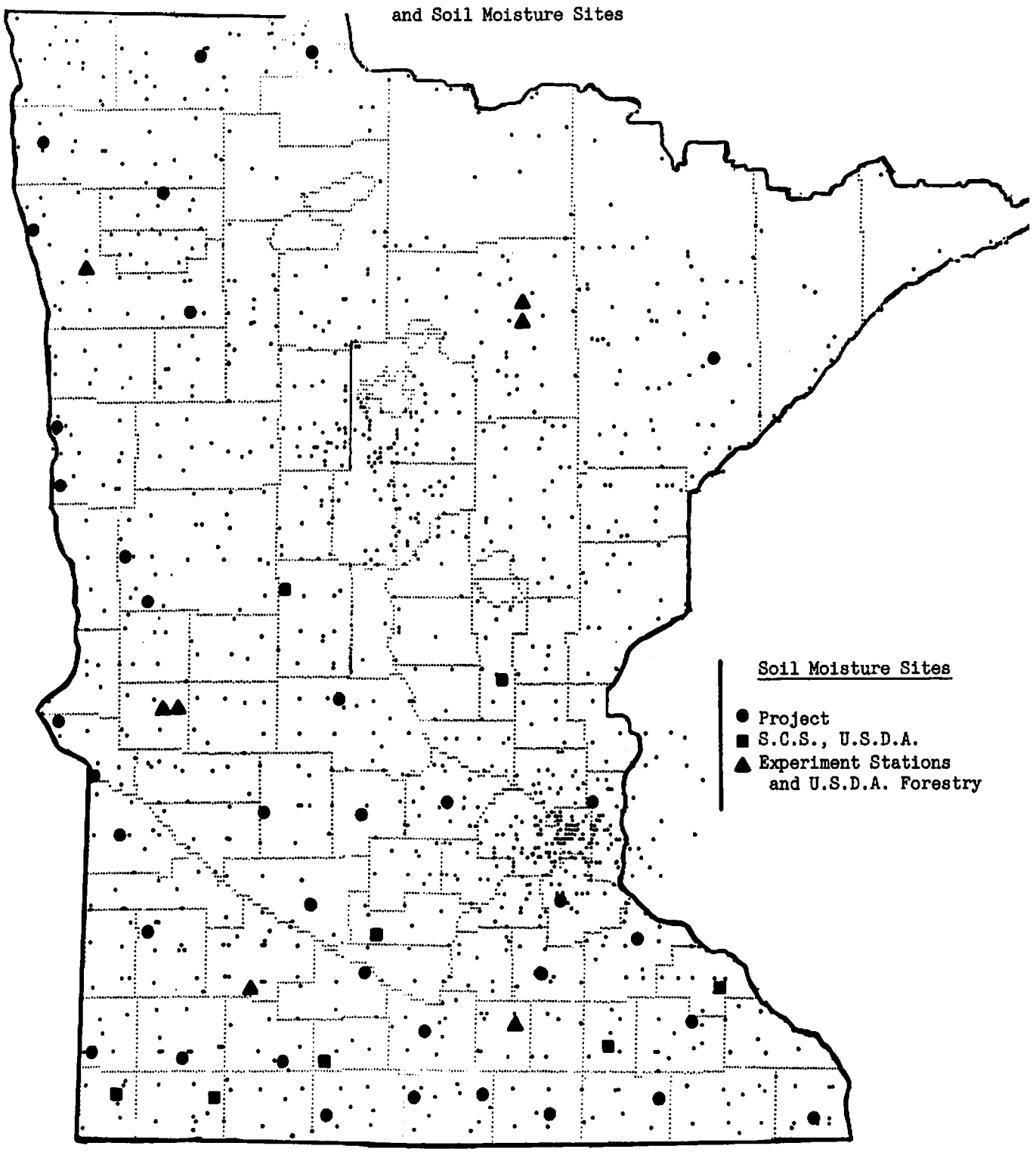
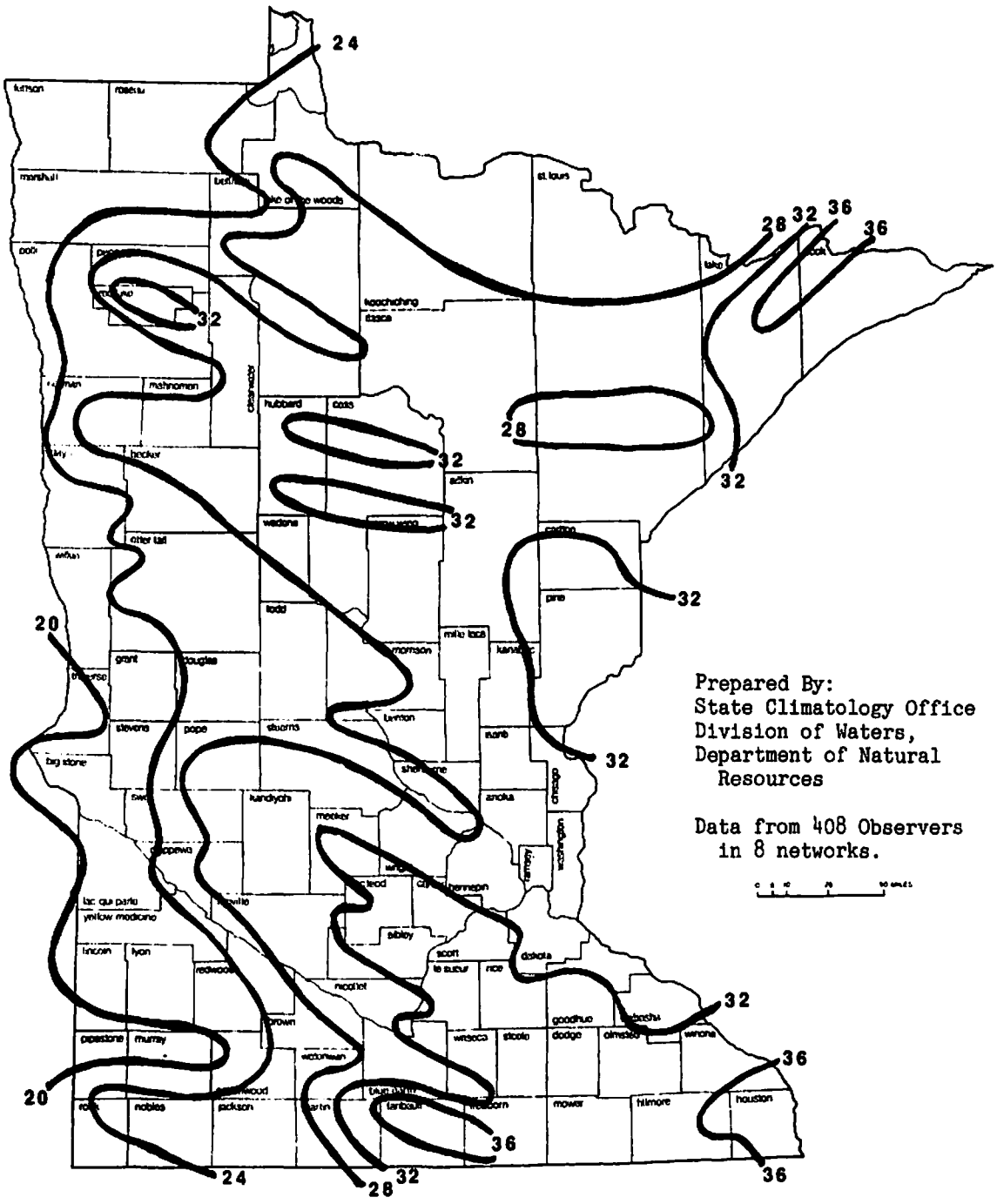


Figure 7.

1981 PRECIPITATION



INFLUENCE OF NITROGEN RATE, TIMING OF NITROGEN APPLICATION AND USE OF NITRIFICATION INHIBITORS FOR IRRIGATED CORN PRODUCTION - Becker, 1981

G.L. Malzer and T.Graff

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

Experimental Procedures

An experiment consisting of 54 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 inhibitors treatments (none, N-Serve-Dow Chemical Co. and Dwell-Terrazole-Olin Corporation) and five nitrogen application programs (all preplant, all 8-leaf, all 12-leaf, 1/3 preplant, 2/3 12-leaf, and 2/3 preplant, 1/3 12 leaf) were utilized. The experimental design also included a control, the three nitrogen rates applied at tasseling, the three N rates applied in split combinations (1/6 preplant, 1/6 8-leaf, 3/6 12-leaf, and 1/6 at tasseling), and one N rate of 150 # N/A with 1/4 #/A inhibitor (N-Serve or Dwell) at the 12-leaf stage. When a nitrification inhibitor was applied with the two times of N application treatments (1/3 - 2/3 or 2/3 - 1/3) the inhibitor was applied only with the preplant application of nitrogen. All nitrogen treatments were applied as urea and all but two nitrification inhibitor treatments were applied at rates of 0.5 # a.i./A as coating on to the urea. All inhibitor treatments were incorporated either by discing in the preplant applications or by utilizing the irrigation water with the later applications. Nitrogen applications were made at preplanting. (April 20th), at the 8-leaf stage of corn growth (June 10th), at the 12-leaf growth stage (June 24th), and at tasseling (July 14th).

Prior to planting broadcast applications of Potassium - Magnesium Sulfate (450 #/A 0-0-22) and Potassium (228 #/A 0-0-60) were made and incorporated by plowing. Corn (Pioneer 3901-100 day R.M.) was planted on April 27th in 30" rows at a population of 30,700 seed/A. Starter fertilizer was applied at the rate of 165 #/A of 8-10-30 banded at planting. A tank mix of Lasso (2 # a.i./A) and Atrazine (1½ # a.i./A) was applied on April 28th for weed control.

Leaf samples from opposite and below the ear at mid-silking were obtained on July 20th dried, ground and analyzed for Kjeldahl nitrogen. Dry matter production was determined on September 21st by hand harvesting 50 ft^2 of plot. Ears were separated from the stalks, field weights obtained and samples removed for moisture and nitrogen determination. Corn yield was determined on October 15th by hand harvesting 100 ft^2 of plot area and samples taken and adjusted to 15.5% moisture.

The irrigation program was started on May 19th and continued through September 3rd with a total of 10.40 inches of water being applied through irrigation. An additional 18.98 inches of water was obtained during the growing season through rainfall.

General Results

Nitrogen loss potential on the coarse textured irrigated soils especially with early nitrogen application were tremendous in 1981. This was primarily due to 5.23 inches of precipitation that was obtained on June 14th and 15th. Nitrogen losses with preplant applications of nitrogen were large enough to reduce potential yields when 225 # N/A had been applied by as much as 84 bu/A when compared to the best nitrogen management treatment. Significant grain yield increases were obtained up through the highest rate of nitrogen application although management (timing) of the nitrogen was more important than the rate applied. When nitrification inhibitors were not compared, the best nitrogen management combination was associated with one late sidedressed appliation (12-leaf) or when applied in four application spread throughout the growing season. Both nitrification inhibitors provided significant grain yield increases indicating that they did minimize nitrogen loss. As has been found in the past, they were not capabable of stopping nitrogen loss, but they did add considerable flexibility into the management program. For example when 150 # N/A was applied at the 12-leaf stage of growth the use of a nitrification inhibitor enabled equal or greater yields when the nitrogen was applied at the 8-leaf growth stage. This type of flexibility may be important to the producer to ensure that adequate nitrogen is available to the crop prior to the tasseling stage of growth.

Table 1. Influence of nitrogen rate, timing of nitrogen application, and nitrification inhibitors on leaf N content, grain yield, yield grain N content and dry matter production on irrigated corn. Becker, MN - 1981

Treatments						Dry Matter Production		
N-Rate	Time	Inh.	Leaf N	Grain Yield	Yield Grain N	Grain	Stover	Total
#/A			%	bu/A	%	--------T/A----------		
Check	-	-	1.26	52.4	0.98	1.30	1.74	3.04
75	ppl	-	1.24	54.8	0.95	1.32	2.30	3.62
75	sp(4)	-	2.47	134.2	1.05	3.18	2.93	6.11
75	sp(2)1/3,2/3	-	2.60	124.3	1.07	3.01	2.65	5.66
75	sp(2)2/3,1/3	-	2.13	93.1	1.02	2.18	2.44	4.62
75	8-leaf	-	2.66	126.6	1.10	3.21	3.05	6.26
75	12-leaf	-	2.82	146.0	1.11	3.44	2.91	6.35
75	Tassel	-	1.67	120.6	1.16	3.05	2.28	5.32
75	ppl	Dwell	1.57	80.0	0.94	1.83	2.26	4.39
75	sp(2)1/3,2/3	Dwell	2.72	124.5	1.03	3.14	3.10	6.24
75	sp(2)2/3,1/3	Dwell	2.18	104.4	1.05	2.38	2.30	4.68
75	8-leaf	Dwell	2.59	147.9	1.05	3.39	3.48	6.87
75	12-leaf	Dwell	2.63	145.9	1.08	3.24	2.98	6.22
75	ppl	N-S	1.59	81.1	0.94	1.64	2.01	3.64
75	sp(2)1/3,2/3	N-S	2.57	123.5	1.01	2.86	2.93	5.80
75	sp(2)2/3,1/3	N-S	2.26	105.4	1.01	2.29	2.54	4.83
75	8-leaf	N-S	2.50	127.6	1.09	2.92	2.80	5.72
75	12-leaf	N-S	2.68	143.1	1.11	3.45	2.88	6.33
150	ppl	-	1.95	92.1	0.97	2.09	2.26	4.35
150	sp(4)	-	2.91	159.0	1.22	3.99	3.52	7.50
150	sp(2)1/3,2/3	-	3.00	133.7	1.12	3.49	3.29	6.78
150	sp(2)2/3,1/3	-	2.68	125.7	1.11	3.14	2.79	5.93
150	8-leaf	-	3.01	157.0	1.30	3.64	3.01	6.65
150	12-leaf	-	3.00	167.5	1.30	4.18	3.23	7.40
150	Tassel	-	1.77	130.4	1.24	3.19	2.22	5.40
150	ppl	Dwell	1.81	95.2	0.99	2.21	2.40	4.61
150	sp(2)1/3,2/3	Dwell	2.92	151.0	1.35	3.88	3.22	7.10
150	sp(2)2/3,1/3	Dwell	2.74	159.6	1.16	3.65	3.11	6.76
150	8-leaf	Dwell	3.00	172.5	1.39	4.05	3.48	7.53
150	12-leaf	Dwell	2.72	175.1	1.28	3.97	3.02	6.98
150	ppl	N-S	2.26	108.3	1.04	2.66	2.56	5.22
150	sp(2)1/3,2/3	N-S	3.11	162.4	1.22	3.94	3.09	7.03
150	sp(2)2/3,1/3	N-S	2.67	149.2	1.12	3.46	3.00	6.46
150	8-leaf	N-S	3.14	177.4	1.41	4.18	3.75	7.93
150	12-leaf	N-S	3.08	159.3	1.26	3.93	2.92	6.85

Table 1 continued on page after next

Table 2. Influence of nitrogen rate, timing of nitrogen application use of nitrification inhibitors on grain N content and nitrogen removal of irrigated corn. Becker, MN - 1981.

Treatment			N Content		N Removal		
N-Rate	Appl. Time	Inhibitor	Grain	Stover	Grain	Stover	Total
#/A			-------%-------		---------lbs/A---------		
Check	-	-	0.96	0.26	25.0	9.2	34.2
75	ppl	-	0.90	0.26	23.7	12.3	36.0
75	sp(4)	-	1.05	0.36	66.6	20.7	87.3
75	sp(2)1/3,2/3	-	1.00	0.32	60.1	16.8	76.9
75	sp(2)2/3,1/3	-	0.95	0.27	41.2	12.9	54.0
75	8-leaf	-	1.03	0.32	66.2	19.5	85.7
75	12-leaf	-	1.10	0.35	75.4	20.3	95.7
75	Tassel	-	1.13	0.45	68.4	20.6	89.0
75	ppl	Dwell	0.92	0.25	33.6	12.8	46.4
75	sp(2)1/3,2/3	Dwell	1.11	0.32	69.3	20.2	89.5
75	sp(2)2/3,1/3	Dwell	1.00	0.28	47.3	12.6	60.0
75	8-leaf	Dwell	1.13	0.35	77.4	24.0	101.3
75	12-leaf	Dwell	1.06	0.36	69.0	21.3	90.3
75	ppl	N-S	0.92	0.26	29.9	10.3	40.2
75	sp(2)1/3,2/3	N-S	1.03	0.29	58.6	16.8	75.4
75	sp(2)2/3,1/3	N-S	0.98	0.29	45.0	14.7	59.7
75	8-leaf	N-S	1.10	0.31	64.0	17.1	81.2
75	12-leaf	N-S	1.11	0.43	76.9	24.6	101.4
150	ppl	-	1.02	0.31	42.8	13.6	56.4
150	sp(4)	-	1.22	0.39	97.2	27.0	124.2
150	sp(2)1/3,2/3	-	1.11	0.34	77.5	22.1	99.5
150	sp(2)2/3,1/3	-	1.06	0.31	66.9	16.9	83.9
150	8-leaf	-	1.23	0.47	89.5	28.3	117.9
150	12-leaf	-	1.22	0.46	101.9	29.6	131.5
150	Tassel	-	1.22	0.47	77.5	20.8	98.3
150	ppl	Dwell	0.99	0.26	43.9	12.5	56.4
150	sp(2)1/3,2/3	Dwell	1.27	0.38	98.0	24.6	122.7
150	sp(2)2/3,1/3	Dwell	1.14	0.37	83.0	23.4	106.4
150	8-leaf	Dewll	1.24	0.60	100.0	41.3	141.2
150	12-leaf	Dwell	1.28	0.52	101.5	31.5	133.0
150	ppl	N-S	0.97	0.29	51.4	14.9	66.3
150	sp(2)1/3,2/3	N-S	1.20	0.46	94.4	28.0	122.3
150	sp(2)2/3,1/3	N-S	1.18	0.35	82.3	20.8	103.1
150	8-leaf	N-S	1.27	0.50	106.4	37.9	144.3
150	12-leaf	N-S	1.27	0.49	99.8	28.4	128.2

Table 2 continued on next page

Table 1 continued

Treatments						Dry Matter Production		
N-Rate	Appl Time	Inh.	Leaf N	Grain Yield	Yield Grain N	Grain	Stover	Total
#/A			%	bu/A	----------T/A----------			
225	ppl	-	1.70	87.4	1.01	2.27	2.39	4.66
225	sp(4)	-	2.86	170.8	1.34	4.20	3.65	7.85
225	sp(2)1/3,2/3	-	3.05	166.5	1.27	3.87	3.42	7.29
225	sp(2)2/3,1/3	-	2.93	160.0	1.26	3.75	3.44	7.20
225	8-leaf	-	3.24	171.6	1.42	4.22	3.82	8.04
225	12-leaf	-	2.97	168.4	1.31	4.04	3.23	7.27
225	Tassel	-	1.85	128.8	1.28	3.06	2.11	5.16
225	ppl	Dwell	2.35	153.3	1.12	3.75	3.70	7.44
225	sp(2)1/3,2/3	Dwell	2.97	179.7	1.34	4.01	3.37	7.39
225	sp(2)2/3,1/3	Dwell	2.83	161.1	1.28	3.88	3.99	7.86
225	8-leaf	Dwell	3.16	169.2	1.39	4.36	3.73	8.09
225	12-leaf	Dwell	3.00	177.6	1.31	3.88	3.18	7.06
225	ppl	N-S	2.52	139.5	1.14	3.00	2.74	5.74
225	sp(2)1/3,2/3	N-S	3.06	174.2	1.38	4.06	2.29	7.35
225	sp(2)2/3,1/3	N-S	2.99	169.6	1.19	3.98	3.31	7.28
225	8-leaf	N-S	3.16	180.5	1.38	4.45	4.19	8.64
225	12-leaf	N-S	3.06	171.6	1.30	4.15	3.35	7.50
150	12-leaf	Dwell 1/4#	2.99	173.5	1.26	4.00	3.58	7.58
150	12-leaf	N-S 1/4#	2.96	170.9	1.28	4.02	3.07	7.08
Significance			**	**	**	**	**	**
BLSD(.05)			0.20	16.4	0.08	0.48	0.60	0.94

(Table 2 con't)

Treatments			N Content		N Removal		
N-Rate	Appl Time	Inhibitor	Grain	Stover	Grain	Stover	Total
#/A			-------%-------		--------lbs/A----------		
225	ppl	-	0.90	0.29	40.7	13.7	54.4
225	sp(4)	-	1.33	0.54	112.1	39.5	151.5
225	Sp(2)1/3,2/3	-	1.24	0.38	95.5	25.8	121.4
225	sp(2)2/3,1/3	-	1.18	0.39	89.2	26.8	116.0
225	8-leaf	-	1.41	0.67	118.6	51.2	169.8
225	12-leaf	-	1.31	0.57	105.2	36.6	141.8
225	Tassel	-	1.26	0.51	76.7	21.0	97.7
225	ppl	Dwell	1.15	0.34	86.7	25.1	111.7
225	sp(2)1/3,2/3	Dwell	1.27	0.54	102.6	36.1	138.7
225	sp(2)2/3,1/3	Dwell	1.23	0.37	95.5	29.3	124.9
225	8-leaf	Dwell	1.38	0.61	120.7	45.0	165.7
225	12-leaf	Dwell	1.32	0.53	102.4	33.1	135.5
225	ppl	N-S	1.12	0.35	68.2	18.8	87.1
225	sp(2)1/3,2/3	N-S	1.24	0.51	101.0	34.0	135.0
225	sp(2)2/3,1/3	N-S	1.24	0.40	98.8	26.1	124.9
225	8-leaf	N-S	1.47	0.59	130.6	49.0	179.6
225	12-leaf	N-S	1.35	0.61	112.1	40.8	152.9
150	12-leaf	Dwell 1/4#	1.23	0.50	98.4	35.7	134.1
150	12-leaf	N-S 1/4 #	1.24	0.49	99.5	30.3	129.8
Significance			**	**	**	**	**
BLSD(.05)			0.09	0.07	13.7	6.1	18.0

Table 1 and 2 (continued)

Treatments	Leaf N	Grain Yield	Yield Grain N	Dry Matter Production Grain	Dry Matter Production Stover	Dry Matter Production Total	N-Content Grain	N-Content Stover	N-Removal Grain	N-Removal Stover	N-Removal Total
	%	bu/A	%	T/A	T/A	T/A	%	%	lb/A	lb/A	lb/A
Factorial Arrangement (Nitrogen Rate X Time of application)											
N-Rate #/A											
75	2.22	114.2	1.06	2.77	2.65	5.42	1.02	0.33	57.4	17.6	75.0
150	2.62	137.9	1.18	3.39	2.90	6.29	1.15	0.39	79.0	22.6	101.7
225	2.65	150.5	1.27	3.63	3.15	6.78	1.23	0.48	91.1	30.7	121.8
Significance	**	**	**	**	**	**	**	**	**	*	**
BLSD(.05)	0.08	6.0	0.03	0.17	0.24	0.37	0.03	0.02	4.4	2.1	5.9
Time											
preplant	1.63	78.1	0.98	1.89	2.32	4.21	0.94	0.28	35.7	13.2	48.9
Sp(4)[1]	2.75	154.7	1.20	3.79	3.36	7.16	1.20	0.43	92.0	29.1	121.0
Sp(2)1/3,2/3	2.88	141.5	1.15	3.46	3.12	6.58	1.12	0.34	77.7	21.6	99.3
Sp(2)2/3,1/3	2.58	126.3	1.13	3.03	2.89	5.92	1.06	0.32	65.8	18.9	84.6
8-Leaf	2.97	151.7	1.27	3.69	3.29	6.98	1.22	0.48	91.4	33.0	124.5
12-Leaf	2.93	160.6	1.24	3.89	3.12	7.01	1.21	0.46	94.2	28.8	123.0
Tassel	1.76	126.6	1.22	3.10	2.30	5.30	1.22	0.48	74.2	20.8	95.0
Significance	**	**	**	**	**	**	**	**	**	**	**
BLSD(.05)	0.12	9.2	0.04	0.26	0.36	0.56	0.04	0.04	6.8	3.2	9.0
Factorial Arrangement (Nitrogen X Inhibitor X Time)											
N-Rate #/A											
75	2.31	115.2	1.04	2.69	2.73	5.42	1.02	0.31	55.8	17.1	72.9
150	2.74	145.7	1.20	3.50	3.01	6.51	1.16	0.41	82.6	24.9	107.5
225	2.86	162.0	1.27	3.84	3.41	7.25	1.25	0.48	97.8	32.8	130.6
Significance	**	**	**	**	**	**	**	**	**	**	**
BLSD(.05)	0.06	4.4	0.02	0.12	0.14	0.23	0.02	0.02	3.5	1.5	4.6
Nitrification Inhibitor											
None	2.60	131.6	1.15	3.19	2.95	6.14	1.11	0.38	72.9	23.1	96.1
Dwell	2.60	146.5	1.18	3.44	3.17	6.62	1.16	0.40	82.1	26.2	108.2
N-Serve	2.71	144.8	1.17	3.40	3.02	6.42	1.16	0.41	81.3	24.5	106.8
Significance	**	**	+	**	*	**	**	**	**	**	**
BLSD(.05)	0.06	4.5	0.03	0.13	0.16	0.26	0.02	0.02	3.7	1.7	4.8
Time											
preplant	1.89	99.1	1.01	2.31	2.55	4.85	0.99	0.29	46.8	14.9	61.7
Sp(2)1/3,2/3	2.89	148.9	1.20	3.58	3.15	6.74	1.16	0.39	84.1	24.9	109.0
Sp(2)2/3,1/3	2.60	136.4	1.13	3.19	2.99	6.18	1.10	0.33	72.1	20.4	92.5
8-Leaf	2.94	158.9	1.28	3.83	3.48	7.30	1.25	0.49	97.0	34.8	131.9
12-Leaf	2.88	161.6	1.23	3.81	3.08	6.89	1.22	0.48	93.8	29.6	123.4
Significance	**	**	**	**	**	**	**	**	**	**	**
BLSD(.05)	0.07	5.7	0.03	0.16	0.19	0.30	0.03	0.02	4.6	2.0	6.0

[1] 1/6, 1/6, 3/6, 1/6

INFLUENCE OF NITROGEN FORM, NITROGEN RATE, TIMING OF NITROGEN APPLICATION AND NITRIFICATION INHIBITORS FOR IRRIGATED CORN - BECKER, MN. 1981

G.L. Malzer and T. Graff

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

Experimental Procedures

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

Prior to planting broadcast application of Potassium-Magnesium Sulfate (462 #/A 0-0-22) and Potassium (228 #/A 0-0-60) were made and incorporated by plowing. Nitrogen application were made prior to planting (April 30th) at the 8-leaf stage (June 12th) and at the 12-leaf stage (June 24th). Corn (Pioneer 3901-100 day R.M.) was planted on May 1 in 30" rows at a population of 30,700 seed/A. Starter fertilizer was applied at the rate of 165 #/A 8-10-30 banded at planting. A tank mix Lasso (2 # ai/A) and Atrazine (1½ # ai/A) was applied on May 5th for weed control.

Leaf samples from opposite and below the ear at mid-silking were obtained on July 20th, dried and analyzed for Kjeldahl nitrogen. Total dry matter production was determined on September 22nd by hand harvesting 50 ft^2 of plot area. Ears were separated from the stalks, field weights obtained, and samples removed for moisture and nitrogen determination. Corn grain yields were obtained on October 14th by hand harvesting 100 ft^2 of plot area. Grain yields were adjusted to 15.5% moisture.

The irrigation program was started on July 2nd and continued through September 10th with a total of 8.75 inches of water being applied through irrigation. An additional 18.57 inches of water obtained during the growing season through rainfall.

General Result

The fertilizer nitrogen loss from this study was not as severe as was obtained on an adjoining study (see this report). This may be partially explained because the preplant applications were made 10 days later on this trial than on the other experiment. Nitrification had probably not advanced to the same degree on this trial when the leaching events took place. Results do suggest that nitrogen losses did take place when nitrogen was applied preplant at the low rate (75 # N/A). The use of 28% N solution was inferior to both anhydrous ammonia and urea across nitrogen rate as well as time of N application. Significant yield increases were obtained to nitrogen application up to 150 # N/A although this N rate appeared to maximize yields when anhydrous ammonia was applied. Since nitrogen losses were not severe, response to nitrification inhibitors when used with anhydrous ammonia were restricted to the preplant applications of 75 # N/A. A 25 bu/A response was obtained with Dwell when used with anhydrous ammonia at 75 # N/A. Inhibitor reponses were also obtained when used with 28% N Solution, but only at the high nitrogen rate.

Table 1. Influence of nitrogen form, nitrogen rates, nitrification inhibitors, timing of nitrogen application on yield grain, yield grain N content, and dry matter production on irrigated corn. Becker, MN-1981.

Treatments				Grain Yield	Yield Grain N	Dry Matter Production			
N-Rate	N-Form	Inh.	Time			Grain	Cob	Stover	Total
#/A				bu/A	%	----------T/A----------			
Check	--	--	--	91.2	0.95	2.02	0.30	1.90	4.27
75	AA	--	ppl	158.2	1.10	3.77	0.53	2.70	7.00
75	AA	--	8-lf	172.7	1.26	4.36	0.62	2.83	7.82
75	AA	--	12-lf	172.3	1.24	3.82	0.52	2.46	6.80
75	28%	--	ppl	144.9	1.04	3.32	0.43	2.46	6.22
75	28%	--	8-lf	143.3	1.09	3.27	0.40	2.26	5.93
75	28%	--	12-lf	148.9	1.07	3.74	0.50	2.52	6.80
75	AA	Dwell	ppl	183.1	1.26	4.26	0.58	2.89	7.72
75	28%	Dwell	ppl	132.1	0.99	3.04	0.42	2.40	5.87
75	AA	N-S	ppl	168.1	1.17	4.18	0.60	2.76	7.54
75	28%	N-S	ppl	131.9	1.02	3.21	0.46	2.48	6.16
150	AA	--	ppl	185.5	1.34	4.44	0.65	3.26	8.35
150	AA	--	8-lf	176.6	1.27	4.20	0.62	2.61	7.43
150	AA	--	12-lf	176.2	1.31	4.06	0.58	2.47	7.10
150	Urea	--	ppl	174.0	1.30	3.92	0.56	2.72	7.20
150	28%	--	ppl	161.9	1.19	3.45	0.55	2.85	6.84
150	28%	--	8-lf	156.5	1.13	3.49	0.44	2.30	6.23
150	28%	--	12-lf	161.4	1.23	3.86	0.50	2.24	6.59
150	AA	Dwell	ppl	185.2	1.32	4.33	0.61	2.79	7.72
150	Urea	Dwell	ppl	176.0	1.26	4.57	0.62	3.08	8.28
150	28%	Dwell	ppl	174.5	1.20	3.92	0.54	3.18	7.64
150	AA	N-S	ppl	191.5	1.35	4.45	0.68	3.07	8.20
150	Urea	N-S	ppl	178.4	1.22	4.29	0.63	3.12	8.04
150	28%	N-S	ppl	176.4	1.14	4.12	0.55	2.91	7.57
Significanace				**	**	**	**	**	**
BLSD(.05)				15.2	0.09	0.47	0.08	0.33	0.72

Factorial Arrangement (Excludes check, and urea treatments)

N-Rate #/A						
75	153.1	1.09	3.63	0.50	2.62	6.75
150	179.2	1.25	4.12	0.59	3.01	7.72
Significance	**	**	**	**	**	**
BLSD(.05)	9.7	0.05	0.28	0.05	0.19	0.40
N-Form						
AA	178.6	1.25	4.24	0.61	2.91	7.76
28%	153.6	1.10	3.51	0.49	2.71	6.72
Significance	**	**	**	**	**	**
BLSD(.05)	9.7	0.05	0.28	0.05	0.19	0.04
Inhibitor						
None	162.6	1.16	3.75	0.54	2.82	7.10
Dwell	168.7	1.19	3.89	0.54	2.81	7.24
N-Serve	167.0	1.17	3.99	0.57	2.81	7.37
Significance	NS	NS	NS	NS	NS	NS
BLSD(.05)	--	--	--	--	--	--

Table 1 (continued on page after next)

Table 2. Influence of nitrogen form, nitrogen rates, nitrification inhibitors, timing of nitrogen application on leaf N content, grain N content and nitrogen removal by irrigated corn. Becker, MN-1981.

Treatments				N-Content			N-Removal		
					Silage				
N-Rate	N-Form	Inh.	Time	Leaf	Grain	Stover	Grain	Stover*	Total
#/A				----------%----------			----------lbs/A----------		
Check	--	--	--	1.42	0.93	0.39	37.2	17.3	54.5
75	AA	--	ppl	2.82	1.07	0.39	80.9	25.4	106.3
75	AA	--	8-lf	3.01	1.20	0.68	105.4	46.4	151.8
75	AA	--	12-lf	2.83	1.27	0.58	96.7	34.7	131.4
75	28%	--	ppl	2.33	1.05	0.41	70.2	23.8	94.1
75	28%	--	8-lf	2.26	1.10	0.42	71.7	22.6	94.2
75	28%	--	12-lf	2.76	1.18	0.64	87.9	39.1	127.0
75	AA	Dwell	ppl	3.02	1.24	0.52	105.4	35.7	141.1
75	28%	Dwell	ppl	2.28	1.01	0.39	61.6	22.2	83.9
75	AA	N-S	ppl	2.70	1.16	0.48	97.3	32.4	129.7
75	28%	N-S	ppl	2.36	1.08	0.46	70.1	26.6	96.7
150	AA	--	ppl	3.23	1.28	0.58	113.4	45.1	158.5
150	AA	--	8-lf	3.22	1.32	0.58	111.4	37.4	148.8
150	AA	--	12-lf	2.77	1.22	0.66	98.8	40.3	139.1
150	Urea	--	ppl	2.76	1.14	0.42	90.8	27.3	118.1
150	28%	--	ppl	2.62	1.04	0.52	71.9	35.0	106.9
150	28%	--	8-lf	2.42	1.06	0.54	73.7	28.8	102.5
150	28%	--	12-lf	2.76	1.25	0.62	96.6	33.8	130.4
150	AA	Dwell	ppl	3.03	1.40	0.58	120.8	39.4	160.2
150	Urea	Dwell	ppl	3.15	1.24	0.54	114.0	40.2	154.7
150	28%	Dwell	ppl	2.87	1.13	0.42	88.9	31.6	120.6
150	AA	N-S	ppl	3.01	1.34	0.68	119.6	51.0	170.7
150	Urea	N-S	ppl	3.12	1.25	0.38	107.0	28.6	135.7
150	28%	N-S	ppl	2.77	1.10	0.42	90.8	29.3	120.1
Significance				**	**	**	**	**	**
BLSD(.05)				0.28	0.10	0.12	13.8	8.1	17.7

Factorial Arrangement (Excludes check, and urea treatments)

N-Rate #/A						
75	2.58	1.10	0.44	80.9	27.7	108.6
150	2.92	1.21	0.53	110.9	38.6	139.5
Significance	**	**	**	**	**	**
BLSD(.05)	0.17	0.06	0.07	8.7	4.9	11.4
N-Form						
AA	2.96	1.25	0.54	106.2	38.2	144.4
28%	2.54	1.07	0.44	75.6	28.1	103.7
Significance	**	**	**	**	**	**
BLSD(.05)	0.17	0.06	0.07	8.7	4.9	11.4
Inhibitor						
None	2.75	1.11	0.48	84.1	32.3	116.4
Dwell	2.80	1.19	0.48	94.2	32.2	126.4
N-Serve	2.71	1.17	0.51	94.4	34.8	129.3
Significance	NS	**	NS	*	NS	*
BLSD(.05)	--	0.05	--	8.4	--	11.7

Table 2 (continued on next page)

Table 1. Influence of nitrogen form, nitrogen rates, nitrification inhibitors, timing of nitrogen application on yield grain, yield grain N content, and dry matter production on irrigated corn. Becker, MN-1981, (continued).

Treatments				Grain Yield	Yield Grain N	Dry Matter Production			
N-Rate	N-Form	Inh.	Time			Grain	Cob	Stover	Total
#/A				bu/A	%	T/A			
Factorial Arrangement (Excludes check, urea, and inhibitor treatments)									
N-Rate #/A									
75				156.7	1.13	3.71	0.51	2.54	6.76
150				169.7	1.24	3.92	0.56	2.62	7.09
Significance				**	**	*	*	NS	*
BLSD(.05)				8.2	0.05	0.18	0.04	--	0.31
N-Form									
AA				173.6	1.25	4.11	0.59	2.72	7.42
28%				152.8	1.12	3.52	0.48	2.44	6.44
Significance				**	**	**	**	**	**
BLSD(.05)				8.2	0.05	0.24	0.51	0.19	0.40
Time									
ppl				162.6	1.16	3.75	0.54	2.82	7.10
8-leaf				162.3	1.19	3.83	0.52	2.50	6.85
12-leaf				164.7	1.22	3.87	0.53	2.42	6.82
Significance				NS	+	NS	NS	**	NS
BLSD(.05)				--	0.04	--	--	0.21	--

Table 2. Influence of nitrogen form, nitrogen rates, nitrification inhibitors, timing of nitrogen application on leaf N content, grain N content and nitrogen removal by irrigated corn. Becker, MN - 1981 (continued)

Treatments				N-Content			N-Removal		
					Silage				
N-Rate	N-Form	Inh.	Time	Leaf	Grain	Stover	Grain	Stover*	Total
				%			lbs/A		
Factorial Arrangement (Excludes check, urea, and inhibitor treatments)									
N-Rate #/A									
75				2.67	1.14	0.52	85.5	32.0	117.5
150				2.84	1.19	0.58	94.3	36.7	131.0
Significance				**	*	*	**	**	**
BLSD (.05)				0.12	0.04	0.06	7.8	4.4	9.3
N-Form									
AA				2.98	1.23	0.58	101.1	38.2	139.3
28%				2.53	1.11	0.52	78.7	30.5	109.2
Significance				**	**	+	**	**	**
BLSD(.05)				0.12	0.06	0.05	7.8	4.4	9.3
Time									
ppl				2.75	1.11	0.48	84.1	32.3	116.4
8-leaf				2.73	1.17	0.56	90.5	33.8	124.3
12-leaf				2.78	1.23	0.62	95.0	37.0	132.0
Significance				NS	**	**	*	+	**
BLSD(.05)				--	0.07	0.09	6.8	3.7	11.5

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

HIGH CORN AND SOYBEAN YIELD TRIALS ON THE COARSE TEXTURED, IRRIGATED SOILS OF MINNESOTA

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

Experimental Procedures

Corn Trial - An experiment consisting of four replications of nine treatments, was arranged in a randomized complete block design. A factorial arrangement consisting of two fertilizer application rates, two varietys and two plant populations, were combined with a control receiving only nitrogen. The fertilizer variables included treatments of 220 + 60 + 220 which might be considered adequate for this site along with a rate of application 50% higher 330 + 90 + 330. Plant population included a base level of 28,000 plants/acre (a reasonable level to utilize under irrigation) a population 50% higher 42,000 plants/acre. The two varieties were Pioneer 3901 and DeKalb XL12. The control treatment which received only 220 lbs N/A as a treatment was planted with Pioneer 3901 at a plant population of 28,000 plants/A.

Soybean Trial - This experiment was located directly south of the corn trial, and was the same site of the previous year corn trial. The soybean experiment consisted of nine treatments, with four replications, and was arranged in a randomized complete block design. A factorial arrangement consisting two fertilizer application rates, two plant populations and two varieties were combined with a control plot receiving no fertilizer treatment. The fertilizer variables included treatments of 0 + 60 + 220 and an application 50% higher 0 + 90 + 330. Plant populations included rates of 5 and 10 seeds/foot of row in 14 inch rows. The two varieties were Hodgson -78 and Exp. #II-68-176. The control treatment was planted with Hodgson-78 at a population of 5 seeds/ft of row. Prior to planting, applications of Potassium magesium sulfate (314 #/A 0-0-22) and zinc (9#/A) as zinc sulfate were broadcast over the experimental area. Boron (2 #/A as Borate 68) was applied with the phosphorus and potassium treatments. The control plots did not receive a boron application. Nitrogen was applied to the corn as broadcast applications of urea throughout the season, with 25% of the nitrogen applied 2 weeks after planting (May 7th), 25% at the 8-leaf stage (June 10th) and 50% of the nitrogen at the 12-leaf stage (July 2nd). Because of a 5.52 inches of precipitation on June 13th and 14th an additional application of nitrogen similar to the amount applied at the8-leaf stage was applied on June 19th. Starter fertilizer was applied at the rate of 165#/A of 8-10-30 banded before planting to mark the rows. Corn (Pioneer 3901 and DeKalb XL12 - 100 day relative maturity) was hand planted into the experimental area on april 24th. Weed control was accomplished utilizing Lasso (2 #ai/A) and mechanically as needed.

Leaf samples from opposite and below the ear at mid-silking were taken on July 6th, dried, ground, and analyzed for elemental concentrations. Total dry matter production was determined on September 22nd by hand harvesting 50 ft^2. Ears were separated from the stalks, field weights obtained, and samples removed for moisture determination and elemental concentration. Corn grain yield were taken on October 9th by hand harvesting 100 ft^2. Grain yields were adjusted to 15.5% moisture. The irrigation program was started on May 16th and continued through September 11th with a total of 9.50 inches of water being applied through irrigation. An additional 18.21 inches of water was obtained during the growing season through rainfall.

The soybeans (Hodgson -78 and Exp. #II-68-176 medium to late maturing) were planted on May 12th utilizing a cone seeder. Leaf samples from the first mature soybean trifoliate were taken on July 28th, dried, ground and analyzed for elemental concentrations. Soybean grain yields were obtained on October 19th. Grain yields were adjusted to 13% moisture. The irrigation program for the soybeans was started on May 16th and continued through September 11th with a total of 9.5 inches of water being applied through irrigation. An additional 21.03 inches of water was obtained during the growing season through rainfall. Weed control was accomplished with Treflan (½ # ai/A) and mechanically as needed.

General Results

The results obtained from the corn and soybean research experiments conducted in 1981 are contained in tables 1-6. The overall corn yield results in 1981 were lower than what has been achieved in the past. In general this is thought to be due to a general lack of both sunshine and warm temperature during pollination and the grain filling period. This resulted in many poorly filled ears. Within the corn experiment, variety had the largest impact on grain yield with Pioneer 3901 on the average being about 20 bu/A better than DeKalb XL12. Increasing plant populations from 28,000 to 42,000 ppa had relatively little influence on grain yield, but did significantly increase stover production as well as total dry matter production. Increasing the rate of fertilization from "high" to "extra high" had no significant influence on grain yield.

Soybean seed yields were significantly higher for Hodgson-78 than for EXP #II-68-178. There was no main effect difference due to increasing the fertilization rate from "high" to "extra high" or by increasing the plant population. There was, however, a significant interaction which suggested that "extra high" fertilization was advantageous at the lower seeding rate.

Table 1. Influence of fertilizer treatment, variety and plant population on corn forage production, grain yield and grain nitrogen. Becker, MN 1981.

Treatments					Corn Forage Production						Harvest Grain			
N	P_2O_5	K_2O	Plant pop	Variety	D.M. Grain	D.M. Stover	Barren Stalks	Grain	Stover	Total	Yield	N Content	D.M. Grain	Shelling
----#/A----					--------%----------			-------T/A--------			bu/A	----------%----------		
220	0	0	28	P	63.08	38.20	2.27	4.15	3.39	7.54	172.0	1.32	70.3	88.3
220	60	220	28	P	64.45	30.40	0.70	4.11	3.29	7.40	170.8	1.45	69.9	88.7
220	60	220	28	D	66.15	32.05	0.78	4.04	3.46	7.50	161.9	1.52	72.2	87.7
220	60	220	42	P	62.18	35.00	1.04	4.25	3.62	7.87	182.7	1.36	69.6	89.2
220	60	220	42	D	64.85	31.85	3.94	4.09	3.81	7.90	160.8	1.56	71.3	87.1
330	90	330	28	P	63.45	30.98	0.63	4.30	3.59	7.88	184.5	1.44	70.5	88.8
330	90	330	28	D	67.40	31.62	0.84	4.05	3.60	7.65	158.2	1.60	73.3	87.0
330	90	330	42	P	62.65	31.68	2.81	4.43	3.99	8.42	185.8	1.38	69.0	89.2
330	90	330	42	D	65.28	33.92	1.24	3.94	3.80	7.73	162.4	1.48	71.7	86.6
Significance					**	*	NS	NS	**	*	**	**	**	**
BLSD(.05)					1.64	5.4	--	--	0.34	0.66	12.8	0.10	1.9	1.2
Factorial Statistics														
Variety														
Pioneer 3901					63.2	32.00	1.30	4.27	3.62	7.89	181.0	1.41	69.8	89.0
DeKalb XL12					65.9	32.40	1.70	4.03	3.67	7.69	160.8	1.54	72.1	87.1
Significance					**	NS	NS	*	NS	NS	**	**	**	**
BLSD(.05)					0.9	--	--	0.18	--	--	6.8	0.05	0.9	0.6
Population (plants per acre)														
28,000					65.4	31.30	0.74	4.12	3.48	7.60	168.9	1.50	71.5	88.0
42,000					63.7	33.10	2.26	4.18	3.80	7.98	172.9	1.44	70.4	88.0
Significance					**	+	*	NS	**	**	NS	*	*	NS
BLSD(.05)					0.9	1.70	1.45	--	0.16	0.27	--	0.05	0.9	--
Fertility														
220+60+220					64.4	32.3	1.62	4.12	3.55	7.67	169.0	1.47	70.8	88.2
330+90+330					64.7	32.0	1.38	4.18	3.74	7.92	172.8	1.48	71.1	87.9
Significance					NS	NS	NS	NS	*	+	NS	NS	NS	NS
BLSD(.05)					--	--	--	--	0.16	0.24	--	--	--	--
Variety X Population														
Pioneer 3901			28		64.0	30.7	0.66	4.20	3.44	7.64	166.4	1.49	70.2	88.8
Pioneer 3901			42		62.4	33.3	1.93	4.34	3.87	8.15	171.4	1.52	69.3	89.2
DeKalb XL12			28		66.8	31.8	0.81	4.04	3.53	7.57	171.7	1.46	72.8	87.3
DeKalb XL12			42		65.1	32.9	2.59	4.01	3.80	7.82	174.1	1.43	71.5	86.8
Significance					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)					--	--	--	--	--	--	--	--	--	--
Variety X Fertility														
Pioneer 3901			220+60+220		63.3	32.7	0.87	4.18	3.46	7.64	176.8	1.40	69.8	88.9
Pioneer 3901			330+90+330		63.0	31.3	1.72	4.36	3.79	8.15	185.2	1.41	69.8	89.0
DeKalb XL12			220+60+220		65.5	32.0	2.36	4.06	3.64	7.70	161.3	1.54	71.8	87.4
DeKalb XL12			330+90+330		66.3	32.8	1.04	3.99	3.70	7.69	160.3	1.54	72.5	86.8
Significance					NS	NS	NS	NS	+	+	NS	NS	NS	NS
BLSD(.05)					--	--	--	--	0.19	0.33	--	--	--	--
Population x Fertility														
28			220+60+220		65.3	31.2	0.74	4.07	3.38	7.45	166.4	1.49	71.1	88.2
28			330+90+330		65.4	31.3	0.73	4.17	3.59	7.76	171.4	1.52	71.9	87.9
42			220+60+220		63.5	33.4	2.49	4.17	3.72	7.88	171.7	1.46	70.4	88.1
42			330+90+330		64.0	32.8	2.02	4.18	3.89	8.08	174.1	1.43	70.4	87.9
Significance			NS		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)					--	--	--	--	--	--	--	--	--	--
Variety x Pop. x Fertility					NS	NS	NS	NS	NS	NS	NS	+	NS	NS
BLSD(.05)					--	--	--	--	--	--	--	0.06	--	--

Table 2. Influence of fertilizer treatment, variety, and plant population on the elemental concentration of the leaf opposite and below the ear at silking. Becker, MN - 1981.

Treatments					Leaf Elemental Concentration											
N	P_2O_5	K_2O	Plant pop	Variety	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
----#/A----					----------%----------					----------ppm----------						
220	0	0	28	P	3.11	0.30	2.31	0.47	0.36	49	119	32	88	26	11	4
220	60	220	28	P	2.96	0.29	2.85	0.40	0.27	55	117	33	74	23	8	8
220	60	220	28	D	2.96	0.31	2.73	0.49	0.31	64	128	29	62	24	10	10
220	60	220	42	P	2.86	0.29	2.70	0.42	0.28	61	120	34	83	22	9	8
220	60	220	42	D	2.92	0.30	2.69	0.49	0.31	56	125	27	58	22	9	9
330	90	330	28	P	3.07	0.31	2.83	0.41	0.26	63	127	34	102	25	9	8
330	90	330	28	D	3.12	0.32	2.92	0.46	0.30	53	124	26	80	26	9	9
330	90	330	42	P	2.84	0.30	2.92	0.39	0.26	54	118	36	84	24	8	9
330	90	330	42	D	3.02	0.30	2.87	0.43	0.27	47	119	29	69	24	8	8
Significance					**	NS	**	**	**	NS	NS	**	**	*	**	**
BLSD(.05)					0.15	--	0.17	0.04	0.03	--	--	6	22	3	1	2
Factorial Statistics																
Variety																
Pioneer 3901					2.93	0.30	2.82	0.40	0.27	58	120	34	86	24	8	8
DeKalb XL12					3.00	0.30	2.80	0.47	0.30	55	124	28	68	24	9	9
Significance					+	NS	NS	**	**	NS	NS	**	**	NS	NS	NS
BLSD(.05)					0.06	--	--	0.02	0.01	--	--	3	11	--	--	--
Population (plants per acre)																
28,000					3.02	0.31	2.83	0.44	0.28	58	124	30	80	24	9	9
42,000					2.91	0.30	2.79	0.43	0.28	54	120	32	74	23	8	9
Significance					**	+	NS	NS	NS	NS	NS	NS	NS	+	*	NS
BLSD(.05)					0.07	0.01	--	--	--	--	--	--	--	1	1	--
Fertility																
220+60+220					2.92	0.30	2.74	0.45	0.29	59	122	31	70	23	9	8
330+90+330					3.01	0.31	2.88	0.42	0.27	54	122	31	84	25	9	8
Significance					*	NS	**	+	*	NS	NS	NS	*	**	NS	NS
BLSD(.05)					0.07	--	0.09	0.02	0.01	--	--	--	11	1	--	--
Variety X Population																
Pioneer 3901			28		3.02	0.30	2.84	0.40	0.26	59	122	34	88	24	9	8
Pioneer 3901			42		2.85	0.29	2.81	0.40	0.27	58	119	35	84	23	8	9
DeKalb XL12			28		3.04	0.31	2.82	0.47	0.31	58	126	28	71	25	9	9
DeKalb XL12			42		2.97	0.30	2.78	0.46	0.29	51	122	28	64	23	8	9
Significance					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*
BLSD(.05)					--	--	--	--	--	--	--	--	--	--	--	1
Variety X Fertility																
Pioneer 3901			220+60+220		2.91	0.29	2.77	0.41	0.27	58	119	34	79	23	9	8
Pioneer 3901			330+90+330		2.95	0.30	2.87	0.40	0.26	58	122	35	93	25	8	8
DeKalb XL12			220+60+220		2.94	0.30	2.71	0.49	0.31	60	126	28	60	23	9	10
DeKalb XL12			330+90+330		3.07	0.31	2.90	0.45	0.28	50	121	28	75	25	9	8
Significance					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)					--	--	--	--	--	--	--	--	--	--	--	--
Population X Fertility																
28			220+60+220		2.96	0.30	2.79	0.44	0.29	59	122	31	68	23	9	9
28			330+90+330		3.09	0.32	2.88	0.44	0.28	58	125	30	91	26	9	8
42			220+60+220		2.89	0.29	2.69	0.45	0.30	58	122	31	71	22	9	9
42			330+90+330		2.93	0.30	2.89	0.41	0.27	50	118	32	77	24	8	9
Significance					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)					--	--	--	--	--	--	--	--	--	--	--	--
Variety X Pop. X Fertility					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)					--	--	--	--	--	--	--	--	--	--	--	--

Table 3. Influence of fertilizer treatment, variety, and plant population on the elemental concentration of forage grain at physiological maturity. Becker, MN - 1981.

Treatments					Leaf Elemental Concentration											
N	P_2O_5	K_2O	Plant pop	Variety	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
----#/A----					----------%----------					----------ppm----------						
220	0	0	28	P	1.37	0.23	0.33	.002	0.14	0.9	21	6	6	20	2	2
220	60	220	28	P	1.40	0.26	0.34	.002	0.14	1.7	21	4	6	21	2	2
220	60	220	28	D	1.50	0.27	0.37	.001	0.16	0.6	22	4	6	24	2	2
220	60	220	42	P	1.40	0.24	0.33	.003	0.15	0.4	22	4	6	20	2	2
220	60	220	42	D	1.46	0.25	0.35	.003	0.15	0.5	20	4	7	22	2	2
330	90	330	28	P	1.36	0.26	0.35	.002	0.15	0.4	22	4	6	23	2	2
330	90	330	28	D	1.54	0.27	0.38	.003	0.16	0.4	22	4	6	25	2	2
330	90	330	42	P	1.42	0.24	0.32	.002	0.14	1.0	22	4	6	21	2	2
330	90	330	42	D	1.46	0.26	0.36	.003	0.15	0.6	21	2	7	23	2	2
Significance					*	*	**	**	NS	NS	*	NS	+	**	NS	NS
BLSD(.05)					0.13	0.03	0.03	.001	--	--	1	--	1	2	--	--
Factorial Statistics																
Variety																
Pioneer 3901					1.39	0.25	0.34	.002	0.15	0.9	22	4	6	21	2	1
DeKalb XL12					1.49	0.26	0.36	.003	0.16	0.5	21	3	7	23	2	2
Significance					**	*	**	**	*	NS	NS	NS	*	**	**	**
BLSD(.05)					0.05	0.01	0.01	.001	0.01	--	--	--	1	1	--	1
Population (plants per acre)																
28,000					1.45	0.26	0.36	.002	0.15	0.8	22	4	6	23	2	2
42,000					1.43	0.25	0.34	.003	0.15	0.6	21	4	7	22	2	2
Significance					NS	*	**	*	NS	NS	+	NS	NS	*	NS	NS
BLSD(.05)					--	0.01	0.01	.001	--	--	1	--	--	1	--	--
Fertility																
220+60+220					1.44	0.26	0.35	.003	0.15	0.8	21	4	6	22	2	2
330+90+330					1.44	0.25	0.35	.003	0.15	0.6	22	3	7	23	2	2
Significance					NS	NS	NS	NS	NS	NS	*	NS	NS	*	NS	NS
BLSD(.05)					--	--	--	--	--	--	1	--	--	1	--	--
Variety X Population																
Pioneer 3901			28		1.38	0.26	0.35	.002	0.15	1.1	22	4	6	22	2	2
Pioneer 3901			42		1.41	0.24	0.33	.003	0.14	0.7	22	4	6	21	2	2
DeKalb XL12			28		1.52	0.27	0.37	.003	0.16	0.5	22	4	6	24	2	2
DeKalb XL12			42		1.46	0.25	0.35	.003	0.15	0.5	21	3	7	22	2	2
Significance					+	NS	NS	NS	NS	NS	+	NS	NS	NS	NS	NS
BLSD(.05)					0.07	--	--	--	--	--	1	--	--	--	--	--
Variety X Fertility																
Pioneer 3901			220+60+220		1.40	0.25	0.34	.002	0.15	1.0	21	4	6	20	2	2
Pioneer 3901			330+90+330		1.39	0.25	0.34	.002	0.15	0.8	22	4	6	22	2	2
DeKalb XL12			220+60+220		1.48	0.26	0.36	.003	0.15	0.6	21	4	7	23	2	2
DeKalb XL12			330+90+330		1.50	0.26	0.37	.003	0.16	0.5	21	3	7	24	2	2
Significance					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)					--	--	--	--	--	--	--	--	--	--	--	--
Population X Fertility																
28			330+90+330		1.44	0.26	0.36	.003	0.15	1.1	21	4	6	22	2	2
28			330+90+330		1.45	0.26	0.36	.003	0.15	0.4	22	4	6	24	2	2
42			220+60+220		1.43	0.25	0.34	.003	0.15	0.4	21	4	6	21	2	2
42			330+90+330		1.44	0.25	0.34	.003	0.15	0.8	22	3	7	22	2	2
Significance					NS	NS	NS	NS	NS	+	NS	NS	NS	NS	NS	NS
BLSD(.05)					--	--	--	--	--	0.7	--	--	--	--	--	--
Variety x Pop. X Fertility					NS	NS	NS	NS	NS	NS	*	NS	NS	NS	NS	NS
BLSD(.05)					--	--	--	--	--	--	1	--	--	--	--	-

Table 4. Influence of fertilizer treatment, variety and plant population on the elemental concentration of forage stover at physiological maturity. Becker, MN - 1981.

Treatments					Forage Stover Elemental Concentration											
N	P_2O_5	K_2O	Plant pop	Variety	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
----#/A----					----------%----------					----------ppm----------						
220	0	0	28	P	0.62	0.05	1.46	0.55	0.28	156	132	78	94	16	9	6
220	60	220	28	P	0.64	0.04	2.28	0.34	0.21	166	128	64	59	12	7	9
220	60	220	28	D	0.74	0.06	2.11	0.47	0.37	176	144	79	76	18	9	9
220	60	220	42	P	0.64	0.05	2.09	0.54	0.28	228	176	102	100	22	9	10
220	60	220	42	D	0.68	0.06	2.00	0.48	0.36	188	150	79	83	14	7	10
330	90	330	28	P	0.66	0.04	2.52	0.36	0.22	169	139	63	73	14	6	7
330	90	330	28	D	0.90	0.06	2.73	0.49	0.33	175	152	83	102	25	8	8
330	90	330	42	P	0.74	0.04	2.38	0.45	0.23	156	128	86	88	19	7	11
330	90	330	42	D	0.74	0.05	2.18	0.50	0.32	154	129	80	95	16	7	8
Significance					**	+	**	NS	**	NS	NS	NS	NS	NS	NS	**
BLSD(.05)					0.10	0.01	0.62	--	0.08	--	--	--	--	--	--	3
Factorial Statistics																
Variety																
Pioneer 3901					0.67	0.04	2.32	0.42	0.24	180	142	79	80	16	7	9
DeKalb XL12					0.76	0.05	2.25	0.49	0.34	173	143	80	89	18	8	9
Significance					**	**	NS	NS	**	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)					0.05	0.01	--	--	0.04	--	--	--	--	--	--	--
Population (plants per acre)																
28,000					0.73	0.05	2.41	0.42	0.28	171	141	72	78	17	7	8
42,000					0.70	0.05	2.16	0.50	0.30	181	146	87	92	18	9	10
Significance					NS	NS	+	+	NS	NS	NS	*	NS	NS	NS	*
BLSD(.05)					--	--	0.23	0.08	--	--	--	12	--	--	--	--
Fertility																
220+60+220					0.68	0.05	2.12	0.46	0.30	189	150	81	80	16	8	10
330+90+330					0.76	0.05	2.45	0.45	0.27	163	137	78	89	18	7	8
Significance					**	NS	*	NS	+	NS	NS	NS	NS	NS	NS	*
BLSD(.05)					0.05	--	0.27	--	0.03	--	--	--	--	--	--	1
Variety X Population																
Pioneer 3901			28		0.65	0.04	2.40	0.35	0.21	167	133	64	66	13	6	8
Pioneer 3901			42		0.69	0.05	2.24	0.50	0.26	192	152	94	94	20	8	10
DeKalb XL12			28		0.82	0.06	2.42	0.48	0.35	176	148	81	89	22	9	9
DeKalb XL12			42		0.71	0.05	2.08	0.49	0.34	171	140	80	89	15	8	9
Significance					**	NS	NS	NS	NS	NS	NS	*	NS	*	+	NS
BLSD(.05)					0.07	--	--	--	--	--	--	18	--	8	2	--
Variety X Fertility																
Pioneer 3901			220+60+220		0.64	0.05	2.19	0.44	0.25	197	152	84	80	17	8	10
Pioneer 3901			330+90+330		0.70	0.04	2.45	0.41	0.22	162	133	74	80	16	7	9
DeKalb XL12			220+60+220		0.71	0.06	2.05	0.47	0.36	182	147	79	80	16	8	10
DeKalb XL12			330+90+330		0.82	0.05	2.45	0.50	0.32	164	140	82	98	20	8	8
Significance					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)					--	--	--	--	--	--	--	--	--	--	--	--
Population X Fertility																
28			220+60+220		0.69	0.05	2.20	0.40	0.29	171	136	72	68	15	7	9
28			330+90+330		0.78	0.05	2.62	0.43	0.27	172	145	73	88	19	7	8
42			220+60+220		0.66	0.05	2.04	0.51	0.32	208	163	91	92	18	8	10
42			330+90+330		0.74	0.05	2.28	0.48	0.27	155	128	83	91	17	8	9
Significance					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)					--	--	--	--	--	--	--	--	--	--	--	--
Variety X Pop. X Fertility					+	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)					0.06	--	--	--	--	--	--	--	--	--	--	--

Table 5. Influence of fertilizer treatment, variety and plant population on the total elemental removal of corn at physiological maturity. Becker, MN - 1981.

Treatments					Total Elemental Uptake											
N	P_2O_5	K_2O	Plant pop	Variety	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
----#/A----					----#/A----											
220	0	0	28	P	155.8	22.2	125.1	35.3	30.9	1.0	1.0	0.6	0.7	0.28	0.08	0.05
220	60	220	28	P	157.0	23.8	178.8	22.3	25.6	1.1	1.0	0.5	0.4	0.25	0.06	0.08
220	60	220	28	D	171.6	25.7	176.6	32.5	38.4	1.2	1.2	0.6	0.6	0.32	0.08	0.08
220	60	220	42	P	164.9	24.0	179.5	39.6	32.8	1.6	1.4	0.8	0.8	0.33	0.08	0.09
220	60	220	42	D	172.4	25.0	181.1	36.4	39.5	1.4	1.3	0.6	0.7	0.28	0.07	0.09
330	90	330	28	P	163.6	24.9	209.8	26.4	28.6	1.2	1.2	0.5	0.6	0.30	0.06	0.07
330	90	330	28	D	189.7	26.0	224.9	36.1	36.4	1.2	1.3	0.6	0.8	0.38	0.08	0.07
330	90	330	42	P	185.6	24.5	218.9	36.0	31.1	1.3	1.2	0.7	0.8	0.34	0.08	0.10
330	90	330	42	D	171.3	23.8	192.0	40.1	36.5	1.2	1.2	0.6	0.8	0.31	0.08	0.07
Significance					*	NS	**	NS	**	NS	NS	*	NS	NS	NS	**
BLSD(.05)					23.9	--	42.1	--	5.2	--	--	0.2	--	--	--	0.02
Factorial Statistics																
Variety																
Pioneer 3901					167.8	24.3	196.7	31.0	29.6	1.3	1.2	0.6	0.6	0.30	0.07	0.09
DeKalb XL12					176.2	25.1	193.5	36.3	37.7	1.3	1.2	0.6	0.7	0.32	0.08	0.08
Significance					NS	NS	NS	NS	**	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)					--	--	--	--	2.3	--	--	--	--	--	--	--
Population (plants per acre)																
28,000					170.4	25.1	197.0	29.3	32.2	1.2	1.2	0.5	0.6	0.30	0.08	0.08
42,000					173.6	24.4	193.0	38.0	35.0	1.4	1.3	0.7	0.8	0.30	0.09	0.09
Significance					NS	NS	NS	*	*	NS	NS	**	*	NS	NS	**
BLSD(.05)					--	--	--	7.8	2.3	--	--	0.1	0.1	--	--	0.01
Fertility																
220+60+220					166.5	24.7	179.0	32.7	34.1	1.4	1.2	0.6	0.6	0.33	0.07	0.09
330+90+330					177.5	24.8	211.0	34.6	33.2	1.2	1.2	0.6	0.7	0.29	0.07	0.08
Significance					*	NS	**	NS	NS	NS	NS	NS	+	+	NS	NS
BLSD(.05)					10.4	--	20.0	--	--	--	--	--	0.1	0.03	--	--
Variety X Population																
Pioneer 3901			28		160.3	24.0	194.0	24.0	27.0	1.1	1.1	0.5	0.5	0.30	0.06	0.08
Pioneer 3901			42		175.3	24.0	199.0	38.0	32.0	1.4	1.3	0.7	0.8	0.30	0.08	0.10
DeKalb XL12			28		180.6	26.0	201.0	34.0	37.0	1.2	1.2	0.6	0.7	0.30	0.08	0.08
DeKalb XL12			42		171.8	24.0	186.0	38.0	38.0	1.3	1.2	0.6	0.7	0.30	0.08	0.08
Significance					*	NS	NS	NS	+	NS	NS	**	NS	NS	+	+
BLSD(.05)					14.8	--	--	--	1	--	--	0.1	--	--	0.01	0.01
Variety X Fertility																
Pioneer 3901			220+60+220		161.0	24.0	179.0	31.0	29.0	1.4	1.2	0.6	0.6	0.30	0.07	0.09
Pioneer 3901			330+90+330		174.6	25.0	214.0	31.0	30.0	1.2	1.2	0.6	0.7	0.30	0.07	0.09
DeKalb XL12			220+60+220		171.9	25.0	179.0	35.0	39.0	1.3	1.2	0.6	0.6	0.30	0.08	0.09
DeKalb XL12			330+90+330		180.5	25.0	208.0	38.0	36.0	1.2	1.2	0.6	0.8	0.30	0.08	0.07
Significance					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)					--	--	--	--	--	--	--	--	--	--	--	--
Population X Fertility																
28			220+60+220		164.2	25.0	177.0	27.0	32.0	1.2	1.1	0.5	0.5	0.30	0.07	0.08
28			330+90+330		176.6	25.0	217.0	31.0	32.0	1.2	1.2	0.6	0.7	0.30	0.07	0.07
42			220+60+220		168.7	25.0	180.0	38.0	36.0	1.5	1.4	0.7	0.7	0.30	0.08	0.09
42			330+90+330		178.4	24.0	205.0	38.0	34.0	1.2	1.2	0.7	0.8	0.30	0.08	0.09
Significance					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)					--	--	--	--	--	--	--	--	--	--	--	--
Variety X Pop. X Fertility					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)					--	--	--	--	--	--	--	--	--	--	--	--

Table 6. Influence of fertilizer treatment, variety, and plant population on yield and elemental concentration of the first mature soybean trifoliate on July 28th. Becker, MN - 1981.

Treatments					Yield	Leaf Elemental Concentration											
N	P_2O_5	K_2O	Plant pop	Variety	Bu/A	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
----#/A----						----------%----------					----------ppm----------						
0	0	0	5	H	56.8	5.52	0.55	2.54	1.08	0.46	18	122	14	114	48	11	46
0	60	220	5	H	60.0	5.43	0.55	2.56	1.00	0.45	18	127	12	114	48	11	63
0	60	220	5	E	57.8	5.49	0.49	2.43	0.90	0.36	24	120	31	104	47	11	56
0	60	220	10	H	63.1	4.76	0.46	2.41	0.96	0.43	25	122	26	114	44	10	60
0	60	220	10	E	61.6	5.56	0.51	2.53	0.94	0.39	20	112	18	110	49	10	55
0	90	330	5	H	63.6	5.25	0.55	2.64	1.00	0.45	21	127	18	120	49	11	62
0	90	330	5	E	60.2	5.75	0.52	2.78	0.96	0.36	18	123	9	119	48	10	59
0	90	330	10	H	62.9	4.96	0.49	2.56	0.97	0.43	25	126	31	127	47	10	63
0	90	330	10	E	57.5	5.11	0.47	2.55	0.91	0.36	23	115	30	116	47	10	57
Significance					+	*	NS	NS	**	**	NS	NS	NS	**	NS	NS	**
BLSD(.05)					5.6	0.62	--	--	0.06	0.07	--	--	--	9	--	--	8
Variety																	
Hodgson-78					62.4	5.10	0.51	2.54	0.98	0.44	22	126	22	119	47	11	62
Exp. #II-68-176					59.3	5.48	0.50	2.57	0.93	0.37	21	117	22	112	48	10	57
Significance					*	**	NS	NS	**	**	NS	*	NS	*	NS	NS	*
BLSD(.05)					2.4	0.26	--	--	0.03	0.31	--	7	--	5	--	--	4
Population																	
5 plant/ft					60.4	5.48	0.53	2.59	0.96	0.40	20	124	17	114	48	11	60
10 plant/ft					61.3	5.10	0.48	2.51	0.95	0.40	23	119	26	117	47	10	59
Significance					NS	**	NS	NS	NS	NS	NS	+	NS	NS	NS	NS	NS
BLSD(.05)					--	0.26	--	--	--	--	--	6	--	--	--	--	--
Fertility																	
0+60+220					60.6	5.31	0.50	2.48	0.95	0.41	22	120	22	110	47	10	58
0+90+330					61.1	5.27	0.51	2.62	0.96	0.40	22	122	22	121	48	10	60
Significance					NS	NS	NS	*	NS	NS	NS	NS	NS	**	NS	NS	NS
BLSD(.05)					--	--	--	0.12	--	--	--	--	--	5	--	--	--
Variety X Population																	
Hodgson-78			5/ft		61.8	5.34	0.55	2.60	1.00	0.45	20	127	15	117	48	11	62
Hodgson-78			10/ft		63.0	4.86	0.47	2.48	0.97	0.43	25	124	28	120	46	10	62
Exp.#II-68-176			5/ft		59.0	5.62	0.50	2.59	0.93	0.36	21	121	20	112	48	10	58
Exp.#II-68-176			10/ft		59.6	5.34	0.49	2.54	0.92	0.37	22	113	24	113	48	10	56
Significance					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)					--	--	--	--	--	--	--	--	--	--	--	--	--
Variety X Fertility																	
Hodgson-78			0+60+220		61.6	5.10	0.50	2.48	0.92	0.44	22	125	19	114	46	11	62
Hodgson-78			0+90+330		63.3	5.11	0.52	2.60	0.99	0.44	23	126	24	124	48	11	62
Exp.#II-68-176			0+60+220		59.7	5.52	0.50	2.48	0.92	0.38	22	116	24	107	48	10	56
Exp.#II-68-176			0+90+330		58.9	5.43	0.49	2.63	0.93	0.36	20	119	20	118	48	10	58
Significance					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)					--	--	--	--	--	--	--	--	--	--	--	--	--
Population X Fertility																	
5/ft			0+60+220		58.9	5.46	0.52	2.49	0.95	0.40	21	124	21	109	47	11	59
5/ft			0+90+330		62.0	5.50	0.53	2.70	0.98	0.40	19	125	14	120	49	11	60
10/ft			0+60+220		62.4	5.16	0.48	2.47	0.95	0.41	22	117	22	112	47	10	58
10/ft			0+90+330		60.2	5.04	0.48	2.55	0.94	0.39	24	120	30	122	47	10	60
Significance					*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)					3.4	--	--	--	--	--	--	--	--	--	--	--	--
Variety X Population X Fertility																	
Significance					NS	*	NS	NS	NS	NS	+	NS	NS	NS	NS	NS	NS
BLSD(.05)					--	0.37	--	--	--	--	5	--	--	--	--	--	--

MICRONUTRIENT FERTILIZATION OF POTATOES AND CORN UNDER IRRIGATION

G.L. Malzer, T. Graff 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 capactives 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 at the Sand Plains Research Farm at Becker, MN. to assess the significance of certain plant nutrients other than N,P, and K on yield and nutrient composition of the plant tissue for potatoes and corn.

Experimental Procedures

Seven treatments, including a control, four micronutrient treatments, and two macronutrient treatments were established in a randomized complete block design with four replications. Rates and types of fertilizer included: 5 lbs. of Copper/A as $C_4SO_4 \cdot 5_2O$, 2 lbs of Boron/A as Solubor, 25 lbs. of Sulfur/A as $CaSO_4$, 75 lbs. of Magnesium as $MgCl_2$, 10 lbs of Zinc/A as $ZnCl_2$ and 3 lbs. of Manganese/A as $MnCl_2$. Application of materials were made to the same plots as was applied in 1978, 1979, and 1980. The corn and potatoes areas were rotated in 1981 so the corn was planted into the 1980 potato area (eight replications) and potatoes were planted into the corn areas, (four replications of each variety).

Fertilizer treatments were applied, incorporated by plowing on April 17th and the potatoes planted on April 23rd. Norlands were planted in 9 inch spacings utilizing 36 inch rows, while Russet Burbanks were planted in 12 inch spacings with the same row width. At the time of planting, starter was used at the rate of 1050 lbs/A of 8-10-30 and a insecticide, Temik 15 G was banded at planting time. Lorox herbicide was applied May 30th at 2#/A (in 53 gal/A spray) for weed control. Sidedressing treatments of nitrogen were made on June 26th (240 lbs/A 34-0-0) and on July 8th (250 lbs/A 34-0-0), along with hilling at the last sidedressing. Samples of the youngest mature potato leaves were obtained 70 days after planting for nutrient composition. The Norland potatoes were harvested on August 28th and the Russet Burbanks on September 23. Irrigation water was applied during the period of May 19th through August 19th with a total addition of 9.75 inches. Precipitation during the period of May-August was 15.28 inches and May-September was 15.55 inches. Utilizing the 1980 potato experimental area, eight replications of the aforementioned treatments were planted to corn. The experimental area had been fertilized with 800 lbs/A 8-10-30 prior to planting on April 27th. A commerical 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 banded at planting. Lasso at (2 #/A ai) was used for weed control. Sidedressing applications of nitrogen were made on June 2nd (240 lbs/A 34-0-0) and June 17th (300 lbs/A 34-0-0) for the season. Leaf samples from opposite and below the ear at mid-silking were taken on July 20th, dried, ground, and analyzed for elemental content. Total dry matter production was determined on September 22nd by hand harvesting 50 ft^2. Ears were separated from the stalks, field weights obtained, and samples removed for moisture determination and elemental content. Corn grain yields were taken on October 12th by hand harvesting 100 ft^2. Grain yields were adjusted to 15.5% moisture. The irrigation program was started on May 19th and continued through September 10th with a total of 11.75 inches of water being applied through irrigation. An additional 17.03 inches of water was obtained during the growing season through rainfall.

General Results

This concludes the fourth consecutive year for the establishment of these plots on the same experimental area. Yields from the experimental area were somewhat reduced from the yields which have been obtained in the past. The lowered potato yields especially, may at least partially explain why no response was obtained to the application of any of the treatments. The corn grain yields although good did not suggest any positive response to the addition of the secondary or micronutrients applied. Elemental concentrations within the plant tissue did reflect, in certain cases, the application of zinc, boron, and copper. Zinc and boron application in the past have provided small positive yield responses. If yield levels would have been higher perhaps yields responses would have been obtained. These experiments will be rotated and conducted again in 1982.

Table 1. Influence of micronutrient fertilizer (also Mg and S) on tuber yield and nutrient concentration of the youngest mature leaves 70 days following planting for Norland and Russet Burbank potatoes.

Treatment	rate/A	Tuber Yield	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
			Norland Potatoes											
			Leaf Concentration											
	#/A	cwt/A	%					ppm						
Control	-	378	4.86	0.36	6.14	1.15	.439	109	159	38	280	18	6	35
Cu	5	364	5.10	0.37	5.89	1.27	.488	112	162	38	312	22	14	39
B	2	380	5.11	0.35	5.78	1.14	.435	94	145	32	296	18	5	38
S	25	360	5.01	0.36	5.94	1.15	.396	99	149	35	355	22	8	34
Mg	75	392	5.05	0.36	5.90	1.14	.604	95	153	37	218	20	6	35
Zn	10	378	5.17	0.38	5.88	1.25	.488	128	184	35	339	30	9	34
Mn	3	365	5.26	0.38	6.18	1.30	.536	106	164	36	270	23	9	34
Significance		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**	**	NS
BLSD (.05)		-	-	-	-	-	-	-	-	-	-	6	3	-
			Russet Burbank Potatoes											
Control	-	366	5.21	0.42	5.63	0.69	.447	63	108	28	220	22	6	29
Cu	5	342	5.31	0.42	5.83	0.71	.432	60	109	48	225	24	12	32
B	2	380	5.47	0.40	5.63	0.72	.413	67	110	31	229	19	5	31
S	25	368	5.29	0.40	5.63	0.69	.416	69	116	34	259	21	6	29
Mg	75	378	5.24	0.42	5.18	0.60	.494	54	102	29	162	22	7	27
Zn	10	355	5.46	0.42	5.54	0.73	.453	72	120	31	225	28	7	32
Mn	3	335	5.31	0.44	5.32	0.71	.481	51	106	33	201	24	8	31
Significance		NS	NS	NS	NS	**	NS	NS	NS	+	NS	NS	*	**
BLSD (.05)		-	-	-	-	0.06	-	-	-	16	-	-	4	3

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

Treatment	rate/A	Harvest Grain Yield 15.5%	Harvest Grain Dry Matter	Harvest Grain N removal	Dry Matter Production (Phsiological Maturity) Stover	Grain	Cob	Total
	#/A	bu/A	%	#/A	T/A			
Control	-	182.9	71.0	113.9	3.20	4.41	0.57	8.18
Cu	5	186.7	70.7	114.9	3.23	4.31	0.58	8.11
B	2	185.0	70.4	116.5	3.42	4.40	0.59	8.41
S	25	182.2	70.6	114.9	3.43	4.48	0.61	8.50
Mg	75	189.1	70.5	119.5	3.08	4.18	0.56	7.83
Zn	10	182.5	70.8	113.6	3.59	4.41	0.59	8.59
Mn	3	185.2	70.2	114.2	3.42	4.47	0.59	8.49
Significance		NS	NS	NS	*	NS	NS	*
BLSD(.05)		-	-	-	0.31	-	-	0.52

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

		Elemental Concentration											
		Silage Stover											
Treatment	rate/A	N	P	K	Ca	Mg	Al	Fe	Na	MN	Zn	Cu	Bu
	#/A	%					ppm						
Control	-	0.65	0.06	2.29	0.36	0.14	148	149	66	62	8	7	7
Cu	5	0.56	0.04	2.36	0.28	0.13	139	128	50	47	7	7	6
B	2	0.56	0.05	2.39	0.34	0.12	136	123	57	65	8	6	10
S	25	0.58	0.04	2.42	0.36	0.14	156	146	59	59	7	6	8
Mg	75	0.54	0.04	2.37	0.30	0.14	147	134	52	54	7	6	8
Zn	10	0.60	0.04	2.40	0.36	0.14	154	139	56	52	21	6	7
Mn	3	0.56	0.04	2.58	0.30	0.11	130	120	54	51	7	6	8
Significance		NS	NS	NS	NS	NS	NS	NS	*	NS	**	NS	**
BLSD (.05)		-	-	-	-	-	-	-	11	-	3	-	2
		Silage Grain											
Control	-	1.34	0.28	0.37	0.002	0.13	1	21	8	6	18	2	2
Cu	5	1.32	0.27	0.37	0.002	0.13	2	20	11	6	17	2	2
B	2	1.35	0.28	0.38	0.002	0.13	1	21	9	6	18	2	3
S	25	1.33	0.28	0.38	0.002	0.13	1	21	8	6	18	2	2
Mg	75	1.35	0.29	0.39	0.002	0.14	2	22	10	6	19	2	2
Zn	10	1.30	0.28	0.38	0.002	0.14	1	23	8	6	25	2	2
Mn	3	1.34	0.28	0.38	0.002	0.13	1	21	9	6	18	2	2
Significance		NS	NS	NS	NS	NS	NS	*	NS	NS	**	NS	**
BLSD (.05)		-	-	-	-	-	-	2	-	-	1	-	1
		Leaf											
Control	-	2.96	0.38	2.82	0.62	0.29	55	136	72	112	23	11	6
Cu	5	2.96	0.37	2.78	0.55	0.27	50	126	72	108	22	13	6
B	2	2.84	0.37	2.86	0.56	0.25	50	129	74	112	23	10	7
S	25	3.00	0.38	2.79	0.60	0.27	59	139	74	113	23	10	6
Mg	75	2.81	0.37	2.83	0.53	0.30	56	132	87	109	24	10	6
Zn	10	2.99	0.37	2.75	0.58	0.29	54	133	81	96	43	11	6
Mn	3	2.95	0.38	2.82	0.60	0.27	56	137	77	115	24	11	6
Significance		NS	NS	NS	+	NS	NS	NS	NS	NS	**	**	*
BLSD (.05)		-	-	-	0.06	-	-	-	-	-	2	1	1

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

		TOTAL ELEMENTAL REMOVAL											
		Silage Stover											
Treatment	rate/A	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	#/A	lbs/A											
Control	-	48.6	4.1	174	26.8	10.4	1.1	1.1	0.49	0.47	0.06	0.05	0.05
Cu	5	42.6	3.3	180	21.4	9.7	1.1	1.0	0.38	0.36	0.05	0.05	0.05
B	2	44.6	4.0	192	27.0	9.8	1.1	1.0	0.46	0.52	0.06	0.05	0.08
S	25	46.6	3.6	196	29.0	11.0	1.2	1.2	0.47	0.48	0.06	0.05	0.06
Mg	75	39.4	3.0	173	22.1	10.3	1.1	1.0	0.38	0.39	0.05	0.04	0.06
Zn	10	51.0	3.6	204	29.8	11.8	1.3	1.2	0.46	0.44	0.18	0.05	0.06
Mn	3	45.4	3.2	208	23.6	9.0	1.0	1.0	0.43	0.41	0.06	0.05	0.06
Significance		+	NS	NS	*	NS	NS	NS	*	NS	**	NS	**
BLSD(.05)		7.9	-	-	6.6	-	-	-	0.08	-	0.03	-	0.02
		Silage Grain											
Control	-	117.8	24.3	33	0.14	11.6	0.01	0.18	0.07	0.05	0.16	0.02	0.02
Cu	5	113.9	23.2	32	0.14	11.0	0.02	0.17	0.09	0.05	0.15	0.02	0.02
B	2	118.7	24.4	33	0.16	11.4	0.01	0.19	0.08	0.05	0.16	0.02	0.03
S	25	119.1	25.0	34	0.17	11.8	0.01	0.19	0.07	0.05	0.16	0.02	0.03
Mg	75	112.9	24.1	33	0.15	11.8	0.01	0.18	0.08	0.05	0.16	0.02	0.02
Zn	10	115.0	25.0	34	0.17	12.1	0.01	0.20	0.07	0.05	0.22	0.02	0.02
Mg	3	120.0	25.1	34	0.16	11.8	0.01	0.18	0.08	0.05	0.16	0.02	0.02
Significance		NS	NS	NS	NS	NS	NS	**	NS	NS	**	NS	**
BLSD(.05)		-	-	-	-	-	-	0.02	-	-	0.01	-	0.01
		TOTAL											
Control	-	166.4	28.5	206	27.0	22.0	1.12	1.30	0.57	0.52	0.22	0.07	0.07
Cu	5	156.5	26.4	212	21.6	20.7	1.09	1.16	0.47	0.41	0.20	0.07	0.07
B	2	163.3	28.4	226	27.2	21.2	1.10	1.17	0.53	0.57	0.22	0.07	0.10
S	25	165.7	28.7	230	29.2	22.8	1.27	1.37	0.54	0.53	0.22	0.07	0.08
Mg	75	152.3	27.1	206	22.2	22.1	1.10	1.17	0.46	0.44	0.22	0.06	0.08
Zn	10	166.0	28.7	238	30.0	23.9	1.31	1.37	0.53	0.49	0.40	0.07	0.08
Mn	3	165.4	28.3	242	23.8	20.8	1.06	1.15	0.51	0.46	0.22	0.06	0.08
Significance		NS	NS	NS	*	NS	NS	NS	NS	NS	**	NS	**
BLSD(.05)		-	-	-	6.6	-	-	-	-	-	0.03	-	0.02

CORN AND SUNFLOWER YIELDS WITH VARYING LEVELS OF SOIL TEST K

C. J. Overdahl and Michael O'Leary

Relatively low soil test K has produced surprisingly high crop yields when under irrigation. This has been demonstrated with aflalfa at Staples as well as with corn and sunflowers at Becker.

Sunflowers were grown at Becker in 1979. In 1980 corn was planted on this site and a sunflower plot was established at an adjacent area previously in rye. In 1981 crops were reversed at these 2 sites.

Potash treatments of 0, 60, 120, 180, 240 and 300 were used in 1979 and the 300 pound treatment was increased to 480 pounds of K_2O for 1980 and 1981 on both experimental areas.

In table 1 the area labelled "B plots" was the initial area where sunflowers were grown in 1979 and the "A plots" was the area established in 1980. This table shows the effect of potash treatments on yields of two crops. Most years the first 60 pounds per acre of K_2O was sufficient for best yields.

Table 2 shows the effect by years on the K soil test level. Soil tests as low as 54 gave good yields. Soil tests down to 3 feet were very low. Evident in table 2 is that soil test increases are very slow. At the highest K rate of 1260 pounds over three years the test increased to 232 and 201 pounds in the two plot areas respectively.

At the Staples irrigation farm alfalfa yielded over 5 tons per acre with a soil test of less than 50 pounds per acre of exchangeable K. The subsoil K was also very low. The irrigation water has no appreciable amounts of potassium.

Plant analysis data in table 3 show that the first 60 pounds of K_2O come close to bringing the plant tissue to the sufficiency levels of 3% for sunflowers and 1.7% for corn.

The evidence from the two irrigation farms point to what could be an interesting student thesis project.

Table 1. Corn and sunflower yields rotated on two adjacent plots Becker, Minnesota, 1979, 1980 and 1981.

K_2O lbs/acre[1]			Yields of Sunflowers and Corn					
			A plots (South)			B plots (North)		
1979	1980	1981	1979 rye	1980 flowers lbs.	1981 corn bu	1979 flowers lbs.	1980 corn bu	1981 flowers lbs.
0	0	0	-	1292	164	1277	161	1416
60	60	60	-	1588	186	1965	190	1814
120	120	120	-	1765	182	2017	198	2022
180	180	180	-	1866	187	2082	195	1990
240	240	240	-	1725	191	2172	193	1914
300	480	480	-	1906	182	2033	197	1904
Significance				*	*	**	**	**
BLSD (.05)				345	14	220	18	200
C.V.				12.6	4.9	7.6	6.4	7.4

[1]Additional fertilizer for corn annually
0 + 50 + 0 broadcast (plow down)
18 - 46 - 0 at 160#/acre as starter
75 + 0 + 0 side dressed at 8 leaf stage
100 + 0 + 0 side dressed at 12 leaf stage

Additional fertilizer for sunflowers annually
60 + 40 + 0 preplant
60 + 0 + 0 July 1
18 - 46 - 0 at 160#/acre in row

Table 2. Soil test K for corn and sunflower plots from two adjacent sites. Becker, Minnesota, 1979, 1980 and 1981.

K_2O lbs/acre			Soil Test K, lbs/acre					
			A plots (South)			B plots (North)		
1979	1980	1981	1979 rye	1980 flowers	1981 corn	1979 flowers	1980 corn	1981 flowers
0	0	0	-	42	63	63	36	71
60	60	60	-	54	85	69	44	94
120	120	120	-	60	97	76	58	85
180	180	180	-	72	107	86	80	108
240	240	240	-	67	142	87	109	128
300	480	480	-	104	232	91	142	201

Table 3. Potassium plant analysis from corn and sunflower rotation on two adjacent plots. Becker, Minnesota, 1979, 1980 and 1981.

			%K in plants[1]					
			A plots (South)			B plots (North)		
1979	1980	1981	1979 rye	1980 flowers	1981 corn	1979 flowers	1980 corn	1981 flowers
0	0	0	-	2.76	1.27	2.60	1.05	2.50
60	60	60	-	2.94	1.67	2.77	1.54	3.14
120	120	120	-	3.19	1.96	2.90	1.93	3.51
180	180	180	-	3.43	2.13	3.01	2.28	3.56
240	240	240	-	3.74	2.27	3.27	2.98	4.05
300	480	480	-	4.28	2.64	3.28	2.41	4.70
Significance				**	**	**	**	**
BLSD (.05)				.37	.27	.30	.27	.68
C.V.				7.7	9.8	6.8	9.9	13.0

[1]Corn-leaf opposition and below ear
Sunflower - 5th leaf

SOIL TEST LAB COMPARISON ON IRRIGATED CORN - BECKER, 1981

W. E. Jokela and M. O'Leary

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

Experimental Procedures

The experiment was established on a Hubbard loamy sand at the Sand Plains Irrigation Farm at Becker, MN. A composite sample was taken in the fall on 1979. The samples were dried, thoroughly mixed, and divided into five subsamples which were sent to five soil testing labs, including the University of Minnesota. A fertilizer recommendation was requested for a 200 bu/acre yield of corn under irrigation. Fertilizer as recommended by each of the five labs was applied in the spring before plowing. The sixth treatment was a no-fertilizer check. Experimental design is randomized complete block with four replications.

After harvest of the 1980 crop, separate samples were taken from each treatment (soil testing lab) and sent to the corresponding soil testing lab for analysis and fertilizer recommendations. The same procedure was followed as in the previous year. In 1981 Pioneer 3901 variety was planted at a population of 30,700 on May 5. Earleaf samples were taken at early silking and two twenty foot rows per plot were harvested for grain at maturity.

Results and Discussion

Soil test results and fertilizer recommendations are shown in Table 1 and 2. Recommended N rates were quite similar, but there were substantial differences in amounts of P and K and in which secondary and micronutrients were recommended.

Elemental analysis of earleaf are given in Table 3. K and Zn shown some variation between lab treatments, but for other elements only the check was significantly different.

Grain yield, grain moisture, and an economic comparison are shown in Table 4. Grain yields varied from 158 to 171 bu/acre, compared to 86 bu/acre on the check. The cost of fertilizer recommended by the various labs ranged from $95 to $127/acre, a considerably smaller range than in 1980 ($81 to $144/acre). The return over cost for the five fertilizer programs varied by only about $19, and all were substantially higher than the no fertilizer check.

Table 1. Soil test results after one year fertilization and cropping. Becker, MN Fall, 1980.

Test	Soil Test Results[1] Lab A	Lab B	Lab C	Lab D	Lab E (U.M.)	Check
pH	6.5	6.2	7.0	6.7	6.4	6.6
Buffer Index	---	6.9	---	7.1	---	---
Phosphorus (Bray 1)	20	26 H	20 VH		8	12
Potassium	10	77 M	68 M	70 L	23	28
Calcium	1100	850 M	2200 M	1000		
Magnesium	220	149 VH	370 M	250		
Sulfur	11	5 L	19 Adq.	19.2	1	8
Iron	25.5	27 VH	17 H	8+		
Manganese	5.5	9 M	4.4 M	2+		
Zinc	3.9	1.8 M	1 VL	2.0	1.1	.6
Copper	.6	.8 L	0.5 H	.4+		
Boron	.3	.8 L		.6 L		
Nitrate-N (0-6")	4		3			
Organic Matter (%)	1.7	1.7 L	ML	1.6	2.0	1.9
C.E.C. (meg/100g)	7.5	6.5		7.3		

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

Table 2. Fertilizer recommendations from 5 soil testing labs for 200 bu/acre irrigated corn following corn. Becker, MN 1981.

Nutrient	Fertilizer Recommended Lab A	Lab B	Lab C	Lab D	Lab E (U.M.)
	----------lb/acre----------				
Nitrogen[1]	265	280	243	240	220
Phosphorus (P_2O_5)	110[2]	65	139	87	110
Potassium (K_2O)	285[2]	190	364	352	240
Sulfur	30	25			20
Zinc		2.5	10		
Manganese		2			
Copper		1.5			
Boron	1.5	1		0.5	
Lime (CCE)		900			

[1]N was split into 3 applications - ¼ preplant, ¼ at 8-leaf, ½ at 12-leaf.

[2]Includes maintenance plus ½ of suggested build rate.

Table 3. Elemental analysis of earleaf at early silking as influenced by fertilization programs from different labs. Becker, MN 1981.

Elemental Analysis of Earleaf

Lab	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	----------%----------					----------ppm----------						
A	3.10	.33	2.46	.46	.30	28	104	53	44	23.6	8.5	6.6
B	3.08	.30	2.44	.45	.33	28	101	52	46	28.0	10.1	9.2
C	3.05	.33	2.66	.43	.25	28	103	49	41	21.1	8.8	7.9
D	3.07	.33	2.64	.42	.28	28	104	52	42	21.3	8.0	7.2
E (UM)	3.17	.31	2.34	.47	.32	28	107	48	46	22.3	8.9	8.4
Check	1.96	.29	2.11	.44	.38	30	78	38	32	17.4	7.0	10.5
Signif.	**	**	**	ns	**	ns	**	+	**	**	ns	ns
BLSD (.05)	.22	.02	.12	-	.06	-	6	10	7	2.7	-	-
C.V.	5.3	4.9	3.6	8.4	11.6	7.0	4.4	14.4	10.0	8.6	6.9	31.8

Table 4. Corn grain yield, grain moisture at harvest, and economic return over fertilizer costs for six fertilization programs. Becker, MN 1981.

Lab	Grain Yield	Grain Moisture	Crop Value @ $2.40/bu	Fertilizer[1] Cost	Return Over Fertilizer Cost
	-----bu/acre---------		----------$/acre----------		
A	158.2	32.5	379.68	112.55	267.13
B	162.6	32.0	390.24	104.61	285.63
C	171.2	32.1	410.88	127.42	283.46
D	159.8	32.8	383.52	104.46	279.06
E (UM)	158.9	31.8	381.36	95.30	286.06
Check	86.4	38.2	207.36	0	207.36
Signif.	**	**			
BLSD (.05)	12.6	2.81			
C.V.	6.0	5.6			

[1]Fertilizer prices used (5/1/81, $/lb): N = .15, P_2O_5 = .25, K_2O = .13, S = .18, Zn = .89, Mn = 1.04, Cu = 2.80, B = 1.90.

1981 WEATHER

1981 was the second warmest year in the past 92-year history of climatological data for Crookston. Above normal precipitation combined with the warm temperatures produced excellent crop yields for 1981. Following a very mild winter, spring arrived early in the Red River Valley. The shallow snow pack began thawing in mid-February with 40 degree temperatures and was completely melted by mid-March. Field preparation for the 1981 growing season commenced the first part of April although there were some reports of farmers seeding as early as March 20. The last spring frost was recorded on May 10 (22°F) which initiated a 141-day growing season ending September 28 (28°F) when the first fall frost occurred. The normal frost-free period for Crookston (temperature 32°F) is 125 days. Nine daily maximum temperature records were set in 1981 and two records were equaled. Four daily precipitation records were also surpassed in 1981. The new weather records are listed in the tables below.

Table 1.

New Record High Temps.		Previous Record High Temps.	
1-24-81	48°	1-24-44	45°
2-14-81	42°	2-14-35	40°
2-16-81	49°	2-16-31	46°
2-17-81	47°	2-17-71	41°
2-18-81	42°*	2-18-30	42°*
2-21-81	47°*	2-21-30	47°*
3-11-81	46°	3-11-02	53°
3-14-81	58°	3-14-35	52°
3-16-81	59°	3-16-10	57°
11-12-81	61°	11-12-34	58°
11-13-81	60°	11-13-73	55°

*Previous year with the same temperature.

Table 2. Average Annual Mean Temperature

1981	1931	90-Yr Average
43.6°	45.0°	39.4°

Table 3.

New Record Daily Precip.		Previous Record Daily Precip.	
5-24-81	1.01"	5-24-43	0.80"
9-06-81	1.81"	9-06-69	1.27"
9-23-81	1.07"	9-23-64	0.90"
10-12-81	0.90"	10-12-30	0.61"

The precipitation for 1981 totaled 24.85 inches of which 23.59 inches were recorded as rain and 1.26 inches of precipitation were contained in 23.1 inches of snow. The water equivalent of the snow for 1981 was .05 inches/1 inch of snow. 65% of the total precipitation (15.87 inches) was recorded during the growing season April 1-Sept. 30. As indicated in Table 4, January, March, April, November and December had slightly below normal precipitation while the remaining months had above normal precipitation. June through October precipitations were 2/3 inches to 1½ inches above normal. For the year, Crookston was 4.18 inches above normal in regard to total precipitation. The 1981 precipitation patterns were very erratic with the Red Lake Falls reporting station located 18 miles northeast of Crookston recording 25.86 inches for the months June through September (12.11 inches above normal) and 36.40 inches for the year (14.11 inches above normal).

Table 4 also lists the mean monthly and annual temperatures for Crookston. June, October, and December were the only months recording mean temperatures lower than normal. January, February, March and November averaged about 10 degrees warmer than normal which account for 1981 being the second warmest year since the weather records were initiated in 1890. The mean yearly temperature for 1981 was 43.6°F which is 4.2°F warmer than the 90-year average of 39.4°F. The only other warmer year since 1890 was 1931 with a mean annual temperature of 45.0°F.

Table 4. Weather summary for 1981 with averages for precipitation and mean temperatures - 1890-1979.

	Precipitation (Inches)					Mean Temperatures (°F)	
Month	Snow	Precip.	Rain	Total	1890-1979	1981	1890-1979
January	5.1	.20	--	.20	.56	13.6	3.7
February	7.0	.56	.09	.65	.59	19.8	8.1
March	0.2	T	.63	.63	.84	33.3	22.9
April	--	--	1.26	1.26	1.57	46.1	41.4
May	--	--	2.63	2.63	2.59	56.0	54.6
June	--	--	4.95	4.95	3.56	62.7	64.4
July	--	--	3.72	3.72	3.09	69.9	69.6
August	--	--	3.69	3.69	2.90	69.7	67.4
September	--	--	3.60	3.60	2.16	58.4	51.5
October	0.5	.02	2.71	2.73	1.43	44.9	45.3
November	3.1	.21	.31	.52	.78	36.7	26.7
December	7.2	.27	--	.27	.60	10.9	11.5
Total	23.1	1.26	23.59	24.85	20.67	43.6	39.4

STARTER FERTILIZER STUDY--SPRING WHEAT

G.E. Varvel and H. Meredith

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

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

Carriers: 1) urea phosphate (17-44-0), 2) diammonium phosphate (18-46-0), 3) cogranulated-urea-urea phosphate (38-13-0) + superphosphate (0-44-0) to give (25-50-0), 4) urea phosphate (17-44-0) + UAN solution (28-0-0) to give (13-28-0), and 5) ammoniated phosphoric acid (10-34-0) + UAN solution (28-0-0) to give (13-28-0).

P Rate: 50 and 100 lb P_2O_5/A.

Methods: All treatments were applied with the seed. The test variety was era and all treatments (seeding + fertilizer) were applied on May 1, 1981. Emergence (stand counts) were taken on May 21, 1981. Whole plant samples were taken at late tillering (June 16, 1981) and maturity (July 27, 1981). Grain harvest was taken August 10, 1981. Soil test data for the study which was located on a Wheatville loam were: O.M.-3.6, pH-7.9, $NaHCO_3$ P-20 lb/A, exchangeable K-322 lb/A, and NO_3-N.-160 lb/A-2'.

Results:
Early plant and forage analyses as affected by the treatments are shown in Table 1. Phosphorus (early plant) and N (forage) were significantly increased as the P rate increased.

Table 1. The effect of starter fertilizer on elemental analyses of spring wheat at late tillering and maturity.

	Elemental Analyses					
	Early Plant (Late Tillering)			Forage (Maturity)		
Carrier	N	P	K	N	P	K
	%			%		
1 (18-44-0)	4.30	.44	4.56	1.48	.21	1.33
2 (18-46-0)	4.37	.44	4.45	1.55	.23	1.27
3 (25-50-0)	4.16	.45	4.49	1.43	.20	1.36
4 (13-28-0)	4.31	.44	4.38	1.47	.20	1.32
5 (13-28-0)	4.28	.45	4.47	1.48	.21	1.45
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	5.0	3.4	6.1	9.1	18.1	16.7
P Rate lb/A						
50	4.22	.43	4.43	1.44	.20	1.36
100	4.35	.45	4.51	1.52	.22	1.34
Significance	N.S.	**	N.S.	*	N.S.	N.S.
B.L.S.D. (.05)						
C.V. (%)	5.0	3.4	6.1	9.1	18.1	16.7

Forage yield, N and P uptake, grain yield, protein, bushel weight, and plant population (early stand counts) as affected by the treatments are shown in Table 2. Grain yield was significantly reduced as P rate increased and plant population was significantly different between carriers. A significant interaction between carrier and P rate was obtained with respect to forage yield (Table 2).

Table 2. The effect of starter fertilizer on forage yield, P and N uptake, grain yield, protein, test weight, and plant population.

Carrier	Rate P_2O_5	Rate N	Forage T.D.M. Yield	Forage P	Forage N	Grain Yield	Grain Protein	Grain Test Weight	Plant Population
	- - - - - - -		lb/A - - - - - - -			Bu/A	%	lb/Bu	Plants/A
18-44-0	50	20	7184	14.7	105	41.8	13.1	56.4	1,071,600
	100	40	6851	14.8	102	39.4	12.9	56.4	1,050,700
18-46-0	50	20	6514	15.3	100	44.3	12.8	56.4	1,006,300
	100	40	6926	16.4	110	40.6	13.0	55.7	1,035,900
25-50-0	50	25	6841	13.6	97	40.9	13.0	56.3	1,110,000
	100	50	7067	13.6	101	39.6	12.8	56.7	1,121,300
13-28-0	50	24	7453	13.4	101	42.6	13.0	56.2	1,095,200
	100	48	6641	14.4	105	38.7	13.4	55.5	1,095,200
13-28-0	50	24	7502	15.0	107	42.0	13.0	56.8	1,161,400
	100	48	6572	14.8	100	39.1	13.2	55.2	1,078,600
Significance			**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)			6.0	19.1	10.6	7.7	2.3	2.2	6.6
Carrier									
1			7018	14.7	104	40.6	13.0	56.4	1,061,200
2			6720	15.8	105	42.4	12.9	56.0	1,021,100
3			6954	13.6	99	40.2	12.9	56.5	1,115,600
4			7047	13.9	103	40.6	13.2	55.8	1,095,200
5			7037	14.9	103	40.6	13.1	56.0	1,120,000
Significance			--	N.S.	N.S.	N.S.	N.S.	N.S.	*
B.L.S.D. (.05)									83,200
P Rate lb/A									
50			7099	14.4	102	42.3	13.0	56.4	1,088,900
100			6811	14.8	104	39.5	13.1	55.9	1,076,300
Significance			--	N.S.	N.S.	**	N.S.	N.S.	N.S.
B.L.S.D. (.05)									

Discussion: The interaction between carrier and P rate was obtained because with carriers 1, 4 and 5 forage yield was reduced as P rate increased, while with carriers 2 and 3 forage yield increased with P rate. Generally, N levels were too high for optimum production which may have caused some lodging at the higher P rates which had higher N rates, but this should have occurred with all carriers. The cause of the interaction is unclear. The significant increase of N in the forage was caused by the additional N in the treatments, not the P.

The significant difference in plant population between carriers did not cause any differences in yield. No reduction in plant population was obtained, even though N levels in excess of 40 lb/A were applied with the seed. Excellent soil moisture at planting probably negated the effect of the high N levels. Further studies will be used to evaluate these carriers.

BROADCAST FERTILIZER STUDY--SPRING WHEAT

G.E. Varvel and H. Meredith

Objective: To evaluate experimental N carriers on a highly calcareous soil.

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

Carriers: 1) cogranulated urea-urea phosphate (38-13-0), 2) cogranulated urea-urea phosphate (34-17-0), 3) urea-ammonium phosphate (28-28-0), 4) urea phosphate (18-44-0), and 5) urea phosphate (18-44-0) + UAN (28-0-0) to give (15-28-0).

N Rate: 30 and 60 lb N/A.

Methods: The treatments were applied May 1, 1981 on a Wheatville loam soil and incorporated with a field cultivator. Phosphorus rates were equalized between treatments with super phosphate (0-44-0). Era wheat was planted that same day. Stand counts (plant population) were taken May 21, 1981. Whole plant samples were taken at late tillering (June 16, 1981) and maturity (July 27, 1981) to measure the relative N efficiency of the carriers. Grain was harvested August 10, 1981. Soil test data for the study were: O.M.-3.6, pH-7.9, NO_3-N.-160 lb/A, $NaHCO_3$ P-20 lb/A, and exchangeable K-322 lb/A.

Results: Early plant and forage analyses as affected by the treatments are shown in Table 1. Nitrogen and phosphorus (early plant) were significantly increased as N rate increased. No significant differences were obtained between carriers.

Table 1. The effect of broadcast N from different carriers on analyses of spring wheat at late tillering and maturity.

	Elemental Analyses					
	Early Plant (Late Tillering)			Forage (Maturity)		
Carrier	N	P	K	N	P	K
	%			%		
1 (38-13-0)	3.88	.48	5.09	1.40	.19	1.50
2 (34-17-0)	4.09	.47	5.08	1.52	.21	1.45
3 (28-28-0)	4.07	.46	4.75	1.54	.22	1.40
4 (18-44-0)	3.96	.48	5.03	1.52	.21	1.41
5 (15-28-0	3.93	.49	5.15	1.46	.20	1.59
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	6.2	10.0	10.0	9.5	15.1	18.7
N Rate lb/A						
30	3.91	.46	4.92	1.47	.21	1.42
60	4.05	.49	5.12	1.51	.20	1.52
Significance	*	*	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)	.14	.03				
C.V. (%)	6.2	10.0	10.0	9.5	15.1	18.7

Forage yield, N and P uptake, grain yield, protein, test weight, and plant population (stand count) as affected by the treatments are shown in Table 2. Forage yields were significantly different between carriers and additional N significantly increased protein. A significant interaction between carrier and N rate was obtained with respect to N uptake.

Table 2. The effect of broadcast N from different carriers on forage yield, N and P uptake, grain yield, protein, test weight, and plant population.

Carrier	N Rate	P_2O_5 Rate	Forage D.M. Yield	Forage Uptake N	Forage Uptake P	Grain Yield	Grain Protein	Grain Test Weight	Plant Population
	- - - - - - - - - -		lb/A - - - - - - - - - -			Bu/A	- % -	- lb -	Plants/A
38-13-0	30	76	6072	89	13	38.7	12.3	57.6	1,136,045
	60	152	6183	83	11	40.9	12.8	57.2	1,109,560
34-17-0	30	76	6670	98	14	43.8	12.5	57.5	1,067,743
	60	152	6306	99	12	40.3	12.7	56.6	1,104,682
28-28-0	30	76	6410	96	13	42.2	12.3	57.8	1,140,924
	60	152	6423	101	15	40.5	12.9	56.7	1,090,045
18-44-0	30	76	5840	81	13	41.5	12.4	57.2	1,166,711
	60	152	6462	105	13	41.5	13.1	56.9	1,196,680
15-28-0	30	76	6582	98	13	43.9	12.4	57.8	1,103,288
	60	152	6969	99	13	44.8	13.0	58.1	1,170,196
Significance			N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)			7.9	10.2	16.7	7.9	2.2	1.5	7.0
Carrier									
1			6127	86	12	39.8	12.6	57.4	1,122,803
2			6488	98	13	42.0	12.6	57.1	1,086,212
3			6417	99	14	41.4	12.6	57.3	1,115,484
4			6151	93	13	41.5	12.7	57.1	1,181,696
5			6776	99	13	44.3	12.7	57.9	1,136,742
Significance			*	--	N.S.	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)			512						
N Rate lb/A									
30			6315	93	13	54.0	12.4	57.6	1,122,942
60			6469	97	13	53.5	12.9	57.1	1,134,233
Significance			N.S.	--	N.S.	N.S.	**	N.S.	N.S.
B.L.S.D. (.05)							.2		

Discussion: Effective evaluation of the N carriers in this study were not obtained. Nitrogen levels in the soil were sufficient for optimum production before any of the treatments were applied, which created an unfavorable environment for N response. The absence of a N response made it difficult to compare the efficiency of the N carriers.

Some differences were obtained between carriers, but these may be actually artificial due to the high N soil levels. Nitrogen did significantly increase early plant N and protein content of the grain, but these would be expected. Significant differences in forage yields between carriers were also obtained, but not in grain yields. An interaction between carrier and N rate was obtained with respect to N uptake, but no explanation is apparent. Additional studies under a N responsive situation will be used to further evaluate the carriers.

HIGH PHOSPHORUS AND POTASSIUM RATES ON CONTINUOUS SPRING WHEAT

G.E. Varvel and R.K. Severson

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

Experimental Procedure:

The ten P and K treatments for the first two years are shown in Table 1. The P and K treatments in the fall of 1980 were broadcast and plowed down. No additional N was applied because the 0-2' soil test showed 140 lb N/A. Era wheat was planted on April 8, 1981 and harvested August 5, 1981. Whole plant samples were taken at late-tillering (June 5, 1981) and soft-dough (July 16, 1981) to determine early plant nutrient concentrations and forage yield and nutrient uptake respectively. Soil samples taken August 18, 1981 were split and sent to the North Dakota State University and University of Minnesota soil testing laboratories for P and K analyses.

Table 1. Phosphorus and potassium treatments applied at Crookston in the high P and K study.

Treatment	Application Date: Spring 1980	Application Date: Fall 1980
	- - - - - P_2O_5 + K_2O	- - - - -
1	0 + 0	0 + 0
2	0 + 100	0 + 100
3	50 + 100	50 + 100
4	100 + 100	100 + 100
5	150 + 100	0 + 100
6	100 + 0	100 + 0
7	100 + 50	100 + 50
8	100 + 150	100 + 0
9	150 + 100	0 + 0
10	100 + 150	0 + 0

Results:

Analyses of the early plant samples are shown in Table 2. The addition of P significantly increased P levels and decreased Zn levels while K levels in the plant increased with added K. Significant differences in B levels were obtained, but they appear to bear no relationship to the treatments.

Table 2. Effect of high P and K rates on the elemental analyses of whole plant samples of spring wheat at late-tillering.

Treatment No.	P_2O_5	K_2O 1/	N	P	K	Ca	Mg	Mn	Zn	Cu	B
	- - lb/A	- -	- - - - - - - - - %					- - - - - - ppm			- - - - - -
1	0	0	4.10	.34	4.08	.40	.37	60	24	6.4	1.8
2	0	100	4.14	.36	4.32	.42	.33	57	24	5.9	1.8
3	50	100	4.08	.43	4.48	.40	.36	58	21	5.8	1.8
4	100	100	3.92	.46	4.50	.37	.36	58	20	6.1	1.8
5	0	100	4.07	.44	4.30	.43	.36	57	22	6.6	1.8
6	100	0	3.94	.44	4.16	.38	.39	62	20	6.0	2.0
7	100	50	4.15	.47	4.27	.43	.38	61	21	5.8	1.9
8	100	0	4.04	.46	4.34	.44	.36	58	21	6.3	1.8
9	0	0	4.07	.44	4.21	.41	.37	60	21	6.0	1.8
10	0	0	4.12	.43	4.34	.40	.37	62	22	5.9	2.1
Significance			N.S.	**	*	N.S.	N.S.	N.S.	**	N.S.	*
B.L.S.D. (.05)				.02	.27				2		0.2
C.V. (%)			4.1	4.3	3.7	10.5	5.8	5.1	5.7	9.0	5.9

1/ Treatments applied in the fall of 1980.

Analyses of the whole plant samples taken at the soft dough stage are shown in Table 3. The results were similar to those obtained from the early plant sampling, P levels increased and Zn levels decreased with added P while K levels increased and B levels decreased with added K.

Table 3. Effect of high P and K rates on the elemental analyses of whole plant samples of spring wheat at the soft-dough stage.

Treatment			Elemental Analyses								
No.	P_2O_5	K_2O 1/	N	P	K	Ca	Mg	Mn	Zn	Cu	B
	- - lb/A - -		- - - - - - - - % - - - - - - - -					- - - - - - ppm - - - - -			
1	0	0	1.64	.23	1.18	.13	.19	31	16	1.8	2.9
2	0	100	1.75	.22	1.27	.14	.16	25	14	1.6	2.6
3	50	100	1.58	.21	1.40	.16	.16	24	12	1.5	2.7
4	100	100	1.60	.25	1.25	.12	.17	29	12	1.5	2.3
5	0	100	1.67	.23	1.38	.14	.17	28	12	1.8	2.3
6	100	0	1.46	.22	1.16	.13	.17	27	12	1.4	2.9
7	100	50	1.59	.24	1.24	.14	.16	27	12	1.5	2.0
8	100	0	1.55	.24	1.30	.14	.15	26	12	1.3	1.9
9	0	0	1.63	.25	1.22	.13	.16	28	14	1.6	2.1
10	0	0	1.68	.24	1.20	.13	.18	29	12	1.6	2.4
Significance			N.S.	*	*	N.S.	N.S.	N.S.	**	N.S.	**
B.L.S.D. (.05)				.03	0.18				1		0.6
C.V. (%)			11.0	7.0	8.0	18.3	10.8	11.1	7.6	15.0	15.6

Grain yield, protein, test weight, forage yield, and P and K uptake values are shown in Table 4. Grain and forage yields increased with added P and K, but the increases were not large. Phosphorus and potassium uptake increased significantly as P and K were added, but the lower P and K rates appeared sufficient for maximum uptake. Test weight and protein were not affected by the treatments.

Table 4. Effect of high P and K rates on grain yield, protein, test weight, forage yield, and P and K uptake of spring wheat.

Treatment			Grain			Forage		
							Uptake	
No.	P_2O_5	K_2O	Yield	Protein	Test Weight	T.D.M. Yield	P	K
	- - lb/A - -		Bu/A	%	lb/Bu	- - - - - lb/A - - - - -		
1	0	0	51.7	12.1	58.9	6793	15.3	80.6
2	0	100	58.5	12.4	58.4	7544	16.2	96.3
3	50	100	59.6	11.9	59.0	7519	15.8	105.9
4	100	100	58.1	12.0	58.5	7550	19.5	97.5
5	0	100	56.6	12.1	58.4	7447	17.3	103.4
6	100	0	53.3	11.9	58.1	7752	17.2	90.2
7	100	50	56.3	12.2	58.2	7924	19.2	98.6
8	100	0	58.0	12.2	57.4	7538	18.4	98.2
9	0	0	58.7	12.3	59.1	7573	18.5	92.7
10	0	0	57.0	12.4	58.4	7096	16.7	84.2
Significance			+	N.S.	N.S.	+	*	*
B.L.S.D. (.05)							3.0	15.8
C.V. (%)			6.2	2.1	1.6	6.1	10.1	9.9

+, * - Indicates significance at the 10% and 5% levels respectively.

The effect of the treatments on soil test P and K levels in the 0-6 inch sample obtained by the University of Minnesota and North Dakota State University soil testing labs is shown in Table 5. Soil test P and K were significantly affected by the treatments according to both labs. A high correlation of soil test P levels with added P was obtained with both the Bray P-1 (50:1) and $NaHCO_3$ extractants, but not with the Bray P-1 (10:1). Exchangeable K was also significantly affected by the treatments according to both labs, but the results from the N.D.S.U. lab correlated with the added K much better than the results from the U of M lab.

Table 5. Effect of high P and K rates on soil test P and K levels.

Treatment			University of Minnesota			North Dakota State Univ.	
			Bray P-1		Exchangeable	$NaHCO_3$	Exchangeable
No.	P_2O_5	K_2O	10:1	50:1	K	P	K
	- - lb/A - -		- lb/A -				
1	0	0	18	26	235	11	205
2	0	100	34	27	267	13	251
3	50	100	43	36	267	20	234
4	100	100	36	39	262	25	249
5	0	100	45	38	288	23	246
6	100	0	34	40	248	30	218
7	100	50	44	42	249	27	220
8	100	0	53	43	277	28	260
9	0	0	47	39	254	23	230
10	0	0	33	34	238	18	216
Significance			+	**	+	**	**
B.L.S.D. (.05)				7		6	30
C.V. (%)			36.6	14.0	9.3	20.7	8.1

+, ** - Indicates significance at the 10% and 1% levels respectively.

RESIDUAL EFFECTS OF PHOSPHORUS ON SPRING WHEAT

G. E. Varvel and R. K. Severson

Phosphorus soil test levels vary widely in soils of the Red River Valley and the effects of applied P fertilizer on these soils for an extended period of time has not been determined. This study was designed to determine the effects of P fertilizer applied one time at various rates over a period of years on a low P testing soil.

Experimental Procedure:
Phosphorus fertilizer was broadcast and incorporated in the fall of 1979. Six rates of P in a randomized, complete block design with 4 replications were used. Solar wheat was planted on April 15, 1981 and harvested Aug. 10, 1981. Whole plant samples were taken at mid-tillering (June 8, 1981) to determine nutrient levels in the plant and at maturity (July 17, 1981) to determine forage yields, elemental analyses of the forage, and nutrient uptake. Soil samples were taken immediately after crop removal (Aug. 10, 1981) to determine the residual effects of the applied P on soil test measurements.

Results:
The effects of the P fertilizer were variable with respect to grain yield and test weight (Table 1). Grain yield tended to increase while test weight decreased (Table 1). A highly significant increase in forage yield, P uptake, and K uptake was obtained (Table 1) but the increase in K uptake was mainly due to the significant increase in forage yield.

The effects of the P fertilizer on elemental analyses of the plant were essentially the same with respect to the samples taken at mid-tillering and maturity. Phosphorus significantly increased P levels and decreased Zn levels in the plant at both sampling dates (Tables 2 and 3). Phosphorus also significantly increased Mg levels at mid-tillering (Table 2) and Mn levels of the plant at maturity (Table 3). The significant differences in Mn levels in the plant at mid-tillering (Table 2) appear unrelated to the treatments.

Soil test measurements taken after crop removal are shown in Table 4. Soil test P levels in the 0-6" depth were significantly increased according to the $NaHCO_3$ method. No other differences were obtained.

Table 1. The residual effect of phosphorus applied in the fall of 1979 on grain yield, test weight, protein, forage yield, and nutrient uptake of spring wheat in 1981.

P_2O_5	Grain			Forage		
		Test		T.D.M.	Uptake	
Rate	Yield	Weight	Protein	Yield	P	K
lb/A	Bu/A	lb/Bu	%	- - - - - - -	lb/A	- - - - - -
0	52.9	57.2	14.9	6374	10.9	63.4
40	58.2	57.1	14.8	6869	12.3	71.7
80	57.7	55.0	14.8	7541	15.1	86.9
120	55.0	54.2	15.1	7706	15.2	88.5
160	57.2	55.5	14.9	8436	16.9	93.8
200	54.4	54.8	15.3	7742	17.6	86.8
Significance	+	*	N.S.	**	**	**
B.L.S.D. (.05)		2.3		878	3.7	17.5
C.V. (%)	4.8	2.5	4.0	7.7	15.8	13.3

Table 2. The residual effect of phosphorus applied in the fall of 1979 on elemental analyses of early plant samples of spring wheat taken at mid-tillering in 1981.

P_2O_5 Rate	Elemental Analyses							
	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A	%				ppm			
0	0.28	4.11	0.34	0.31	65	25	6	3
40	0.30	4.18	0.34	0.31	60	24	6	3
80	0.34	4.13	0.42	0.33	62	26	6	3
120	0.37	4.35	0.35	0.36	61	23	6	3
160	0.36	4.21	0.35	0.35	65	20	6	3
200	0.39	4.04	0.34	0.39	66	20	5	3
Significance	**	N.S.	N.S.	**	*	*	N.S.	N.S.
B.L.S.D. (.05)	0.05			0.04	4	4		
C.V. (%)	8.9	5.1	18.3	7.2	4.0	11.4	2.8	7.2

Table 3. The residual effect of phosphorus applied in the fall of 1979 on elemental analyses of whole plant samples of spring wheat taken at maturity in 1981.

P_2O_5 Rate	Elemental Analyses							
	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A	%				ppm			
0	0.17	0.99	0.13	0.17	27	17	1.3	2
40	0.18	1.04	0.14	0.17	26	16	1.3	2
80	0.20	1.15	0.19	0.18	28	14	1.4	3
120	0.20	1.14	0.17	0.19	26	12	1.3	2
160	0.20	1.11	0.18	0.18	28	10	1.2	3
200	0.23	1.12	0.16	0.20	31	11	1.3	2
Significance	*	N.S.	N.S.	N.S.	**	**	N.S.	N.S.
B.L.S.D. (.05)	0.04				3	3		
C.V. (%)	12.0	8.3	19.7	12.8	5.7	13.8	15.8	13.2

Table 4. The residual effect of phosphorus applied in the fall of 1979 on soil test measurements taken after crop removal in 1981.

P_2O_5 Rate	N.D.S.U.						U of M			
	pH		$NaHCO_3$ P		Exchangeable K		pH	Bray P1 10:1	Bray P1 50:1	Exchangeable K
	0-6"	6-12"	0-6"	6-12"	0-6"	6-12"	0-6"	0-6"	0-6"	0-6"
lb/A			lb/A					lb/A		
0	8.1	8.3	14	4	266	198	7.9	21	28	296
40	7.9	8.0	12	5	278	228	7.9	28	31	295
80	7.9	8.0	17	6	293	240	7.9	18	25	272
120	8.0	8.1	21	5	279	225	7.9	26	26	298
160	8.1	8.2	22	5	271	214	7.8	29	31	291
200	8.0	8.2	22	5	269	206	7.9	25	32	290
Significance	N.S.	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)			8							
C.V. (%)	1.7	1.6	26.4	39.8	6.3	9.4	1.4	60.6	19.7	10.2

RESIDUAL EFFECTS OF POTASSIUM ON SPRING WHEAT

G. E. Varvel and R. K. Severson

Potassium levels in soils of the Red River Valley have historically been quite high and the need for K fertilizer on these soils has been limited. In spite of these high levels, large amounts of K fertilizer are applied annually on these soils. This study was initiated in the spring of 1980 to determine if additional K was needed for small grain production in this area.

Experimental Procedure:
This study was designed to determine the residual effects of K that had been applied in the previous year. Six rates of K had been applied and incorporated on April 21, 1980. A randomized, complete block design with 4 replications was used. Morex barley was planted on April 14, 1981 and harvested July 27, 1981. Whole plant samples taken July 10, 1981 were used to determine forage yields and nutrient uptake. Soil samples were taken on Aug. 10, 1981 after crop removal to determine residual levels in the soil.

Results:
Potassium fertilizer applied in 1980 caused few differences in spring barley yield or quality in 1981 (Table 1). Protein levels were significantly different, but they seemed to have no relationship to the treatments (Table 1).

Forage analyses are shown in Table 2. Potassium levels in the plant were significantly increased, but no other differences were obtained.

Soil test measurements taken after crop removal in 1980 were not affected by the treatments (Table 3). Potassium levels in the 0-6" depth tended to increase, but the increase was not significant.

Table 1. The effect of potassium applied in 1980 on barley grain yield, test weight, protein content, plump and thin kernels, forage yield, and nutrient uptake in 1981.

K_2O	Grain					Forage		
		Test		Plump	Thin	T.D.M.	Uptake	
Rate	Yield	Weight	Protein	Kernels	Kernels	Yield	P	K
lb/A	Bu/A	lb/B	%			lb/A		
0	59.8	44.9	11.7	79.5	4.9	5962	12.3	62.9
50	59.5	44.9	11.0	69.2	4.8	6095	12.5	74.4
100	60.2	44.4	12.0	69.5	6.3	6493	12.6	73.8
150	61.3	44.9	11.2	70.9	4.3	6060	11.9	71.1
200	67.4	45.4	11.2	74.3	3.8	6274	11.3	79.4
250	59.8	45.6	10.7	76.7	3.6	5935	10.2	78.2
Significance	N.S.	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)			0.9					
C.V. (%)	11.3	2.0	4.7	12.2	4.6	13.5	20.0	13.9

Table 2. The effect of potassium applied in 1980 on the elemental analyses of spring barley forage at maturity in 1981.

K_2O Rate	Elemental Analyses							
	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A	%				ppm			
0	0.20	1.06	0.30	0.24	25	12	3	5
50	0.20	1.21	0.32	0.24	24	12	2	5
100	0.19	1.14	0.33	0.24	24	12	3	4
150	0.20	1.18	0.31	0.23	23	12	2	4
200	0.18	1.28	0.27	0.24	21	10	2	4
250	0.17	1.31	0.29	0.24	21	10	2	5
Significance	N.S.	**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)		0.15						
C.V. (%)	14.0	7.5	12.7	14.4	14.9	12.8	19.9	31.5

Table 3. The effect of potassium applied in 1980 on soil test measurements taken after crop removal in 1981.

K_2O Rate	pH		$NaHCO_3$ P		Exchangeable K	
	0-6"	6-12"	0-6"	6-12"	0-6"	6-12"
lb/A			lb/A			
0	8.2	8.3	12	7	228	210
50	8.2	8.2	9	7	235	214
100	8.2	8.3	11	8	231	208
150	8.2	8.2	8	6	233	210
200	8.2	8.4	9	6	246	213
250	8.3	8.3	8	5	248	210
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	1.1	1.2	29.9	33.3	5.2	8.4

PHOSPHORUS AND POTASSIUM FERTILITY STUDIES ON OILSEED SUNFLOWER

G. E. Varvel and R. K. Severson

Fertilizer response data for oilseed sunflower in Minnesota, especially with respect to phosphorus and potassium is limited in nature and amount. These studies were designed to generate additional information on P and K response to improve current fertilizer recommendations.

Experimental Procedure:
Three locations were used for P experiments (1, 2, and 4) and 2 locations were used for K experiments (3 and 5). Six rates of P or K were applied and incorporated on April 24, 1981 in each experiment. Blanket applications of 100 lb K_2O/A were made over the P experiments and 80 lb P_2O_5/A over the K experiments. A randomized, complete block design with 4 replications was used for all experiments. Oilseed sunflower was seeded at all locations around May 1, 1981 in 30-inch rows. Different varieties were used at each location.

Whole plant samples were taken at various times throughout the growing season to determine the effect of the fertilizer treatments on crop growth, nutrient content, and removal. Leaf samples were also taken to determine the effect of the fertilizer treatments at pollination.

Seed yield and harvest population were taken at maturity. Oil content and elemental analyses of the seed were measured to determine the effects of the treatments.

Soil test results for each experiment are shown below:

Experiment	pH	NO_3-N	$NaHCO_3$ P	Exchangeable K
		lb/A-2'	lb/A	lb/A
1	7.5	173	24	283
2	7.7	148	20	248
3	7.5	118	18	280
4	7.6	174	19	229
5	7.5	170	15	240

Results:
Experiment 1. Above ground dry matter yields, elemental analyses, and nutrient uptake are shown in Tables 1 and 2 for the June 25 and Aug. 13 sampling dates. No significant differences were obtained at either date.

Elemental analyses of leaf samples taken Aug. 13 are shown in Table 3. The phosphorus treatments significantly affected P levels in the leaf, but the levels didn't increase with respect to the treatments.

Seed yield, oil content, elemental analyses of the seed, and nutrient removal by the seed are shown in Table 4. The phosphorus treatments had no affect on any of the variables.

Experiment 2. Above ground dry matter yields, elemental analyses, and nutrient uptake are shown in Tables 5-7 for the June 25, Aug. 13, and Sept. 16 sampling dates. The phosphorus treatments significantly increased P uptake at the Aug. 13 and Sept. 16 dates (Tables 6 and 7), but no other differences were obtained.

Elemental analyses of leaf samples taken Aug. 13 are shown in Table 8. No differences were obtained.

Seed yield, oil content, elemental analyses of the seed, and nutrient removal by the seed are shown in Table 9. No differences were obtained.

Experiment 3. Above ground dry matter yields, elemental analyses, and nutrient uptake are shown in Tables 10 and 11 for the June 25 and Aug. 13 sampling dates. The potassium treatments had no affect on any of the variables at either date.

Elemental analyses of leaf samples taken Aug. 13 are shown in Table 12. No differences were obtained.

Seed yield, oil content, elemental analyses of the seed, and nutrient removal by the seed are shown in Table 13. The potassium treatments had no affect on any of the variables.

Experiment 4. Elemental analyses of leaf samples taken Aug. 13 are shown in Table 14. The phosphorus treatments significantly affected K and Cu levels in the leaf.

Seed yield, oil content, elemental analyses of the seed, and nutrient removal by the seed are shown in Table 15. No differences were obtained.

Experiment 5. Elemental analyses of leaf samples taken Aug. 13 are shown in Table 16. The potassium treatments significantly increased K levels in the leaf.

Seed yield, oil content, elemental analyses of the seed, and nutrient removal by the seed are shown in Table 17. No differences were obtained.

Conclusions:
Plant analyses, seed yield, seed analyses, and oil content data from these experiments indicate that no response to either P or K was obtained. These results would have been predicted based upon the soil test levels for each of the experiments. All of the locations tested in the medium to high range for P and K where the probability of response is very low. Even though no fertilizer response was obtained, the data provides information on dry matter accumulation, nutrient content, and nutrient removal by the seed for oilseed sunflower. These results are shown in Tables 18 and 19.

Table 1. The effect of phosphorus on the elemental analyses, dry matter yield and nutrient uptake of oilseed sunflower in experiment 1 (approximate height-10 inches).

P_2O_5	Elemental Analyses									T.D.M.	Uptake		
Rate	N	P	K	Ca	Mg	Mn	Zn	Cu	B	Yield	N	P	K
lb/A	%					ppm				lb/A			
0	4.12	.49	5.35	2.58	1.14	83	27	10	57	419	17	2.0	22.2
40	4.05	.46	5.14	2.69	1.18	87	29	11	59	556	22	2.5	28.6
80	4.16	.57	5.13	2.50	1.26	84	30	10	58	545	23	3.1	28.0
120	4.29	.57	5.45	2.53	1.19	92	29	11	57	521	22	3.0	28.6
160	4.22	.47	5.48	2.52	1.10	85	30	11	57	466	20	2.2	25.3
200	4.06	.50	5.33	2.58	1.07	77	27	9	57	511	21	2.7	28.2
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	6.2	19.2	17.2	9.0	20.5	18.9	21.9	23.3	6.2	15.1	13.9	28.9	29.8

Table 2. The effect of phosphorus on the elemental analyses, dry matter yield, and nutrient uptake of oilseed sunflower in experiment 1 (90% pollinated).

P_2O_5	Elemental Analyses									T.D.M.	Uptake		
Rate	N	P	K	Ca	Mg	Mn	Zn	Cu	B	Yield	N	P	K
lb/A	%					ppm				lb/A			
0	2.14	.32	2.43	1.61	1.26	41	22	10	50	6701	143.9	21.4	160.8
40	2.17	.29	2.34	1.79	1.33	45	24	12	52	7323	158.5	21.3	169.5
80	2.23	.36	2.12	1.80	1.34	43	23	9	50	7014	156.1	25.1	149.2
120	2.17	.33	2.20	1.62	1.25	48	22	10	49	6913	149.5	22.4	155.0
160	2.12	.32	2.47	1.76	1.25	42	23	11	54	7406	156.7	23.8	182.8
200	2.21	.35	2.38	1.78	1.25	39	25	10	49	6935	153.4	24.2	165.5
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	5.9	18.0	23.0	8.8	16.1	15.4	12.9	19.4	8.4	7.9	8.0	17.9	24.4

Table 3. The effect of phosphorus on the elemental analyses of leaf samples of oilseed sunflower in experiment 1.

P_2O_5 Rate	Elemental Analyses N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A	%					ppm			
0	3.56	.38	2.75	2.87	1.56	64	28	19	99
40	3.33	.33	2.51	2.93	1.51	62	32	22	93
80	3.27	.42	2.50	3.15	1.51	60	29	17	94
120	3.49	.35	2.76	2.73	1.55	65	28	21	83
160	3.64	.37	3.07	2.93	1.37	61	31	23	113
200	3.52	.41	2.65	3.12	1.45	59	30	18	92
Significance	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)		0.08							
C.V. (%)	8.1	11.3	29.1	11.4	22.0	20.6	16.7	26.0	18.1

Table 4. The effect of phosphorus on seed yield, oil content, elemental analyses of the seed, and nutrient removal by the seed of oilseed sunflower in experiment 1.

P_2O_5 Rate	Seed Yield	Oil	Elemental Analyses N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Nutrient Removal N	P	K
lb/A	lb/A	%	%					ppm					lb/A		
0	2280	49.6	2.61	0.60	0.90	0.18	0.37	40	21	47	14	11	59.5	13.8	20.5
40	2260	49.7	2.36	0.57	0.87	0.18	0.35	40	21	46	13	11	53.1	12.8	19.5
80	2270	49.2	2.58	0.62	0.91	0.18	0.36	38	20	45	13	11	58.4	14.0	20.6
120	2260	49.6	2.62	0.59	0.86	0.17	0.36	38	21	40	12	11	59.1	13.3	19.4
160	2300	49.0	2.45	0.60	0.92	0.18	0.36	43	22	46	13	12	56.5	13.8	21.3
200	2140	48.5	2.68	0.63	0.92	0.19	0.37	40	21	46	12	12	57.7	13.6	19.9
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	7.0	2.4	9.9	12.2	8.0	3.6	7.8	7.8	7.0	11.7	12.7	4.1	11.7	15.7	12.6

Table 5. The effect of phosphorus on the elemental analyses, dry matter yield, and nutrient uptake of oilseed sunflower in experiment 2 (approximate height-10 inches).

P_2O_5 Rate	Elemental Analyses N	P	K	Ca	Mg	Mn	Zn	Cu	B	T.D.M. Yield	Uptake N	P	K
lb/A	%					ppm					lb/A		
0	3.89	.46	4.44	2.49	1.79	84	29	11	51	500	20	2.3	22.0
40	3.77	.46	4.74	2.14	1.72	71	30	9	49	573	22	2.6	27.2
80	3.63	.45	4.88	2.57	1.71	88	29	9	51	536	19	2.4	26.2
120	3.78	.46	4.41	2.40	1.87	76	27	8	49	507	19	2.3	22.7
160	3.69	.45	4.62	2.59	1.79	83	29	8	49	596	22	2.7	27.4
200	3.77	.49	4.78	2.38	1.79	77	29	12	52	612	23	3.0	29.1
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	5.7	5.0	12.7	9.8	13.8	21.3	10.4	27.1	5.5	15.1	16.6	17.3	17.3

Table 6. The effect of phosphorus on the elemental analyses, dry matter yield, and nutrient uptake of oilseed sunflower in experiment 2 (90% pollinated).

P_2O_5 Rate	Elemental Analyses									T.D.M. Yield	Uptake		
	N	P	K	Ca	Mg	Mn	Zn	Cu	B		N	P	K
lb/A	%					ppm				lb/A			
0	1.92	.24	2.33	1.55	1.54	32	24	10	48	5971	115.0	14.6	140.0
40	1.83	.26	2.56	1.44	1.53	32	22	11	49	6652	121.7	17.3	169.5
80	1.60	.24	2.05	1.51	1.55	32	20	10	46	6729	108.5	16.0	139.6
120	1.91	.28	2.16	1.41	1.42	29	21	9	47	6937	132.2	19.4	150.2
160	1.71	.28	2.17	1.52	1.48	29	22	9	47	6967	119.1	19.7	151.6
200	1.60	.26	2.42	1.45	1.51	30	19	10	47	6440	104.0	16.7	156.7
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.
B.L.S.D. (.05)												3.8	
C.V. (%)	11.2	8.4	21.6	7.6	7.5	13.9	13.1	15.3	5.2	6.6	14.1	10.8	23.4

Table 7. The effect of phosphorus on the elemental analyses, dry matter yield, and nutrient uptake of oilseed sunflower in experiment 2 at maturity.

P_2O_5 Rate	Elemental Analyses									T.D.M. Yield	Uptake		
	N	P	K	Ca	Mg	Mn	Zn	Cu	B		N	P	K
lb/A	%					ppm				lb/A			
0	1.65	.24	2.27	1.40	1.27	26	22	10	45	6317	104.5	15.4	144.3
40	1.57	.25	2.22	1.18	1.20	26	21	10	39	5675	89.0	14.0	125.8
80	1.51	.27	2.04	1.24	1.15	25	22	10	42	6011	90.7	16.2	123.5
120	1.41	.28	1.86	1.28	1.27	25	20	9	44	5881	83.4	16.4	110.8
160	1.38	.33	2.07	1.25	1.14	24	24	10	41	6705	94.2	22.1	140.9
200	1.46	.28	2.39	1.41	1.23	29	18	9	45	5760	83.8	16.3	138.1
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	+	N.S.	N.S.	N.S.	N.S.	*	N.S.
B.L.S.D. (.05)												5.3	
C.V. (%)	12.6	15.3	23.9	16.9	9.3	23.3	8.8	14.0	7.2	9.1	19.2	15.6	30.7

Table 8. The effect of phosphorus on the elemental analyses of leaf samples of oilseed sunflower in experiment 2.

P_2O_5 Rate	Elemental Analyses								
	N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A	%					ppm			
0	3.25	.39	3.21	2.73	1.82	42	37	20	98
40	3.58	.40	2.97	2.86	1.68	51	34	23	99
80	3.60	.38	2.64	2.78	1.89	51	30	18	100
120	3.39	.39	2.67	2.90	1.88	47	32	17	102
160	3.31	.40	2.58	2.93	1.88	47	33	17	98
200	3.63	.41	3.00	2.74	1.74	44	32	18	104
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	9.3	9.5	17.5	9.3	8.3	15.7	12.8	26.0	11.1

Table 9. The effect of phosphorus on seed yield, oil content, elemental analyses of the seed, and nutrient removal by the seed of oilseed sunflower in experiment 2.

P_2O_5 Rate	Seed Yield	Oil	Elemental Analyses P	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Nutrient Removal P	K
lb/A	lb/A	%	%				ppm					lb/A	
0	1770	48.5	0.58	0.91	0.18	0.37	39	20	49	19	13	10.3	16.1
40	1850	50.0	0.56	0.94	0.18	0.36	38	20	48	22	12	10.4	17.3
80	1830	48.3	0.60	0.93	0.20	0.38	57	22	47	17	13	10.8	17.0
120	1850	48.7	0.59	0.98	0.18	0.37	37	19	45	17	13	11.0	18.1
160	1960	48.7	0.62	0.96	0.18	0.38	36	19	48	18	13	12.1	18.8
200	1970	49.1	0.61	0.91	0.17	0.38	39	21	45	18	13	12.1	17.9
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	7.1	2.3	9.4	4.4	5.5	5.9	28.3	9.6	6.7	21.4	7.0	13.0	9.4

Table 10. The effect of potassium on the elemental analyses, dry matter yield, and nutrient uptake of oilseed sunflower in experiment 3 (approximate height-10 inches).

K_2O Rate	Elemental Analyses N	P	K	Ca	Mg	Mn	Zn	Cu	B	T.D.M. Yield	Uptake N	P	K
lb/A	%					ppm					lb/A		
0	3.77	.49	4.85	2.66	1.51	71	26	8	52	541	20	2.7	26.3
50	3.98	.46	4.03	2.46	1.83	81	31	10	52	400	16	1.8	15.8
100	3.68	.44	4.86	2.42	1.77	82	31	9	51	526	19	2.3	25.7
150	3.82	.44	5.21	2.32	1.44	74	31	11	50	439	16	1.9	23.7
200	3.96	.46	4.69	2.46	1.71	78	30	8	52	533	21	2.5	25.0
250	3.98	.53	5.01	2.66	1.58	65	29	8	55	672	27	3.6	32.5
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	7.0	9.3	12.5	9.4	13.3	14.6	9.4	17.5	7.3	33.1	35.8	38.0	38.0

Table 11. The effect of potassium on the elemental analyses, dry matter yield, and nutrient uptake of oilseed sunflower in experiment 3 (90% pollinated).

K_2O Rate	Elemental Analyses N	P	K	Ca	Mg	Mn	Zn	Cu	B	T.D.M. Yield	Uptake N	P	K
lb/A	%					ppm					lb/A		
0	1.74	.31	2.43	1.64	1.11	28	19	8	53	6217	108.1	19.1	150.3
50	1.65	.25	2.15	1.62	1.19	30	19	8	52	6540	107.9	16.0	142.1
100	1.82	.27	2.53	1.73	1.22	38	22	8	56	6468	117.3	17.0	162.7
150	1.66	.24	2.61	1.74	1.15	33	20	9	55	6296	105.4	15.4	161.8
200	1.82	.29	2.54	1.72	1.26	34	21	8	57	6596	120.0	19.2	166.8
250	1.72	.32	2.55	1.71	1.09	26	19	7	57	7145	122.9	22.9	180.0
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	7.5	16.6	17.3	7.0	11.4	15.6	11.2	20.8	8.5	11.9	16.1	24.5	17.0

Table 12. The effect of potassium on the elemental analyses of leaf samples of oilseed sunflower in experiment 3.

K_2O Rate	Elemental Analyses								
	N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A	%					ppm			
0	3.61	.40	2.62	3.25	1.63	43	32	21	97
50	3.29	.37	2.54	3.21	1.79	48	36	23	102
100	3.45	.38	2.67	3.25	1.65	55	32	20	94
150	3.42	.35	2.95	3.16	1.52	53	35	24	96
200	3.31	.40	2.64	2.91	1.83	42	35	17	88
250	3.37	.45	2.54	3.32	1.54	42	32	18	105
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	7.6	14.8	11.0	7.5	10.1	17.1	10.5	24.3	11.4

Table 13. The effect of potassium on seed yield, oil content, elemental analyses of the seed, and nutrient removal by the seed of oilseed sunflower in experiment 3.

K_2O Rate	Seed Yield	Oil	Elemental Analyses									Nutrient Removal	
			P	K	Ca	Mg	Fe	Mn	Zn	Cu	B	P	K
lb/A	lb/A	%	%				ppm					lb/A	
0	1870	48.3	0.60	0.95	0.20	0.37	41	19	48	24	19	11.1	17.7
50	1840	48.8	0.55	0.91	0.20	0.36	46	19	49	24	18	10.1	16.7
100	2020	49.4	0.57	0.87	0.19	0.37	40	21	48	23	15	11.4	17.7
150	1830	50.5	0.55	0.87	0.19	0.36	37	19	49	24	15	10.1	15.8
200	1710	48.9	0.57	0.91	0.19	0.37	41	20	48	23	15	9.8	15.6
250	1730	49.2	0.61	0.94	0.19	0.37	45	20	47	22	16	10.5	16.2
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	9.2	2.9	10.6	4.5	6.8	6.8	30.1	9.3	8.5	9.1	18.5	12.6	9.7

Table 14. The effect of phosphorus on the elemental analyses of leaf samples of oilseed sunflower in experiment 4.

P_2O_5 Rate	Elemental Analyses								
	N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A	%					ppm			
0	3.21	.36	2.97	3.26	1.65	73	36	19	105
40	3.36	.40	2.61	3.09	1.79	63	32	18	89
80	3.41	.37	2.60	3.24	1.81	64	38	20	88
120	3.13	.40	2.78	3.22	1.53	69	29	13	86
160	3.31	.37	2.65	3.41	1.81	69	31	20	99
200	3.46	.38	2.28	3.40	1.92	65	34	16	90
Significance	N.S.	N.S.	*	N.S.	N.S.	N.S.	N.S.	*	N.S.
B.L.S.D. (.05)			.44					6	
C.V. (%)	6.6	11.8	9.7	5.6	13.4	16.3	17.8	18.9	14.7

Table 15. The effect of phosphorus on seed yield, oil content, elemental analyses of the seed, and nutrient removal by the seed of oilseed sunflower in experiment 4.

P_2O_5 Rate	Seed Yield	Oil	Elemental Analyses P	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Nutrient Removal P	K
lb/A	lb/A	%	%				ppm					lb/A	
0	1870	48.4	0.60	0.90	0.19	0.36	38	23	51	14	14	11.2	16.9
40	1950	47.5	0.62	0.89	0.19	0.38	45	22	49	14	13	12.2	17.5
80	1890	47.3	0.62	0.86	0.19	0.37	42	23	55	15	14	11.7	16.2
120	2000	47.4	0.66	0.93	0.19	0.39	42	24	45	13	13	13.3	18.6
160	2080	47.8	0.61	0.88	0.19	0.37	41	22	44	14	13	12.6	18.2
200	2020	46.8	0.68	0.89	0.19	0.39	43	23	49	12	14	13.7	18.0
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	8.2	2.1	10.1	8.1	3.9	7.0	14.9	7.4	16.0	10.4	5.5	13.2	12.4

Table 16. The effect of potassium on the elemental analyses of leaf samples of oilseed sunflower in experiment 5.

K_2O Rate	Elemental Analyses N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A	%					ppm			
0	3.45	.36	2.15	2.78	2.06	60	40	18	85
50	3.59	.33	2.20	3.14	2.06	66	41	18	89
100	3.42	.36	2.29	3.65	1.87	67	32	17	91
150	3.39	.35	2.13	3.22	2.02	67	36	16	89
200	3.48	.35	2.78	3.16	1.66	61	32	16	95
250	3.50	.35	2.79	3.40	1.68	61	29	17	90
Significance	N.S.	N.S.	**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)			.38						
C.V. (%)	7.0	10.7	10.3	11.6	12.4	15.6	19.4	22.9	9.3

Table 17. The effect of potassium on seed yield, oil content, elemental analyses of the seed, and nutrient removal by the seed of oilseed sunflower in experiment 5.

K_2O Rate	Seed Yield	Oil	Elemental Analyses P	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Nutrient Removal P	K
lb/A	lb/A	%	%				ppm					lb/A	
0	1650	46.5	0.59	0.89	0.19	0.38	43	23	55	16	15	9.6	14.6
50	1870	46.6	0.59	0.87	0.19	0.37	46	23	52	14	14	11.0	16.3
100	1880	46.8	0.59	0.91	0.18	0.38	48	23	58	16	15	11.1	17.1
150	1970	47.5	0.58	0.90	0.18	0.37	53	23	49	15	14	11.5	17.8
200	2040	47.7	0.59	0.88	0.19	0.38	51	23	47	15	14	12.0	17.9
250	1940	47.0	0.56	0.87	0.19	0.37	55	23	52	15	14	10.9	16.7
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	10.0	2.1	7.8	4.6	5.8	4.7	18.3	8.6	12.3	8.2	4.4	12.2	10.8

Table 18. Above ground dry matter yields, nutrient analyses of the plant, and nutrient uptake of oilseed sunflower at various sampling dates.

Experiment	Date	T.D.M.	Analyses N	Analyses P	Analyses K	Uptake N	Uptake P	Uptake K
	1981	lb/A	- - - - - % - - - -			- - - lb/A - - - -		
1	6-25	503	4.15	0.51	5.31	20.8	2.6	26.8
	8-13	7049	2.17	0.33	2.70	153.0	23.3	188.5
2	6-25	554	3.76	0.46	4.64	20.8	2.6	25.7
	8-13	6616	1.76	0.26	2.28	116.7	17.3	151.3
	9-16	6058	1.50	0.28	2.14	91.0	16.7	130.6
3	6-25	518	3.87	0.47	4.77	20.1	2.5	24.8
	8-13	6544	1.73	0.28	2.47	113.7	18.3	160.6

Table 19. Seed yields, nutrient analyses of the seed, and nutrient removal by the seed of oilseed sunflower at maturity.

Experiment	Yield	Analyses N	Analyses P	Analyses K	Removal N	Removal P	Removal K
	lb/A	- - - - - % - - - - - -			- - - - - lb/A - - - - -		
1	2253	2.55	0.60	0.90	57.4	13.5	20.2
2	1872		0.59	0.94		11.1	17.5
3	1834		0.57	0.91		10.5	16.6
4	1972		0.63	0.89		12.4	17.6
5	1893		0.58	0.89		11.0	16.7

PHOSPHORUS AND POTASSIUM FERTILITY STUDIES ON NONOILSEED SUNFLOWER

G. E. Varvel and R. K. Severson

Phosphorus and potassium response data for nonoilseed sunflower in Minnesota is limited. Additional information needs to be generated to determine the optimum levels of P and K fertilization for maximum production. These studies were initiated with those objectives in mind.

Experimental Procedure:
Two locations were used with a P and K experiment at both. A randomized, complete block design with 6 treatments was used for all experiments. At both locations, the P studies had 100 lb K_2O/A broadcast over the entire experiment while the K studies had 80 lb P_2O_5/A broadcast over the entire experiment. All treatments were applied and incorporated on April 16, 1981. Nonoilseed sunflower, Dahlgren 716, was seeded on May 6, 1981 in 30 inch rows.

Whole plant samples were taken from all of the experiments at various times to measure total above ground plant growth, nutrient content, and nutrient uptake as affected by P or K fertilizer. Seed yields were also taken.

Soil test results from samples taken on April 16, 1981 were: Experiments 1 and 2 (pH-7.6, NO_3-N (lb/A-2')-130, $NaHCO_3$ P (lb/A)-11, and exchangeable K (lb/A) - 180). Experiments 3 and 4 (pH-7.6, NO_3-N (lb/A-2')-113, $NaHCO_3$ P (lb/A)-14, and exchangeable K (lb/A)-266).

Results:
Experiment 1. Above ground dry matter yields, elemental analyses, and nutrient uptake are shown in Tables 1-3 for the June 24, Aug. 11, and Sept. 10 sampling dates respectively. The phosphorus treatments significantly increased P and Ca and decreased Zn levels in the plant at the June 24 sampling date (Table 1), significantly increased P levels in the plant and P uptake at the Aug. 11 sampling date (Table 2), and caused no differences at the Sept. 10 sampling date (Table 3).

Elemental analyses of leaf samples taken Aug. 7 are shown in Table 4. The phosphorus treatments significantly increased P and decreased Zn levels in the leaf. Significant differences in Mg levels in the leaf were also obtained but they appear unrelated to the treatments.

Seed yields were taken Sept. 14 but will not be reported here due to the amount of insect damage which caused tremendous variability in plot yields nearest the edge of the field.

Experiment 2. Above ground dry matter yields, elemental analyses, and nutrient uptake are shown in Tables 5-7 for the June 24, Aug. 11, and Sept. 10 sampling dates respectively. The potassium treatments significantly affected Mn levels in the plant at the June 24 sampling date (Table 5) and K levels in the plant at the Aug. 11 sampling date (Table 6), but they appear unrelated to the treatments. No other differences were obtained.

Elemental analyses of leaf samples taken Aug. 7 are shown in Table 8. The potassium treatments significantly affected K, Ca, and Mn levels in the leaf, but the Ca and Mn levels do not appear related to the treatments.

Seed yields taken on Sept. 14 will not be reported here due to the amount of insect damage which caused tremendous variability in plot yields nearest the edge of the field.

Experiment 3. Above ground dry matter yields, elemental analyses, and nutrient uptake are shown in Tables 9 and 10 for the June 24 and Aug. 12 sampling dates. The potassium treatments significantly increased K levels in the plant, dry matter yields, and K uptake and decreased Mg levels in the plant at the Aug. 12 sampling date (Table 10). No differences were obtained at the June 24 sampling date (Table 9).

Elemental analyses of leaf samples taken on Aug. 7 are shown in Table 11. The potassium treatments significantly increased K levels and decreased Mg levels in the leaf.

Harvest populations, seed yield, elemental analyses of the seed, and nutrient removal are shown in Table 12. No differences were obtained.

Experiment 4. Above ground dry matter yields, elemental analyses, and nutrient uptake are shown in Table 13 for the June 24 sampling date. The phosphorus treatments significantly increased P levels in the plant and P uptake and reduced Zn levels in the plant. No other sampling dates were used because of water damage to parts of the experiment.

Elemental analyses of leaf samples taken Aug. 7 are shown in Table 14. The phosphorus treatments significantly increased P levels in the leaf but had no effect on the other variables.

Seed yield, harvest populations, elemental analyses of the seed, and nutrient removal are shown in Table 15. The phosphorus treatments significantly increased P and K levels in the seed. Seed yield and Mn, Zn and Cu levels in the seed were also significantly affected, but the differences do not appear related to the treatments. Some of the variability was due to insect damage to the seed which was greater in the plots closest to the edge of the field.

Conclusions:
The results from these experiments were highly variable, but some information has been gained. Soil, plant and leaf analyses data indicate that a P response in experiments 1 and 4 and a K response in experiment 2 would have been obtained if water and insect damage had not bee incurred on the studies. Precipitation at these locations exceeded 40 inches during the growing season and due to the topography of the locations, rapid drainoff did not occur.

In spite of these problems, a summary of results from all the experiments established some basic levels in dry matter production, nutrient content, and nutrient uptake for nonoilseed sunflower (Table 16). Nutrient analyses and removal data for the seed are shown in Table 17.

Table 1. The effect of phosphorus on the elemental analyses, dry matter yield, and nutrient uptake of sunflower whole plants in experiment 1 (approximate height-10 inches).

P_2O_5	Elemental Analyses									T.D.M.	Uptake		
Rate	N	P	K	Ca	Mg	Mn	Zn	Cu	B	Yield	N	P	K
lb/A	%					ppm					lb/A		
0	3.79	.37	5.84	1.90	.97	85	26	9	45	242	9.1	.9	14.3
40	3.71	.50	6.42	2.35	.92	86	29	9	50	398	14.7	2.1	26.4
80	3.72	.47	6.31	2.37	.88	83	25	7	50	379	14.0	1.8	24.0
120	3.72	.53	5.92	2.39	.96	94	24	10	52	399	14.9	2.2	23.9
160	3.70	.47	5.97	2.43	.91	89	20	8	48	356	13.2	1.7	21.2
200	3.63	.68	6.41	2.30	.93	77	22	8	49	455	16.6	3.3	29.5
Significance	N.S.	+	N.S.	+	N.S.	N.S.	+	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	3.5	26.2	7.8	10.4	9.9	21.4	17.1	44.2	6.4	30.8	31.5	59.7	36.6

Table 2. The effect of phosphorus on the elemental analyses, dry matter yield, and nutrient uptake of sunflower whole plants in experiment 1 (90% pollinated).

P_2O_5	Elemental Analyses									T.D.M.	Uptake		
Rate	N	P	K	Ca	Mg	Mn	Zn	Cu	B	Yield	N	P	K
lb/A	%					ppm					lb/A		
0	1.95	.20	2.69	1.55	1.14	50	23	9	51	3804	74.6	7.7	102.4
40	1.98	.24	3.17	1.61	1.05	41	23	9	55	4794	94.1	11.2	149.4
80	1.93	.24	3.34	1.58	1.02	35	18	7	52	4884	95.8	11.9	164.3
120	1.97	.25	2.54	1.62	1.26	45	21	9	52	5123	102.9	12.9	128.1
160	1.92	.27	3.03	1.81	1.09	51	19	8	53	5172	100.1	14.1	157.8
200	2.04	.29	2.96	1.76	1.15	46	19	9	55	5231	104.5	15.3	154.6
Significance	N.S.	*	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.	N.S.	N.S.	*	N.S.
B.L.S.D. (.05)		.06					5					4.7	
C.V. (%)	8.6	13.9	16.7	8.6	13.1	17.5	13.3	39.8	7.2	15.4	22.7	23.0	22.3

Table 3. The effect of phosphorus on the elemental analyses, dry matter yield, and nutrient uptake of sunflower whole plants in experiment 1 at maturity.

P_2O_5 Rate	Elemental Analyses									T.D.M. Yield	Uptake		
	N	P	K	Ca	Mg	Mn	Zn	Cu	B		N	P	K
lb/A	%					ppm				lb/A			
0	1.51	.21	2.24	1.38	.84	38	26	11	48	5591	83.8	11.7	124.6
40	1.57	.24	2.54	1.40	.82	30	25	10	47	6244	97.9	14.8	160.0
80	1.55	.24	2.64	1.33	.78	28	19	9	46	6660	102.8	15.8	175.1
120	1.49	.25	2.18	1.28	.90	33	20	9	44	6505	97.0	15.9	143.0
160	1.55	.32	2.50	1.45	.83	34	21	11	49	5532	83.4	17.1	134.9
200	1.41	.26	2.34	1.40	.93	30	20	13	48	6325	88.6	16.6	148.4
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	14.2	20.9	16.3	11.4	17.2	26.3	18.5	43.4	9.6	13.9	14.7	17.0	21.1

Table 4. The effect of phosphorus on the elemental analyses of leaf samples of nonoilseed sunflower in experiment 1.

P_2O_5 Rate	Elemental Analyses								
	N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A	%					ppm			
0	3.47	.27	2.81	2.52	1.35	69	28	15	80
40	3.50	.27	3.14	2.62	1.21	50	23	15	82
80	3.48	.29	2.96	2.65	1.29	56	20	11	84
120	3.52	.31	2.59	2.77	1.54	66	24	15	83
160	3.14	.32	3.00	2.69	1.29	65	21	12	76
200	3.18	.35	2.89	2.98	1.40	59	19	14	92
Significance	N.S.	**	N.S.	N.S.	*	N.S.	*	N.S.	N.S.
B.L.S.D. (.05)		.05			.23		7		
C.V. (%)	7.1	10.1	13.8	9.7	10.0	22.3	17.0	51.7	11.3

Table 5. The effect of potassium on the elemental analyses, dry matter yield, and nutrient uptake of sunflower whole plants in experiment 2 (approximate height-10 inches).

K_2O Rate	Elemental Analyses									T.D.M. Yield	Uptake		
	N	P	K	Ca	Mg	Mn	Zn	Cu	B		N	P	K
	%					ppm				lb/A			
0	3.56	.56	6.19	2.22	1.03	70	28	10	52	496	17.3	3.0	31.4
50	3.66	.60	6.39	2.16	1.00	83	23	8	53	534	19.6	3.2	34.3
100	3.50	.60	6.33	2.26	.90	80	24	7	49	471	16.5	3.0	29.9
150	3.61	.52	6.00	2.38	1.09	104	25	9	54	437	15.8	2.3	26.2
200	3.60	.54	6.61	2.10	.99	81	24	8	49	469	16.9	2.5	31.0
250	3.39	.55	6.76	1.88	1.00	59	24	9	46	427	14.6	2.5	29.4
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)													
C.V. (%)	4.6	27.2	7.9	11.7	11.3	20.1	14.4	38.0	8.3	33.0	33.2	48.7	36.9

Table 6. The effect of potassium on the elemental analyses, dry matter yield, and nutrient uptake of sunflower whole plants in experiment 2 (90% pollinated).

K_2O Rate	Elemental Analyses N	P	K	Ca	Mg	Mn	Zn	Cu	B	T.D.M. Yield	Uptake N	P	K
lb/A	%					ppm				lb/A			
0	1.95	.27	3.28	1.49	1.01	30	23	11	53	4689	89.5	12.3	153.3
50	2.00	.28	3.25	1.73	1.19	45	21	8	64	5949	119.0	16.7	193.4
100	1.87	.23	2.84	1.78	1.21	48	18	9	56	5257	97.6	11.8	149.3
150	1.69	.24	2.93	1.47	1.27	46	19	10	50	5272	88.7	12.4	154.5
200	1.81	.24	3.44	1.53	1.01	37	17	8	45	4690	83.3	11.0	162.3
250	1.83	.25	3.42	1.49	1.05	29	24	13	54	5307	102.7	13.3	182.0
Significance	N.S.	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)			0.45										
C.V. (%)	7.1	9.0	5.0	7.4	7.2	16.9	21.6	42.1	10.1	10.4	8.2	10.9	13.1

Table 7. The effect of potassium on the elemental analyses, dry matter yield, and nutrient uptake of sunflower whole plants in experiment 2 at maturity.

K_2O Rate	Elemental Analyses N	P	K	Ca	Mg	Mn	Zn	Cu	B	T.D.M. Yield	Uptake N	P	K
	%					ppm				lb/A			
0	1.82	.23	2.12	1.22	.88	21	22	12	38	6396	117.3	14.7	134.1
50	1.59	.26	2.41	1.05	.83	28	20	8	36	7145	113.5	18.6	172.4
100	1.44	.20	2.74	1.06	.77	24	18	9	32	6921	99.2	13.5	189.8
150	1.42	.22	2.44	.99	.99	24	22	12	34	5988	84.8	12.9	145.8
200	1.55	.27	2.68	1.18	.71	24	21	11	34	6952	107.5	18.4	183.0
250	1.61	.21	2.36	1.02	.87	21	28	16	37	6256	100.7	13.1	147.6
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	8.6	13.4	14.4	8.4	11.0	8.8	30.2	43.5	11.3	9.8	15.4	12.5	11.1

Table 8. The effect of potassium on the elemental analyses of leaf samples of nonoilseed sunflower in experiment 2.

K_2O Rate	Elemental Analyses N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A	%					ppm			
0	3.17	.33	3.28	2.75	1.36	53	27	18	85
50	3.23	.34	2.99	2.67	1.48	71	21	11	89
100	3.25	.33	3.04	3.12	1.28	74	22	13	96
150	3.30	.31	3.44	2.47	1.41	59	24	21	79
200	3.28	.32	3.26	3.02	1.30	69	24	16	83
250	3.32	.34	3.61	2.52	1.26	52	25	22	83
Significance	N.S.	N.S.	*	*	N.S.	**	N.S.	N.S.	N.S.
B.L.S.D. (.05)			0.42	0.52		16			
C.V. (%)	5.5	9.7	7.9	11.3	15.2	14.9	20.9	48.1	12.0

Table 9. The effect of potassium on the elemental analyses, dry matter yield, and nutrient uptake of sunflower whole plants in experiment 3 (approximate height-10 inches).

K_2O Rate	Elemental Analyses N	P	K	Ca	Mg	Mn	Zn	Cu	B	T.D.M. Yield	Uptake N	P	K
lb/A	%					ppm				lb/A			
0	3.30	.47	5.76	2.45	.91	83	21	9	50	313	10	1.5	18
50	3.19	.44	5.72	2.31	.98	84	22	11	49	360	12	1.6	21
100	3.50	.46	5.69	2.36	.95	81	22	11	49	338	12	1.6	19
150	3.42	.45	5.68	2.74	.96	95	22	12	50	346	12	1.4	20
200	3.30	.43	5.84	2.40	.88	87	22	11	48	358	12	1.3	21
250	3.21	.47	6.20	2.38	.87	78	23	11	49	319	10	1.5	20
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	5.2	16.8	5.4	11.8	9.9	14.1	13.9	25.8	5.9	17.0	15.5	24.3	20.3

Table 10. The effect of potassium on the elemental analyses, dry matter yield, and nutrient uptake of sunflower whole plants in experiment 3 (90% pollinated).

K_2O Rate	Elemental Analyses N	P	K	Ca	Mg	Mn	Zn	Cu	B	T.D.M. Yield	Uptake N	P	K
lb/A	%					ppm				lb/A			
0	1.88	.24	2.20	1.74	1.31	44	19	9	46	5398	85.6	12.6	118.8
50	1.88	.24	2.58	1.54	1.29	43	21	10	45	5019	94.6	12.2	128.2
100	1.80	.23	2.60	1.70	1.26	42	18	9	45	5140	92.1	11.7	133.5
150	1.87	.24	2.73	1.72	1.21	42	19	10	44	5255	98.1	12.6	143.6
200	1.74	.22	3.08	1.55	1.10	39	18	10	42	5433	94.6	11.6	168.0
250	1.75	.22	3.20	1.54	1.03	36	20	9	44	6076	106.0	13.2	194.7
Significance	N.S.	N.S.	**	N.S.	**	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.	**
B.L.S.D. (.05)			.48		.16					685			28.8
C.V. (%)	5.3	8.2	11.3	10.9	8.5	12.2	23.2	25.5	8.9	7.5	15.4	12.9	13.1

Table 11. The effect of potassium on the elemental analyses of leaf samples of nonoilseed sunflower in experiment 3.

K_2O Rate	Elemental Analyses N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A	%					ppm			
0	3.05	.31	2.44	2.99	1.72	66	21	16	69
50	2.97	.31	2.59	2.86	1.76	69	23	17	69
100	3.07	.33	2.68	3.20	1.65	73	20	16	73
150	3.33	.32	2.85	2.92	1.56	65	21	15	59
200	3.06	.31	3.00	3.07	1.45	71	22	20	67
250	3.12	.30	3.22	2.93	1.41	64	22	17	68
Significance	N.S.	N.S.	**	N.S.	**	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)			.31		.17				
C.V. (%)	5.6	8.7	7.4	10.2	6.8	9.5	22.8	31.9	12.1

Table 12. The effect of potassium on seed yield, harvest population, elemental analyses of the seed, and nutrient removal at maturity of nonoilseed sunflower in experiment 3.

K_2O Rate	Seed Yield	Harvest Population	Elemental Analyses N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Nutrient Removal N	P	K
lb/A	lb/A	Plants/A	%					ppm					lb/A		
0	1633	18,590	3.22	0.55	0.85	0.24	0.38	43	25	40	15	19	51.9	8.8	13.8
50	1629	18,590	2.89	0.50	0.82	0.21	0.35	39	23	37	16	17	47.6	8.2	13.4
100	1637	19,310	3.23	0.56	0.87	0.24	0.38	44	26	36	14	19	52.8	9.1	14.1
150	1751	18,440	3.11	0.54	0.86	0.23	0.37	47	25	37	14	18	54.6	9.5	15.0
200	1801	17,280	3.35	0.54	0.85	0.23	0.36	46	25	38	15	18	60.3	9.7	15.4
250	1679	16,990	3.34	0.57	0.89	0.23	0.38	49	26	40	15	19	56.1	9.6	15.0
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	13.4	7.1	7.1	8.9	4.4	7.4	7.8	10.3	9.2	18.6	12.9	6.3	14.8	18.0	13.6

Table 13. The effect of phosphorus on the elemental analyses, dry matter yield, and nutrient uptake of sunflower whole plants in experiment 4 (approximate height-10 inches).

P_2O_5 Rate	Elemental Analyses N	P	K	Ca	Mg	Mn	Zn	Cu	B	T.D.M. Yield	Uptake N	P	K
lb/A	%					ppm					lb/A		
0	3.37	.36	5.89	1.94	1.00	63	21	8	43	354	12.3	1.3	21.2
40	3.47	.41	5.87	2.07	.99	59	21	9	44	380	13.1	1.5	22.4
80	3.46	.53	5.52	2.21	1.03	63	19	8	47	397	13.6	2.1	22.4
120	3.06	.66	5.69	2.11	.96	50	18	7	42	375	11.6	2.5	21.5
160	3.11	.69	5.76	2.17	1.02	53	18	7	45	427	13.4	2.9	24.6
200	3.29	.76	5.88	2.08	1.03	52	18	8	44	397	13.1	3.0	23.8
Significance	N.S.	**	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.	N.S.	N.S.	*	N.S.
B.L.S.D. (.05)		.19					3					1.2	
C.V. (%)	7.5	22.1	7.7	11.4	11.9	20.6	10.4	14.9	5.8	17.6	22.2	32.9	21.1

Table 14. The effect of phosphorus on the elemental analyses of leaf samples of nonoilseed sunflower in experiment 4.

P_2O_5 Rate	Elemental Analyses N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A	%					ppm			
0	3.34	.32	3.43	2.54	1.31	50	27	24	81
40	3.07	.31	3.24	2.74	1.34	46	24	19	67
80	3.15	.37	3.14	2.81	1.37	49	19	15	74
120	3.08	.38	3.44	2.89	1.32	50	20	14	74
160	3.10	.40	3.18	2.92	1.34	49	19	16	79
200	3.23	.37	3.45	2.65	1.41	52	20	18	75
Significance	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)		0.08							
C.V. (%)	8.3	12.3	5.2	8.7	10.7	14.6	18.1	29.3	9.8

Table 15. The effect of potassium on seed yield, harvest population, elemental analyses of the seed, and nutrient removal at maturity of nonoilseed sunflower in experiment 4.

P_2O_5 Rate	Seed Yield	Harvest Population	Elemental Analyses N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Nutrient Removal N	P	K
lb/A	lb/A	Plants/A	%					ppm					lb/A		
0	1329	16,840	3.30	0.61	0.94	0.24	0.41	53	28	55	19	20	43.8	8.1	12.5
40	1620	16,840	3.20	0.55	0.93	0.23	0.39	49	24	51	18	20	51.9	8.8	15.0
80	1671	17,420	3.14	0.63	0.95	0.23	0.42	50	25	41	15	19	52.7	10.5	15.8
120	1476	17,230	3.34	0.67	1.01	0.25	0.43	50	26	44	16	21	49.2	9.9	14.9
160	1614	17,230	3.47	0.67	0.98	0.24	0.43	58	27	45	16	21	49.2	10.8	15.7
200	1258	17,420	3.56	0.68	1.02	0.24	0.45	56	29	53	19	22	55.9	8.6	12.9
Significance	+	N.S.	N.S.	**	**	N.S.	N.S.	N.S.	*	*	*	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)				0.06	0.06				3	10	3				
C.V. (%)	11.9	4.9	6.0	6.0	3.6	9.7	6.7	9.1	7.4	12.8	11.2	6.3	13.4	15.5	13.6

Table 16. Dry matter yields, nutrient content, and nutrient uptake of nonoilseed sunflower at various sampling dates.

Experiment	Sampling Date	T.D.M.	Nutrient Content N	P	K	Uptake N	P	K
	1981	lb/A	%			lb/A		
1	6-24	372	3.71	0.50	6.14	13.7	2.0	23.2
1	8-11	4801	1.96	0.25	2.99	95.0	12.2	143.8
1	9-10	6135	1.52	0.25	2.41	92.4	15.3	147.6
2	6-24	470	3.54	0.56	6.40	16.7	2.7	30.3
2	8-11	5211	1.86	0.25	3.19	96.2	12.9	166.1
2	9-10	6642	1.56	0.23	2.47	104.1	15.4	163.4
3	6-24	327	3.32	0.45	5.81	10.8	1.5	19.1
3	8-11	5387	1.82	0.23	2.73	95.2	12.3	147.8
4	6-24	388	3.29	0.57	5.77	12.8	2.2	22.6

Table 17. Nutrient analyses and removal data for the seed of nonoilseed sunflower.

Experiment	Seed Yield	Nutrient Content N	P	K	Removal N	P	K
	lb/A	%			lb/A		
3	1688	3.19	0.54	0.86	53.9	9.2	14.4
4	1528	3.33	0.63	0.97	50.1	9.6	14.6

EFFECTS OF NITROGEN RATE AND PLACEMENT ON TWO MALTING BARLEY VARIETIES

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The importance of malting barley in Northwest Minnesota has generated the need for additional information on nitrogen fertilization with the release of higher yielding varieties. These varieties have higher yield potentials, greater straw strength and better disease resistance than previously released varieties, but their performance under varying nitrogen management programs has had very little testing. This study was established to evaluate the effects of nitrogen and its placement on two of the recently released varieties, Morex and Glenn.

Experimental Procedure:

The treatments consisted of nitrogen fertilizer (28-0-0) at rates of 0, 50, 100 and 150 lb N/A, surface applied (broadcast) and injected (6 inches deep, 14 inches apart), on two malting barley varieties in a complete factorial arrangement. Four replications were used. The fertilizer was applied and the varieties planted on May 1, 1981.

Whole plant samples were taken at late tillering (6-16-81) and N content was determined. Forage samples were taken at soft dough (7-20-81) to measure total N uptake. Grain was harvested (7-28-81) to determine yield and quality. Lodging scores were taken (7-13-81).

Initial soil test results indicated 70 lb NO_3-N/A available in the top 2 feet.

Results:

The effects of the treatments are shown in Table 1. A significant variety by nitrogen rate interaction was obtained with respect to grain yield and test weight. Morex increased in yield with the addition of the first 50 lb/A N applied and then decreased as additional N was added while Glenn also increased in yield with the first 50 lb/A N applied and then its yield remained the same as additional N was added. The test weight of Morex decreased with each increment of additional N while Glenn's test weight did not start to decrease until 100 lb/A N was added.

Significant differences in early plant N content, forage yield, protein, and plump kernels were obtained between the varieties (Table 1). Morex was significantly higher in early plant N content and protein and significantly lower in forage yield and plump kernels than Glenn. No significant differences in forage N, N uptake, or lodging were obtained between the varieties.

Increasing nitrogen significantly increased early plant N content, forage yield, forage N content, N uptake, protein, and lodging and significantly reduced plump kernels (Table 1).

Nitrogen placement caused significant differences in early plant N content, forage N content, N uptake and test weight (Table 1). Injection of the N caused significantly higher early plant N content, forage N content, and N uptake and significantly reduced test weight when compared to the surface N application.

Table 1. Influence of N rate, placement and variety on early plant N, forage yield, N content and N uptake, grain yield, bushel weight, protein, plump kernels, and lodging.

			Forage			Grain				
Variety	N-Rate	N[1/]	D.M. Yield	N[2/]	N Uptake	Yield	Test Weight	Protein	Plump Kernels	Lodging[3/]
	lb/A	%	lb/A	%	lb/A	Bu/A	lb/Bu	%	%	
Morex	0	2.36	5885	0.89	52.7	64.6	45.1	9.5	64.2	1.00
Morex	50	2.78	7539	1.11	83.3	82.3	43.7	11.0	58.9	1.13
Morex	100	3.36	7976	1.19	95.0	78.9	42.3	12.0	57.2	1.88
Morex	150	3.47	8104	1.37	110.8	74.0	41.2	12.8	52.0	3.13
Glenn	0	2.02	6284	0.86	54.1	66.0	45.3	9.2	74.7	1.00
Glenn	50	2.56	7939	1.05	82.9	87.8	45.1	10.5	72.0	1.00
Glenn	100	2.86	8550	1.25	107.1	89.5	43.8	11.7	63.6	1.75
Glenn	150	3.24	8293	1.27	104.9	88.7	42.7	12.4	60.2	2.63
Significance		N.S.	N.S.	N.S.	N.S.	*	*	N.S.	N.S.	N.S.
C.V. (%)		8.6	8.0	9.8	12.3	7.7	1.7	5.1	16.0	33.5
Main Effects										
Variety										
Morex		2.99	7376	1.14	85.4	74.9	43.1	11.3	58.1	1.78
Glenn		2.67	7767	1.11	87.2	83.0	44.2	11.0	67.6	1.59
Significance		**	**	N.S.	N.S.			*	**	N.S.
B.L.S.D. (.05)		0.12	308					0.3	5.1	
N Rate lb/A										
0		2.19	6085	0.88	53.4	65.3	45.2	9.4	69.4	1.00
50		2.67	7739	1.08	83.1	85.1	44.4	10.7	65.4	1.06
100		3.11	8263	1.22	101.0	84.2	43.1	11.8	60.4	1.81
150		3.36	8198	1.32	107.8	81.4	41.9	12.6	56.1	2.88
Significance		**	**	**	**			**	**	**
B.L.S.D. (.05)		0.15	389	0.07	6.7			0.3	7.2	0.36
N Placement										
Surface		2.77	7625	1.07	82.9	79.2	43.8	11.0	63.6	1.59
Injected		2.89	7518	1.18	89.7	78.7	43.4	11.3	62.1	1.78
Significance		*	N.S.	**	**	N.S.	*	N.S.	N.S.	N.S.
B.L.S.D. (.05)		0.12		0.06	5.4		0.4			

[1/] Kjeldahl N (whole plant - late tillering).

[2/] Kjeldahl N.

[3/] Lodging scores (1=erect, 5=flat).

THE EFFECTS OF ANHYDROUS AMMONIA AT PLANTING TIME ON SPRING WHEAT AND BARLEY

G.E. Varvel and R.K. Severson

Anhydrous ammonia has become the main N source used in the Northern Great Plains on small grains, but most of it is applied in the fall preceding the crop year. This practice works satisfactorily in most years, but cases do arise where spring application of the N fertilizer becomes necessary. In these cases, some questions have arisen concerning the timing of anhydrous application with respect to seeding time. The main concern has been possible germination damage if seeding was done too soon after the anhydrous application. This study was designed to determine the effect of anhydrous ammonia at planting time on spring wheat and barley.

Experimental Procedure:

Three years of field experiments were conducted on a Wheatville loam soil. Results reported here are from the final year (1981) of the study. The experiment was conducted using a split-plot design with time of seeding as the main plot with combinations of 4 reates of N (0, 40, 80 and 120 lb/A) at 3 application depths (3, 6 and 9 inches) in a factorial arrangement as subplots within each main plot. Four replications were used. Times of seeding were 0, 24 and 48 hours after the anhydrous treatments were applied on May 5, 1981.

Stand counts were taken on May 30, 1981. Yield samples were taken on July 28 and August 11, 1981 for the barley and wheat respectively with subsamples taken for protein analyses.

Initial soil test levels for the study were: pH-7.9, NO_3-N (0-2')-50 lb/A, $NaHCO_3$ P-30 lb/A, and exchangeable K-330 lb/A.

Results:

Grain yield, protein, and stand count were not affected by time of seeding of wheat or barley (Table 1). Nitrogen significantly increased yield and protein of wheat and barley and reduced barley stand count. It had no affect on wheat stand count (Table 1). Depth of application significantly reduced stand count of both wheat and barley, wheat yield, and increased protein of barley. No significant interactions were obtained.

Table 1. Effects of time of seeding after anhydrous application, N rate, and depth of application on yield, protein, and stand count of spring wheat and barley.

Seeding Time 1/	Wheat			Barley		
	Yield	Protein	Stand	Yield	Protein	Stand
	Bu/A	%	Plants/m^2	Bu/A	%	Plants/m^2
0	38.4	12.4	183	55.2	12.0	174
24	39.6	12.6	201	54.7	11.8	185
48	37.7	12.5	197	52.7	11.7	184
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	11.7	4.7	10.7	13.1	5.5	9.9
N Rate lb/A						
0	33.4	11.3	193	43.5	10.5	181
40	39.8	12.1	194	54.6	11.2	186
80	41.1	13.2	193	61.0	12.4	180
120	40.1	13.5	193	57.8	13.2	177
Significance	**	**	N.S.	N.S.	**	N.S.
B.L.S.D. (.05)	1.9	0.1		3.0	0.3	
Application Depth inches						
3	39.2	12.4	199	54.1	11.6	185
6	39.6	12.5	200	56.1	11.9	188
9	36.9	12.6	182	52.5	12.0	170
Significance	**	N.S.	**	*	*	**
B.L.S.D. (.05)	1.8		8	3.1	0.3	7

1/ - Seeding times in hours after anhydrous application.

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

G.E. Varvel and R. K. Severson

The objective of this study was to measure the effect of different fertilizer programs over a 10-year period on soil test levels in a continuous wheat cropping system on a Wheatville loam soil. Measurements on a yearly basis will provide information for evaluation and determination of the most effective fertilizer program.

Experimental Procedure:
Five treatments in a randomized, complete block design with 4 replications were used. Each treatment was based upon soil test data from the plots on which that treatment had been applied in the previous year. All treatments were applied in the fall of 1980 and plowed down. Era wheat was planted April 8, 1981 and harvested Aug. 8, 1981. Whole plant samples taken July 16, 1981 at soft dough were used to determine forage yields and analyzed for nutrient content so that N, P and K uptake could be calculated. Soil samples taken August 18, 1981 were analyzed for N, P and K to determine the effects of the 1981 treatments and to establish the 1982 treatments.

Results:
The treatments caused no significant differences in grain yield (Table 1). All treatments which had fertilizer applied caused significantly higher protein, N removal, forage yield, and N, P, and K uptake values than were obtained with the check treatment (Table 1). Test weight of the grain was significantly reduced where fertilizer had been applied.

Table 1. The effect of various fertilizer programs on grain yield, test weight, protein, N removal, forage yield, and N, P, and K uptake of Era wheat.

Treatment			Grain				Forage			
				Test		N	T.D.M.	Uptake		
N	P_2O_5	K_2O	Yield	Weight	Protein	Removal	Yield	N	P	K
- - - lb/A - - -			Bu/A	lb/Bu	%	lb/A	- - - - - - - lb/A - - - - - -			
0	0	0	50.3	59.0	12.0	63.7	5720	76.9	11.4	67.8
50	0	20	54.7	56.1	13.5	77.9	7373	107.6	15.7	87.7
50	0	50	53.2	56.6	13.5	75.7	7273	103.2	14.3	94.1
60	0	20	54.0	55.9	14.0	79.5	7330	116.6	14.5	96.5
50	30	20	56.5	57.2	13.5	80.1	7334	107.7	17.0	98.2
Significance			N.S.	*	**	*	**	**	**	**
B.L.S.D. (.05)				2.4	0.4	13.2	973	15.4	3.1	17.3
C.V. (%)			9.9	2.5	2.2	10.2	8.7	9.9	13.0	12.2

Soil test results from the fall of 1981 sampling are shown in Tables 2 and 3. Table 2 contains NO_3-N levels at the various depths and total NO_3-N levels for the 0-2' and 0-5' depths. Significant differences in NO_3-N for the 0-1' and 1-2' depths and total NO_3-N for the 0-2' depth were obtained between the check and all the other treatments (Table 2).

Table 2. The effect of various fertilizer programs on NO_3-N soil test levels.

Treatment			NO_3-N					Total NO_3-N	
N	P_2O_5	K_2O	0-1'	1-2'	2-3'	3-4'	4-5'	0-2'	0-5'
- - - - lb/A - - - -			- - - - - - - lb/depth - - - - - - -					- - lb/A - -	
0	0	0	14	5	5	10	11	18	43
50	0	20	22	21	37	28	10	42	116
50	0	50	22	12	35	29	13	34	110
60	0	20	23	18	44	38	18	41	141
50	30	20	19	14	40	64	19	33	155
Significance			+	+	N.S.	N.S.	N.S.	*	N.S.
B.L.S.D. (.05)			8	14				15	
C.V. (%)			23.8	58.4	96.4	114.1	81.9	26.8	61.9

+,* - Indicates significance at the 10% and 5% levels respectively.

Table 3 contains pH, P and K soil test measurements for the 0-6" and 6-12" depths from the North Dakota State University soil testing laboratory and for the 0-6" depth from the University of Minnesota soil testing laboratory. Significant differences in $NaHCO_3$ P levels and Bray P-1 (50:1) levels were obtained between the fertilizer programs and the check. [3]No other differences were obtained.

Table 3. The effect of various fertilizer programs on pH, P and K soil test measurements.

Treatment			N.D.S.U.						U of M			
			pH		$NaHCO_3$ P		Exchangeable K		pH	Bray P-1		Exchangeable K
N	P_2O_5	K_2O	0-6"	6-12"	0-6"	6-12"	0-6"	6-12"	0-6"	10:1 0-6"	50:1 0-6"	0-6"
- - - - lb/A - - -					- - lb/A - - - - - - - - - -					- - - lb/A - - - - - - -		
0	0	0	8.3	8.4	6	4	226	188	7.9	3	18	247
50	0	20	8.2	8.3	11	8	245	199	8.0	5	26	253
50	0	50	8.2	8.4	10	7	243	199	8.0	5	27	253
60	0	20	8.2	8.3	11	5	233	183	7.9	7	27	244
50	30	20	8.2	8.3	14	9	228	189	7.9	11	31	242
Significance			N.S.	N.S.	**	**	N.S.	N.S.	N.S.	N.S.	**	N.S.
B.L.S.D. (.05)					4	3					5	
C.V. (%)			0.9	0.9	26.0	30.5	7.2	4.8	0.7	95.0	12.8	6.7

Nitrogen Fertilization and Nitrogen Utilization by Fourteen Small Grain Varieties -- Crookston, MN. - 1981*

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

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

Experimental Procedures

Fourteen varieties of hard red spring wheat were compared at nitrogen application rates of 0,60, and 120#N/A at the Northwest Experiment Station at Crookston. Nitrogen was applied as a spring application of ammonium nitrate broadcast and incorporated. The treatments were arranged in a split plot design with nitrogen as the main effect and the 14 varieties planted within a uniformly fertilized area. All treatments were replicated four times. Experimental plots were planted into areas 4' x 20' on April 10th, utilizing a cone seeder.

Dry matter production was determined at approximately the "soft dough" stage of growth (July 17th) and samples collected for nitrogen content and calculation of nitrogen uptake. Yield grain was harvested August 4th by harvesting 16 ft^2 of plot area. The above ground growth (grain + straw) was removed from the experimental plot and placed in a forced air dryer. After drying, the samples were weighted, thrashed, and the grain re-weighed for yield determination. Straw weight was determined by difference. Samples of both the grain and the straw were collected for determination of nitrogen content and total nitrogen removal.

General Results

The yield results obtained in 1981 were excellent when considering the exceptionally dry conditions that were experienced early in the growing season. Grain yields ranged from 34-62 bu/A with the top yielding varieties including MN7125,MN7222, Butte, Olaf, and MN70170 R. Grain yields were substancially increased with the addition of 60#/A of fertilizer nitrogen, but were significantly reduced when the rate of nitrogen application was increased to 120 #N/A. Varieties reflecting the largest decrease included Kitt, Marquis, MN7125 and Waldron. Protein content of the grain was significantly increased by nitrogen fertilizer up through the highest rate of application (120#N/A). Waldron, Coteau, Olaf, WS1809 and Chris were among the varieties with the highest protein content while Era, MN7125, MN7222 and MN70170R were among the lower protein varieites. Total nitrogen removal by the crop was increased with nitrogen application but varied significantly between varieties with a significant N x Variety interaction. Olaf, Butte, MN7125, Waldron, and Kitt removed the highest total amount of nitrogen. These varieties were not necessarily the varieties with the highest nitrogen removal with the grain.

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

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

Nitrogen Rate	Variety	Grain Yield	Grain N Content	Grain Test wt.	Forage Total Dry Matter	Forage N Content
#/A		bu/A	%	#/bu	T/A	%
0	-	41.6	2.24	58.5	3.18	0.81
60		49.9	2.46	58.4	3.75	1.06
120		48.5	2.63	57.7	3.76	1.31
Significance		**	**	NS	**	**
BLSD (.05)		1.3	0.09	0.5	0.21	0.08
-	Coteau	44.9	2.74	59.9	3.63	0.97
-	WS 1809	45.2	2.63	56.5	3.16	1.20
-	Era	50.4	2.05	59.4	3.36	1.08
-	Mn 70170R	51.1	2.29	59.3	3.58	1.11
-	Chris	40.2	2.60	58.6	3.48	1.05
-	James	46.7	2.45	57.1	3.60	1.03
-	Waldron	43.9	2.76	57.4	3.83	0.94
-	Mn 7125	56.6	2.12	58.1	3.84	1.05
-	Butte	53.7	2.38	61.2	4.04	0.97
-	Olaf	51.1	2.69	58.9	3.74	1.12
-	Mn 7222	55.0	2.17	56.5	3.76	1.03
-	Thatcher	33.5	2.47	56.1	3.28	0.99
-	Marquis	32.3	2.42	58.4	3.26	1.10
-	Kitt	48.4	2.45	57.5	3.36	1.15
Significance		**	**	**	**	**
BLSD (.05)		3.9	0.11	1.0	0.25	0.14
0	Coteau	36.3	2.57	59.3	3.29	0.70
0	WS1809	39.4	2.40	56.7	2.79	0.92
0	Era	37.8	1.80	58.7	2.45	0.76
0	Mn70170R	45.5	2.00	59.9	3.15	0.78
0	Chris	34.7	2.44	58.4	3.02	0.84
0	James	41.4	2.21	57.6	3.08	0.80
0	Waldron	39.0	2.65	57.3	3.47	0.83
0	Mn7125	48.6	1.90	57.4	3.42	0.79
0	Butte	44.7	1.95	61.4	3.73	0.62
0	Olaf	46.8	2.62	59.7	3.46	0.91
0	Mn7222	52.3	1.94	59.1	3.29	0.76
0	Thatcher	38.1	2.44	56.7	3.15	0.83
0	Marquis	34.9	2.18	59.2	3.24	0.87
0	Kitt	43.6	2.23	58.1	3.05	0.93
60	Coteau	48.5	2.75	60.7	3.82	0.98
60	WS1809	47.1	2.67	56.4	3.52	1.21
60	Ear	57.0	2.02	59.7	3.82	1.16
60	Mn 70170R	54.2	2.29	59.9	3.76	1.15
60	Chris	42.5	2.48	59.0	3.70	1.06
60	James	49.1	2.50	57.7	3.88	1.05
60	Waldron	48.2	2.73	57.5	3.91	0.88
60	Mn 7125	62.8	2.13	59.0	4.01	1.04
60	Butte	59.2	2.52	61.0	4.07	1.07
60	Olaf	52.5	2.70	59.2	3.82	1.14
60	Mn 7222	57.0	2.26	55.5	3.95	0.97
60	Thatcher	32.6	2.48	56.2	3.43	0.97
60	Marquis	33.2	2.56	58.0	3.34	1.01
60	Kitt	54.3	2.45	57.9	3.51	1.12

"Table 1 continued on page after next"

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

Nitrogen Rate	Variety	Harvest Straw Dry Matter	Harvest Straw N Content	Nitrogen Removal Forage	Nitrogen Removal Straw	Nitrogen Removal Grain	Grain a Straw
#/A		T/A	%	#/A			
0		1.90	0.30	51.9	11.6	48.0	59.7
60		2.33	0.46	73.3	21.4	63.3	84.8
120		2.29	0.61	98.1	27.7	66.0	93.7
Significance		*	**	**	**	**	**
BLSD (.05)		0.26	0.05	6.4	1.6	2.7	2.8
-	Coteau	2.30	0.39	71.6	18.5	64.4	82.9
-	WS 1809	1.83	0.46	76.8	17.1	62.0	79.1
-	Era	1.95	0.49	76.0	20.1	54.4	74.5
-	Mn 70170R	2.07	0.47	81.8	20.2	61.2	81.4
-	Chris	2.31	0.47	74.7	22.2	54.5	76.7
-	James	2.32	0.45	75.4	21.3	59.6	80.9
-	Waldron	2.36	0.44	73.5	20.9	63.1	84.0
-	Mn 7125	2.22	0.47	82.1	21.4	62.7	84.1
-	Butte	2.32	0.44	79.1	20.7	67.2	87.9
-	Olaf	2.42	0.44	84.6	21.6	71.4	93.0
-	Mn 7222	2.08	0.46	79.2	19.3	62.1	81.4
-	Thatcher	2.15	0.44	65.5	18.8	42.9	61.6
-	Marquis	2.09	0.49	71.3	20.1	40.5	60.6
-	Kitt	2.02	0.51	78.7	21.4	61.9	83.3
Significance		**	**	NS	*	**	**
BLSD (.05)		0.16	0.06	-	3.9	6.1	7.0
0	Coteau	1.90	0.29	46.3	11.0	48.2	59.1
0	WS 1809	1.54	0.31	52.2	9.5	48.9	58.5
0	Era	1.48	0.28	37.4	8.5	34.8	43.3
0	Mn 70170R	1.67	0.33	49.8	11.3	47.6	58.9
0	Chris	2.07	0.28	51.6	11.9	44.0	56.0
0	James	2.06	0.29	50.7	11.7	47.3	59.0
0	Waldron	2.12	0.32	58.8	13.5	53.7	67.2
0	Mn 7125	1.90	0.28	53.5	10.6	47.7	58.3
0	Butte	2.05	0.26	45.3	10.8	45.1	56.0
0	Olaf	2.12	0.35	63.4	14.8	64.0	78.8
0	Mn 7222	1.86	0.34	50.5	12.4	52.6	65.1
0	Thatcher	2.14	0.30	52.5	12.9	48.1	61.0
0	Marquis	2.09	0.30	56.3	12.7	39.5	52.3
0	Kitt	1.66	0.34	58.1	11.5	50.9	62.3
60	Coteau	2.49	0.37	75.6	18.4	69.1	87.5
60	WS 1809	1.97	0.45	84.8	17.5	65.0	82.5
60	Era	2.26	0.53	88.7	23.8	59.5	83.2
60	Mn 70170R	2.26	0.49	86.8	22.2	64.3	86.5
60	Chris	2.59	0.45	78.3	23.4	54.6	78.0
60	James	2.43	0.45	81.0	22.3	63.7	86.0
60	Waldron	2.42	0.45	68.8	21.5	68.9	90.4
60	Mn 7125	2.47	0.50	84.7	24.6	69.3	93.9
60	Butte	2.49	0.47	86.7	23.1	77.2	100.3
60	Olaf	2.49	0.39	87.1	19.1	73.5	92.6
60	Mn 7222	2.13	0.49	76.1	20.8	66.6	87.4
60	Thatcher	2.25	0.45	66.5	20.2	41.8	61.9
60	Marquis	2.14	0.48	66.5	20.6	44.0	64.7
60	Kitt	2.19	0.52	78.4	22.5	69.0	91.5

"Table 2 continued on next page"

Table 1. Influence of nitrogen fertilizer and variety on yield, N content and test weight of 14 red spring wheat varieties (con't)

Nitrogen Rate	Variety	Grain Yield	Grain N Content	Grain Test wt.	Forage Total Dry Matter	Forage N Content
#/A		bu/A	%	#/bu	T/A	%
120	Coteau	50.1	2.92	59.6	3.78	1.23
120	WS1809	49.3	2.83	56.4	3.19	1.46
120	Era	56.3	2.35	59.9	3.82	1.33
120	Mn 70170R	53.7	2.57	58.2	3.82	1.43
120	Chris	43.6	2.88	58.3	3.73	1.26
120	James	49.7	2.63	56.2	3.83	1.23
120	Waldron	44.4	2.90	57.4	4.11	1.13
120	Mn 7125	58.5	2.34	57.9	4.09	1.32
120	Butte	57.1	2.67	61.2	4.32	1.22
120	Olaf	53.9	2.74	57.9	3.95	1.31
120	Mn 7222	55.7	2.32	54.9	4.04	1.36
120	Thatcher	30.0	2.49	55.4	3.29	1.18
120	Marquis	28.8	2.53	57.9	3.20	1.42
120	Kitt	47.3	2.69	56.6	3.52	1.41
Significance		**	**	+	NS	NS
BLSD (.05)		9.1	0.28	2.4	-	-

Table 2 Influence of nitrogen fertilization and variety on straw production and nitrogen uptake by forage, straw, and grain of 14 hard red spring wheat varieites (con't)

Nitrogen Rate	Variety	Harvest Straw Dry Matter	Harvest Straw N Content	Nitrogen Removal Forage	Nitrogen Removal Straw	Nitrogen Removal Grain	Grain a Straw
#/A		T/A	%	#/A			
120	Coteau	2.51	0.52	92.9	26.0	76.0	102.0
120	WS 1809	1.99	0.61	93.3	24.3	71.9	96.2
120	Era	2.10	0.67	101.9	28.0	68.8	96.8
120	Mn 70170R	2.27	0.60	108.7	27.2	71.8	98.9
120	Chris	2.27	0.69	94.3	31.3	64.7	96.1
120	James	2.48	0.60	94.6	29.8	67.7	97.5
120	Waldron	2.54	0.55	92.8	27.9	66.7	94.6
120	Mn7125	2.29	0.64	108.1	29.2	71.0	100.2
120	Butte	2.41	0.59	105.2	28.3	79.2	107.5
120	Olaf	2.64	0.59	103.3	30.9	76.6	107.5
120	Mn 7222	2.26	0.55	110.3	24.8	67.1	91.8
120	Thatcher	2.06	0.57	77.4	23.2	38.7	61.9
120	Marquis	2.05	0.67	91.2	27.0	37.8	64.8
120	Kitt	2.22	0.68	99.7	30.2	65.9	96.1
Significance		*	NS	NS	NS	**	**
BLSD (.05)		0.43	-	-	-	13.3	14.9

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

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

(Annual reports of this experiment have been reported in Soil Series 74 through 109 and some of this information will not be include here).

The fertilizer treatments have now been annually applied to the same plot area for 22 years. After ear corn removal and stalk cutting, the fall plow down N treatments are broadcast on their respective plots and the entire area is then plowed to an approximate 12 inch depth. The fall surface N treatments are then broadcast, with no further working of the plow area. Each plot is 20' x 77.5' and the 4 replication are arranged in a randomized block. Spring N treatments are broadcast before seedbed preparation late in April or early May. The corn is planted in 30 inch rows at a plant population of 20,000 plant/A, using a band starter fertilizer of 8-24-12 at a rate of 180 lbs/A over the entire experimental area, thus supplying an additional 14 #N/A to all the plots. Nitrogen sidedressing treatments were boradcast on June 20th. Nitrogen concentrations for the yield grain were determined and are reported along with plot yields in table 1. The yields obtained in 1981 were below average when considering the long term previous average for this experiment. Treatment averages in 1981 appeared to follow the trends which had been established with the long term average yields. The extremely dry conditions experienced at the S.W. Experiment Station early in the growing season appeared to have a considerable influence on the results obtained.

Twenty-one Year Average

The average grain yields for the twenty years of this experiment are shown in Table 2. Only modest differences were obtained between nitrogen forms, time of application, and incorporation in the 1981 experiment. The major yield differences that were obtained in 1981 were due to the rate of nitrogen fertilization. The twenty-one year average would suggest that when only 40 # of N/A was fall applied, urea was slightly better than ammonium nitrate with very little difference due to incorporation.

Plowing down 80 # 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 yields as with spring applications although ammonium nitrate applied in the fall was inferior to spring applications at the 40 # N/A rate of application.

Table 1. Average N in yield grain, grain yield at 15.5% moisture, and 21 year corn average from Webster loam fertilized annually with NH_4NO_3 or urea.

N applied annually lbs/A	Yield Grain % N	Yield Grain bu/A Rep I	Rep II	Rep III	Rep IV	Ave
Check	1.12	74.7	61.2	51.9	60.2	62.0
40-NH_4NO_3-fpd[2]	1.20	77.7	90.4	74.3	67.2	77.4
40-urea-fpd	1.22	65.5	97.1	73.2	112.1	87.0
40-NH_4NO_3 - fps[3]	1.22	101.8	87.9	70.6	97.4	89.4
40-urea - fps	1.20	83.2	73.4	77.2	88.1	80.5
80-NH_4NO_3 - fpd	1.38	85.0	77.0	95.9	100.6	89.6
80 - urea - fpd	1.38	93.7	101.8	100.9	111.0	101.8
160 - NH_4NO_3 - fpd	1.45	67.1	104.6	96.8	96.8	91.3
160 - urea - fpd	1.40	116.9	77.2	85.1	111.1	97.6
40 - NH_4NO_3-std[4]	1.15	102.8	87.5	74.5	95.1	90.0
40 - urea - std	1.12	97.5	94.4	68.3	86.0	86.6
80 - NH_4NO_3-std	1.28	101.6	104.3	102.9	96.9	101.4
80 - urea - std	1.30	91.1	97.7	96.8	125.8	102.8
40 - NH_4NO_3-sd[5]	1.22	72.2	77.1	87.5	97.6	83.6
40 - urea - sd	1.25	102.3	76.8	87.3	83.4	87.4
80 - NH_4NO_3-sd	1.38	65.5	95.3	68.6	87.7	79.3
80 - urea - sd	1.32	103.8	96.4	64.6	84.6	87.4
160 -NH_4NO_3-sd	1.45	105.5	75.9	93.6	111.9	96.7
Significance	**					*
BLSD (.05)	0.07					21.9

[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 top dress [5]sd -- sidedress

Table 2. Yields of ear corn during 21 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 and additonal 14 lbs N/A as starter fertilizer annually (8-24-12@ 180#/A).
[2]fpd -- fall plow down [3] fps -- fall plow surface [4] std -- spring topdress [5] sd -- sidedress

Table 2.(con't).

	1970	1971	1972	1973	1974	1975	*1/ 1977	1978	1979	1980	1981	21 yr Ave.
Check	85.7	40.8	75.6	69.2	53.4	58.3	141.2	64.6	37.6	46.5	65.8	63.1
40 NH_4NO_3-fpd[2]	96.3	88.7	113.6	92.0	80.5	88.6	145.1	98.1	63.1	67.6	77.4	81.0
40 Urea-fpd	120.4	100.7	113.9	101.5	96.9	96.6	165.2	110.2	76.7	65.2	87.0	87.6
40 NH_4NO_3-fps	122.5	81.5	109.9	93.0	88.3	78.2	149.4	101.3	64.6	69.7	89.4	83.8
40 Urea-fpd	121.2	82.4	106.7	97.8	85.0	78.9	156.8	101.4	80.2	63.8	80.5	86.5
80 NH_4NO_3-fpd	134.7	108.0	143.1	121.7	103.6	89.2	156.9	128.4	94.8	90.3	89.6	101.1
80 Urea -fpd	141.4	107.8	140.1	117.9	107.2	96.9	146.0	123.6	86.2	84.7	101.8	98.8
160 NH_4NO_3-fpd	141.7	120.2	147.6	121.0	113.1	90.4	149.8	129.3	108.7	109.3	91.3	104.4
160 Urea-fpd	140.4	110.6	151.7	114.9	105.1	82.4	163.0	124.4	127.3	103.7	97.6	106.6
40 NH_4NO_3-std	125.6	84.0	117.0	104.0	82.8	88.0	160.0	97.4	86.6	77.2	90.0	91.1
40 Urea-std	118.9	94.6	116.5	97.1	94.5	89.0	165.2	103.9	74.5	64.3	86.6	89.8
80 NH_4NO_3-std	140.4	122.7	142.7	118.0	92.9	97.6	162.9	117.1	87.3	74.4	101.4	101.4
80 Urea-std	146.2	116.0	142.1	117.6	108.5	93.6	162.2	127.4	100.3	84.4	102.8	103.9
40 NH_4NO_3-sd[5]	127.1	104.5	136.0	99.1	82.7	91.8	153.8	106.8	99.2	71.9	83.6	92.3
40 Urea-sd	117.1	100.5	133.9	103.9	80.4	92.6	165.4	104.8	94.2	80.4	87.4	91.9
80 NH_4NO_3-sd	127.7	97.6	124.7	109.4	87.6	95.3	163.2	110.6	106.3	76.9	79.3	95.4
80 Urea-sd	140.5	124.4	149.8	124.0	95.6	90.1	162.8	126.7	118.1	89.6	87.4	104.8
160 NH_4NO_3-sd	136.9	104.2	150.0	117.1	105.5	91.3	160.3	126.0	148.0	109.8	96.7	106.6
Ave. annual corn yield in bu/A	127.0	99.4	128.6	106.6	92.4	88.3	157.2	111.2	919	79.4	88.6	93.8
Significance											**	**
C.V. (%)											14.2	10.1
BLSD (.05)											21.9	5.2

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

*1/ 1976 No Yields Taken

NITRATE CORRELATION STUDY WITH CORN FOLLOWING CORN, SOYBEANS AND WHEAT - Lamberton, MN - 1981

G.L. Malzer and W.W. Nelson

The rates of fertilizer nitrogen recommended for corn production in Minnesota are currently based upon yield goal and previous cropping history. In many respects depending on the climate conditions, these recommendations have the potential of being too high or too low. Nitrate nitrogen correlation studies were started in 1976 in S.W. MN. to determine if residual nitrates could be used as a predictive tool in fertilizer recommendations. Adjustments in fertilizer recommendations are currently made on the basis of previous cropping history. For this reason, three separate experiments were established at the SW Experiment Station in 1980 and again in 1981 to evaluate the importance of previous crop in respect to residual nitrate nitrogen and fertilizer nitrogen response.

Experimental Procedures

Three separate experiments were established utilizing corn with previous cropping histories of corn, soybeans and wheat. Six different rates of nitrogen fertilizer (none, 40, 80, 120, 160 and 240 # N/A) were applied as spring applications of urea. The six nitrogen rates were replicated four times in each experiment. The fertilizer was applied on April 28th and incorporated by field cultivator, corn (Pioneer 3732) was planted on April 29th at 24,000 seeds/A. A tank mix of Lasso (2 1/2 # ai/A) and Bladex (1 1/2 # ai/A) was used for weed control.

Yields were taken by combine and justed to 15.5% moisture, and a subsample taken for Kjeldahl nitrogen.

General Results

The climate experienced at Lamberton in 1981 was characterized by being extremely dry during the first part of the growing season with more than adequate precipitation later in the season. Considering these extremes corn grain yields were quite respectable. Added fertilizer nitrogen increased corn grain yields on corn following corn up through the 160 # N/A application. There was no yield response to the addition of nitrogen with corn following soybeans or corn following wheat. The grain yields on the corn following soybeans were comparable to the higher rates of nitrogen on the corn following corn. Yield levels on the corn following wheat area were considerably reduced suggesting that some other factor other than nitrogen limited full expression of the yield potential in 1981. Responses reflected the quantity of residual nitrate nitrogen as well as previous cropping history.

A new soil testing technique has been developed and implemented for use in Western Minnesota in making nitrogen fertilizer recommendations to corn. The recommendation is based on three major factors: 1) Residual nitrate nitrogen - samples are requested from a 0-2' depth or a 0-2' and 2-4' depths - corrections are made for positional availability of nitrate nitrogen (water utilization characteristics) 2) A credit for organic matter mineralization and 3) An adjustment for previous cropping history. This information is used to calculate a base yield, and the fertilizer N requirement is based on the difference between this value and the producers yield goal. This technique provided very good fertilizer nitrogen recommendations when used with the 1981 research information. Further details concerning this procedure will be forthcoming.

Table 1. Influence of nitrogen rates on yield grain content and grain yield on corn following corn, soybeans and wheat at Lamberton, MN - 1981

	Corn/Corn		Corn/Soybeans		Corn/Wheat	
Treatments	Grain N	Yield	Grain N	Yield	Grain N	Yield
#N/A	%	bu/A	%	bu/A	%	bu/A
Check	1.25	91.4	1.21	128.4	1.21	104.1
40	1.18	111.2	1.27	137.6	1.28	106.6
80	1.20	121.7	1.31	144.6	1.34	100.2
120	1.36	114.4	1.37	143.6	1.32	113.7
160	1.34	132.6	1.42	133.8	1.49	109.9
240	1.40	136.4	1.36	131.6	1.39	110.4
Significance	NS	**	*	NS	*	NS
BLSD (.05)	-	18.1	0.14	-	0.15	-

Table 2. 1980 Fall nitrates for corn, soybeans, and wheat plots

depth	corn	soybeans	wheat
ft	----------ppm----------		
0-1	2.5	4.8	11.4
1-2	0.9	1.9	4.0
2-3	0.9	2.0	5.5
3-4	1.9	3.8	9.7
4-5	2.5	4.7	11.1

WEST CENTRAL EXPERIMENT STATION - MORRIS

WEATHER SUMMARY - 1981

Month	Period	Precipitation 1981	Precipitation 94-yr. av.	Precipitation Dev. from av.	Air Temperature 1981	Air Temperature 94-yr. av.	Air Temperature Dev. from av.	Soil (10 cm) Temperature 1981	Soil (10 cm) Temperature 10-yr.av.
January	1-31	.23	.68	- .45	12.9	8.0	+4.9	18.1	20.7
February	1-28	1.43	.67	+ .76	19.9	12.6	+7.3	21.2	23.9
March	1-31	.67	1.09	- .42	35.0	26.7	+8.4	36.9	29.2
April	1-10	.57	.58	- .01	45.3	37.9	+7.4	43.5	
	11-20	.10	.65	- .55	47.1	44.4	+2.7	48.6	
	21-31	1.11	1.08	+ .03	49.7	48.2	+1.5	51.1	
Total or av.		1.78	2.31	- .53	47.4	43.5	+3.9	46.1	41.4
May	1-10	.25	.78	- .53	51.4	51.9	-0.5	55.7	
	11-20	T	.95	- .95	53.6	55.8	-2.2	60.8	
	21-31	1.69	1.25	+ .44	59.3	60.1	-0.8	61.9	
Total or av.		1.94	2.98	-1.04	55.0	56.1	-1.1	59.5	57.1
June	1-10	1.91	1.26	+ .65	64.4	63.1	+1.3	67.1	
	11-20	3.76	1.27	+2.49	61.7	66.5	-4.8	66.6	
	21-30	1.01	1.38	- .37	64.0	68.2	-4.2	67.9	
Total or av.		6.68	3.91	+2.77	63.4	66.0	-2.5	67.2	69.3
July	1-10	T	1.48	-1.48	72.4	70.0	+2.4	81.0	
	11-20	3.64	1.03	+2.61	72.1	71.3	+0.8	77.1	
	21-31	.12	1.03	- .91	66.0	71.5	-5.5	74.2	
Total or av.		3.76	3.54	+ .23	70.1	71.0	-0.9	77.3	76.7
August	1-10	1.30	1.05	+ .25	71.2	70.3	+0.9	77.5	
	11-20	.15	.90	- .75	66.4	69.2	-2.8	76.3	
	21-31	1.22	.98	+ .24	66.1	66.9	-0.8	70.1	
Total or av.		2.67	2.93	- .26	67.8	68.7	-0.9	74.5	73.9
September	1-30	.54	2.19	-1.65	58.5	59.1	-0.6	63.2	61.5
October	1-31	3.28	1.62	+1.66	44.2	47.3	-3.1	44.2	47.8
November	1-30	.64	.96	- .32	36.0	29.7	+6.3	37.1	33.6
December	1-31	.56	.68	- .12	12.1	15.5	-3.4	29.0	23.4
April-August Growing Season		16.83	15.67	+1.16	60.7	61.1	-0.4	64.9	63.8
January-December Annual		24.18	23.56	+ .62	43.8	42.0	+1.8	48.1	46.7

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, 105, 107 and 109. The last manure applications were made in the fall of 1978, but fertilizer has been applied to the fertilized check each year.

I. Planting Information

The plots were planted to Pioneer 3901 on April 28, 1981. Counter @ 8.8 lbs/acre (1 lb/acre active ingredient) was applied in the row to the entire area at planting. Starter fertilizer consisting of 154 lbs/acre of 10-26-26 was applied to the fertilized treatment. Nitrogen in the form of urea and zinc as $ZnSO_4$ were applied to the fertilized plots to provide 125 lbs/acre of N and 12 lbs/acre of Zinc, respectively, on October 30, 1980. Lasso (2.5 lbs/acre) and Bladex (2.2 lbs/acre) were broadcast on April 29, 1981. Atrazine (1.5 lbs/acre) and booster concentrate (1 qt/acre) were applied June 5, 1981.

II. Soil Sampling and Analysis

A. 1980 Measurements

NO_3-N was the only variable measured in the fall of 1980. The values shown in Table 1 indicate very little change from those values one year earlier.

B. 1981 Measurements

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

III. Plant Tissue Analysis (Table 2)

There were significant effects on all elements except copper. There were some significant effects of solid beef manure on increasing leaf levels of P, K and Fe and decreasing leaf levels of Ca, Mg and Zn as compared to the fertilized check. The effects of liquid beef manure were similar with most elements.

IV. Growth and Yield Measurements (Table 3)

A. Early plant height and dry matter - Plants on the manure treated plots were taller (except for LB1) and weighed more than on the fertilized check.

B. Grain - In no cases were there significant differences in yield or grain N content between manure treated and fertilized plots. There were significant differences in grain moisture, but there were no clear trends.

C. Silage - Some manure treated plots were significantly wetter than the fertilized check. There were no significant differences in yield between the manure treated and fertilized plots. The ear:stalk ratios were not significantly affected by treatment.

V. Summary

The 1981 cropping season was the third since manure had been applied. It appears that even the lowest rates of each manure were sufficient for yields equal to or higher than the fertilized check.

Table 1. Effect of two types of beef cattle manure and commercial fertilizer on the NO_3-N level of a Tara soil profile - Fall 1980.

Depth - ft -	Treatment CK	FE	SB1	SB2	SB3	LB1	LB2	LB3
	- NO_3-N, ppm -							
0-1	8.3	13.9	28.5	33.7	98.0	11.2	14.4	63.6
1-2	1.4	77.8	23.6	127.3	158.7	33.9	52.0	136.4
2-3	2.4	70.0	78.7	148.9	178.7	52.4	47.9	130.0
3-4	5.9	48.1	53.3	127.0	149.3	35.4	51.9	129.0

Table 2. Summary of analysis of corn leaves at silking - 1981.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	2.44	.26	1.17	.42	.50	80	17.1	2.2	74	4.6
FE	2.71	.25	1.41	.47	.46	82	21.8	2.2	100	4.1
SB1	2.82	.37	2.04	.46	.30	92	13.9	2.7	100	4.2
SB2	2.96	.54	2.45	.39	.22	99	16.9	2.0	74	3.6
SB3	2.78	.55	2.62	.35	.21	93	19.0	1.9	62	3.5
LB1	2.67	.30	1.57	.46	.41	81	15.4	2.7	90	4.1
LB2	2.79	.34	1.92	.43	.36	88	15.1	3.1	91	4.0
LB3	2.86	.48	2.08	.46	.31	104	12.4	2.1	87	4.0
Significance	**	**	**	**	**	**	**	NS	*	**
BLSD(.05)	0.24	.07	.23	.05	.03	8	2.8	--	8	0.7
CV(%)	4.6	10.9	7.6	6.5	6.3	5.5	10.1	23.6	4.9	10.6

Table 3. Summary of plant measurements - 1981.

Treatment	Early plant height inches	Early plants (10) dry weight grams	Grain: Moisture at harvest %	Grain: Yield @ 15.5% M Bu/A	Grain: Nitrogen %	Silage: Dry matter at harvest %	Silage: Silage yield (D.M.) lbs/A	Silage: Ear wt. ÷ Silage wt. %
CK	23.0	47.0	23.1	94.8	1.10	48.2	9033	58.7
FE	23.8	57.7	22.4	133.1	1.41	46.0	12300	59.0
SB1	30.5	123.7	19.9	135.6	1.32	51.7	14297	59.4
SB2	31.5	130.7	18.9	125.7	1.51	50.8	13020	59.8
SB3	31.7	129.5	20.0	142.3	1.48	45.0	14242	59.4
LB1	24.4	71.3	21.1	131.6	1.38	52.6	13783	59.8
LB2	28.6	98.4	19.4	132.1	1.42	52.6	13777	59.1
LB3	30.8	117.9	19.7	136.7	1.47	50.2	14434	58.7
Significance	**	**	**	**	*	**	**	NS
BLSD(.05)	1.8	15.9	0.8	19.3	0.24	4.3	2744	--
CV(%)	4.0	10.1	2.8	8.3	8.8	4.7	11.2	2.3

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 from previous years are given in Soil Series 88, 89, 91, 95, 97, 99, 103, 105, 107 and 109. Manure was applied in 1970 and 1971 only. Fertilizer has been applied to the fertilized checks each year.

I. Planting Information

Twenty-four rows of corn (var. Pioneer 3901) were planted in each plot on April 28, 1981. Counter at 8.8 lbs/acre (1 lb/acre active ingredient) was applied in the row at planting to all plots. Starter fertilizer consisting of 154 lbs/acre of 10-26-26 was applied to the fertilized treatment only. Nitrogen in the form of urea and zinc as $ZnSO_4$ were applied to the fertilized plots to provide 125 lbs/acre of N and 12 lbs/acre of zinc, respectively, on October 30, 1980. Lasso (2.5 lbs/acre) and Bladex (2.2 lbs/acre) were applied broadcast on April 29, 1981. Atrazine (1.5 lbs/acre) and booster concentrate (1 qt/acre) were applied on June 5, 1981.

II. Soil Sampling and Analysis

A. 1980 Measurements

NO_3-N was the only variable measured in the fall of 1980. The values shown in Table 1 indicate that levels in most soil zones changed little in the past year. The only exception was a substantial increase in the 3- to 4-foot increment of SB.

B. 1981 Measurements

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

III. Plant Tissue Analysis

The nutrient concentrations in the ear leaves at silking in 1981 are given in Table 2. There were significant effects on most elements. The concentrations of P and K were higher in all manure treatments than in the fertilized treatment. There were significant differences between at least one manure treatment and the fertilized treatment for N, Ca, Mg, Zn, Cu and B.

IV. Growth and Yield Measurements (Table 3)

A. Early plant height and dry matter - Plants on the manure treated plots were taller than those on the fertilized treatment. Dry matter differences were not significant.

B. Grain - There were no significant differences in grain yield or grain N content between the manure treatments and the fertilized treatment.

C. Silage - There were no significant differences between the manure treatments and the fertilized treatment in silage yield, but there were minor differences in the ear:stalk ratio.

V. Summary

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

Table 1. Effect of high rates of manure and commercial fertilizer ten years (fall 1980) 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	5.9	10.3	14.9	16.4	6.6
1-2	4.8	31.6	26.9	85.3	11.4
2-3	0.6	48.1	79.7	131.3	45.0
3-4	1.1	34.5	95.7	130.3	47.7

Table 2. Summary of analysis of corn leaves at silking - 1981.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	2.01	.21	0.96	.48	.53	76	16.4	2.4	88	5.6
FE	2.70	.28	1.33	.51	.51	88	21.1	2.1	85	4.4
SB	2.68	.38	2.08	.43	.25	90	15.2	3.2	84	3.8
LB	2.69	.43	1.90	.51	.28	97	13.0	2.4	74	4.1
LH	2.35	.34	1.82	.46	.33	85	20.3	3.8	76	4.3
Significance	**	**	**	*	**	*	**	*	NS	**
BLSD(.05)	0.32	.05	0.25	.06	.05	11	3.7	0.8	--	0.4
CV(%)	5.7	9.0	8.6	6.6	6.7	7.3	13.0	17.7	16.9	5.2

Table 3. Summary of plant measurements - 1981.

Treatment	Early plant height inches	Early plants (10) dry wt. grams	Grain: Ear moisture at harvest %	Grain: Yield @ 15.5% M. Bu/A	Grain: Nitrogen %	Silage: Dry matter at harvest %	Silage: Silage yield (D.M.) lb/A	Silage: Ear wt. ÷ silage wt. %
CK	18.4	59.5	22.8	67.2	0.92	49.8	8315	53.6
FE	24.1	82.9	20.3	115.6	1.35	48.7	13032	59.2
SB	31.2	90.5	19.5	114.6	1.37	53.5	13483	59.9
LB	32.0	108.0	19.7	115.0	1.31	52.8	12958	60.1
LH	27.9	78.2	20.0	107.0	1.34	53.2	13151	61.6
Significance	**	NS	**	**	*	*	**	**
BLSD(.05)	1.6	--	1.2	36.8	0.29	2.9	814	1.9
CV(%)	3.3	44.8	3.2	6.2	9.6	2.9	3.8	1.8

NITROGEN FERTILIZATION AND NITROGEN UTILIZATION BY EIGHT SMALL GRAIN VARIETIES - MORRIS, MN - 1981

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

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 provide 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 Procedure

Eight 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, MN. Nitrogen was applied as spring applications of ammonium nitrate broadcast and incorporated. The treatments were arranged in a split plot design with nitrogen as the main effect and the eight varieties planted within a uniformly fertilized area. All treatments were replicated four times. Experimental plots were planted into areas 4' x 20' on April 10th, utilizing a cone seeder.

Total plant dry matter was measured at approximately the "soft dough" stage of growth (July 9th) for the earlier maturing varieties and (July 16th) for the later maturing varieties. Samples were collected for nitrogen content and calculation of nitrogen uptake. Yield grain was harvested on July 27th for the early maturing varieties and July 29th for the later maturing varieties by harvesting 16 ft^2 of the plot area. The above ground growth (straw and 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.

General Results

Wheat grain yields were significantly influenced both by rate of nitrogen application and variety. In general response was limited to the first 60 # N/A application although some varieties such as Coteau provide modest increases upto the 120 # N/A rate of application. Varieties when averaged across nitrogen rates provided a range of 34-47 bu/A, with MN7222, Era and MN70170R among the top yielding varieties. These same varieties were among the highest yielding reguardless of nitrogen rate. The protein content of the grain was not influence by N rate, but was influenced by variety with MN70170R having the highest protein content among the highest yielding varieties. Total nitrogen removal was influenced both by rate of N fertilization and variety. In general as nitrogen rate increased so did total nitrogen uptake. The quantity of nitrogen translocated into the grain also increased but at a much slower rate than grain nitrogen removal suggesting that a large portion of the nitrogen taken up remained in the straw. When averaged over nitrogen rate there was very little difference between varieties in their ability to accumulate nitrogen in the grain. When evaluating varieties within nitrogen rates, the varieties did show some differences. At low (check) nitrogen levels MN7222 was able to acculate a larger proportion of its total N uptake

in the grain, while at the higer nitrogen rates (120 # N/A) Coteau and Waldron exhibited the greatest ability to translocate its nitrogen into the grain. Further research is needed in this area to assist in developing varieties which are both effective in nitrogen uptake and efficient in translocation into the grain.

Table 1. Influence of nitrogen fertilizeration and variety on yield, N content and test weight, of eight spring wehat varieties.

Nitrogen Rate	Variety	Grain Yield	Grain N content	Grain Test wt	Forage Total Dry matter	Forage N content
#/A		bu/A	%	#/bu	T/A	%
0	-	29.6	2.55	58.2	2.45	1.03
60	-	45.0	2.59	58.0	3.40	1.16
120	-	46.2	2.64	56.6	3.59	1.28
Significance		**	NS	*	**	**
BLSD(.05)		4.2	-	1.3	0.36	0.08
-	Coteau	38.8	3.00	59.2	3.28	1.18
-	WS1809	33.6	2.67	55.6	3.33	1.36
-	Era	44.8	2.29	58.8	3.30	1.08
-	Mn70170R	43.8	2.52	57.8	3.24	1.17
-	Chris	34.6	2.71	57.9	3.44	1.08
-	James	42.7	2.51	58.0	3.37	1.17
-	Waldron	37.0	2.80	57.8	3.12	1.10
-	MN7222	46.6	2.24	56.0	3.10	1.14
Significance		**	**	**	**	**
BLSD(.05)		3.7	0.09	1.1	0.22	0.09
0	Coteau	25.7	2.81	59.1	2.35	1.16
0	WS1809	24.7	2.58	57.9	1.84	1.09
0	Era	34.2	2.18	59.5	2.61	1.00
0	MN70170R	34.2	2.62	57.6	2.67	0.99
0	Chris	27.1	2.52	57.8	2.77	1.11
0	James	32.6	2.57	58.3	2.75	1.04
0	Waldron	23.0	2.86	58.2	2.37	0.89
0	MN7222	35.2	2.26	57.1	2.24	0.96
60	Coteau	42.9	3.09	58.9	3.68	1.24
60	WS1809	37.9	2.76	55.2	2.52	1.37
60	Era	51.2	2.33	60.1	3.55	1.04
60	MN70170R	48.5	2.33	58.8	3.46	1.20
60	Chris	37.6	2.86	59.2	3.58	1.04
60	James	47.7	2.39	58.8	3.51	1.16
60	Waldron	41.5	2.79	58.2	3.43	1.22
60	MN7222	52.3	2.19	55.1	3.47	1.06
120	Coteau	47.7	3.10	59.6	3.80	1.15
120	WS1809	38.3	2.68	53.7	2.62	1.61
120	Era	49.1	2.37	57.0	3.75	1.21
120	MN70170R	48.7	2.61	57.1	3.60	1.33
120	Chris	39.2	2.76	57.7	3.99	1.09
120	James	47.9	2.57	56.8	3.85	1.30
120	Waldron	46.4	2.78	57.1	3.56	1.18
120	MN7222	52.5	2.29	54.7	3.58	1.40
Significance		NS	**	+	NS	**
BLSD(.05)		-	0.18	2.4	-	0.18

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

Nitrogen Rate	Variety	Harvest Dry Matter	Straw N Content	Nitrogen Removal Forage	straw	Grain	Grain + straw
#/A		T/A	%	#/A			
0	-	1.24	0.36	50.8	8.6	38.6	47.2
60	-	2.05	0.42	78.7	17.2	59.7	76.9
120	-	2.40	0.60	91.1	28.5	63.2	91.7
Significance		**	**	**	**	**	**
BLSD(.05)		0.20	0.10	8.5	4.4	5.4	8.1
-	Coteau	2.12	0.40	78.1	17.9	60.9	78.8
-	WS1809	1.39	0.59	64.3	17.3	46.9	64.2
-	Era	1.93	0.47	72.5	19.2	53.6	72.8
-	Mn70170R	1.87	0.49	77.3	19.3	57.0	76.2
-	Chris	2.09	0.42	74.6	18.6	48.9	65.6
-	James	2.12	0.48	79.5	20.5	55.5	75.8
-	Waldron	1.93	0.40	69.9	16.1	53.8	70.0
-	MN7222	1.72	0.44	72.2	16.0	54.3	70.4
Significance		**	**	**	+	**	**
BLSD(.05)		0.13	0.06	9.1	9.1	5.9	7.5
0	Coteau	1.33	0.33	56.3	8.8	37.6	46.4
0	WS1809	0.79	0.50	40.1	8.0	33.0	41.0
0	Era	1.29	0.35	52.6	8.8	38.5	47.3
0	MN70170R	1.28	0.36	53.9	9.1	46.4	55.5
0	Chris	1.32	0.28	62.4	7.5	35.3	42.8
0	James	1.45	0.44	56.6	11.6	42.8	54.5
0	Waldron	1.27	0.34	41.5	8.4	34.4	42.8
0	MN7222	1.15	0.28	43.2	6.5	41.4	47.6
60	Coteau	2.39	0.39	91.0	18.5	68.4	86.9
60	WS1809	1.54	0.53	68.6	16.5	54.4	70.8
60	Era	2.08	0.44	74.1	18.3	62.0	80.3
60	MN70170R	1.94	0.43	82.8	16.7	58.6	75.3
60	Chris	2.25	0.40	74.7	17.9	55.3	73.2
60	James	2.28	0.41	81.5	18.4	59.5	77.9
60	Waldron	2.08	0.38	83.7	15.9	60.0	75.9
60	MN7222	1.85	0.43	72.9	15.7	59.4	75.0
120	Coteau	2.65	0.49	87.0	26.4	76.7	103.0
120	WS1809	1.84	0.74	84.2	27.4	53.3	80.7
120	Era	2.42	0.63	90.9	30.7	60.2	90.9
120	MN70170R	2.39	0.67	95.3	31.9	65.9	97.8
120	Chris	2.68	0.57	86.6	30.5	56.2	86.7
120	James	2.62	0.60	100.4	31.4	63.8	95.1
120	Waldron	2.45	0.49	84.4	24.1	67.1	91.2
120	MN7222	2.16	0.60	100.4	25.9	62.5	88.4
Significance		NS	NS	+	NS	NS	NS
BLSD(.05)		-	-	15.9	-	-	-

EFFECTS OF NITROGEN AND PHOSPHORUS APPLICATION METHODS ON SPRING WHEAT - 1981

West Central Experiment Station - Morris

S. D. Evans

The objective of this study was to compare nitrogen and phosphorus application methods on spring wheat. The study was initiated to determine if dual banding of dry forms of nitrogen and phosphorus is more effective than broadcast or drill applications on spring wheat growth and yield.

Experimental Procedures

Treatments used are given in Table 1. The experimental area had been in oats in 1980. In September the area was chisel plowed. The fall treatments were applied on November 5-6, 1980. Rates were calculated to give equal final rates of N and P. Materials used were urea (46-0-0) and triple superphosphate (0-46-0). The materials were mixed and applied with an air seeder as described in Table 1.

Era wheat was seeded April 7 and harvested August 7 with a plot combine. Whole plant samples were collected on July 17 and were used to calculate forage yield and N and P uptake.

Soil test results for the area were: pH = 7.7-8.2, NO_3-N (0-2') = 21 lb/A, Bray exchangeable P = 16 lb/A, extractable K = 219. The soil type was a complex of Tara and McIntosh silt loams.

Results and Discussion

The results from this study are shown in Table 1. The dry matter yield was increased significantly by nitrogen application, but there was no significant effect of placement or the combination of N and P. Phosphorus uptake was higher where N and P were applied together than where N only was applied. Nitrogen uptake was closely related to N rate applied. The highest % N and N uptake occurred with the drill application of 70 N + 40 P_2O_5 and this treatment was significantly different from the same N and P rates surface broadcast or deep banded.

Grain yields were also related largely to N application rate. There was a significant difference in yield between the check treatment and the 40 lb/A N rate and between the 40 lb/A N rate and the 80 lb/A N rate. In no case were there significant differences in yields between placement methods. There appeared to be a phosphorus response at the higher N rate. Grain protein was not significantly affected by treatment.

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

	Whole Plants @ Soft Dough Stage					Lodging Score		
Treatment Description[1]	D.M. Yield	Phosphorus	Phosphorus Uptake	Nitrogen	Nitrogen Uptake	at Harvest[3]	Grain Yield	Grain Protein
	lb/A	%	lb/A	%	lb/A		Bu/A	%
Check	4324	.200	8.58	1.15	47.8	2.0	33.7	12.0
35 N + 40 P_2O_5, Surface BCST	5674	.199	11.24	1.07	62.6	3.2	44.1	12.1
70 N + 40 P_2O_5, Surface BCST	7198	.172	12.34	0.98	70.7	4.5	57.2	12.7
35 N + 40 P_2O_5, Deep Band[2] (12" Spacing)	5234	.192	10.02	1.06	56.0	2.8	47.9	11.4
70 N + 40 P_2O_5, Deep Band (12" Spacing)	6722	.162	10.76	0.95	63.6	3.8	55.1	12.0
25 N, Surface BCST + 10 N and 40 P_2O_5 with Drill	6373	.156	10.04	0.91	59.8	3.8	47.5	12.2
60 N, Surface BCST + 10 N and 40 P_2O_5 with Drill	7415	.182	13.29	1.27	93.2	5.8	60.8	13.0
35 N, Deep Band (12" Spacing)	5404	.158	8.62	1.00	54.4	2.8	44.9	11.7
70 N, Deep Band (12" Spacing)	6410	.152	9.81	1.07	69.1	3.8	47.7	11.7
40 P_2O_5, Deep Band (12" Spacing)	3886	.182	7.07	0.96	37.0	1.5	31.4	12.4
Significance:	**	NS	*	NS	*	**	**	NS
BLSD (.05):	1442	-	4.26	-	29.0	2.3	11.5	-
CV (%)	16.9	20.0	23.7	24.2	28.5	37.5	16.8	9.1

[1] All material except drill applications were made on Nov. 5-6, 1980. All plots were chisel plowed during or after fertilizer application.

[2] Deep bands applied with Wil-Rich Air Seeder with chisel points, depth 8-10".

[3] Lodging score: 1 = No lodging, 9 = Flat.

EFFECTS OF NITROGEN AND PHOSPHORUS APPLICATION METHODS ON CORN - 1981

West Central Experiment Station - Morris

S. D. Evans and G. L. Malzer

The objective of this study was to compare nitrogen and phosphorus application methods on corn. The study was initiated to determine if dual banding of dry forms of nitrogen and phosphorus is more effective than broadcast applications on corn growth and yield.

Experimental Procedures

Treatments used are given in Table 1. The experimental area had been in oats in 1980. Soil test results in August 1980 were: pH = 6.6-7.8, Bray exchangeable P = 14*-32 lb/A, extractable K = 296-416 lb/A. A fertilizer application consisting of 110 lb/A of P_2O_5 and 70 lb/A of K_2O was broadcast on September 10, 1980. The entire area was chisel plowed on September 18. The fall treatments were applied November 5-6, 1980. The deep bander was pulled thru the check and surface broadcast so that all plots had the same tillage.

The area was dug with a field cultivator keeping the tillage depth above the fall applied bands. The area was drug and planted to corn (Pioneer 3906) @ 22,000 seeds/acre on May 5. Ear leaf samples at silking were collected on July 24. Silage yields with ears and stover being separated were taken on September 16. Grain yields were taken with a plot combine on October 19.

Results and Discussion

The results of the study are shown in Table 1. The silage and grain yields were not significantly affected by treatment. There was some apparent N response in grain yield with the 35-lb N rate generally yielding more than the check and the 70-lb N rate yielding more than the 35-lb N rate.

Ear leaf N concentrations were significantly affected by treatment. However the only significant differences are between those plots receiving no nitrogen and those receiving 70 lb/A of nitrogen. Ear leaf P concentrations were not significantly different.

The only significant variable measured in the stover was percent N. The deep band treatments with N and P appeared to have lower values than the same N levels without P. There were no consistent effects of N rates.

Grain analysis showed significant effects on percent N and N uptake. The treatments with no N were significantly lower than all other treatments. At the 35-lb N rate surface broadcast was significantly higher than deep band but at the 70-lb N rate the percent N values were identical. There appeared to be little effect on the P. The N uptake figures show a significant effect of N rates but no effect of placement or P. The percent P and P uptake figures show no effect of treatment.

Table 1. Effect of N and P application methods on corn.

N[1] Rate	P_2O_5[1] Rate	Placement Method[2]	Ear Leaf Analysis at Silking N	Ear Leaf Analysis at Silking P	Stover N	Stover N Uptake	Stover P	Stover P Uptake	Grain N	Grain N Uptake	Grain P	Grain P Uptake	Silage Yield	Grain Yield
lb/A	lb/A	-	%	%	%	lb/A	%	lb/A	%	lb/A	%	lb/A	T DM/A	Bu/A
0	0	-	2.57	.29	.44	20.2	.057	2.7	1.18	89.4	.28	20.8	6.09	112.6
35	40	SB	2.79	.28	.54	27.4	.062	3.1	1.37	111.4	.27	21.8	6.56	110.8
70	40	SB	3.09	.30	.58	27.2	.058	2.7	1.49	122.8	.27	22.0	6.47	127.6
35	40	DB	2.65	.30	.49	23.1	.060	2.9	1.21	100.6	.28	22.9	6.53	124.4
70	40	DB	2.94	.30	.49	25.0	.050	2.6	1.40	118.9	.27	22.6	6.80	128.0
35	0	DB	2.85	.30	.61	28.0	.078	3.3	1.34	105.4	.25	19.6	6.22	121.6
70	0	DB	2.97	.28	.58	31.5	.054	2.9	1.37	124.4	.25	23.2	7.26	132.3
0	40	DB	2.58	.28	.48	23.9	.071	3.4	1.27	96.3	.26	19.5	6.28	113.4
Significance			**	NS	+	NS	NS	NS	**	*	NS	NS	NS	NS
BLSD (.05)			.30	-	-	-	-	-	.08	21.5	-	-	-	-
CV (%)			5.7	4.8	13.2	20.0	30.8	21.5	3.5	10.3	7.8	8.1	10.4	8.0

[1] N Source - Urea (46-0-0), P_2O_5 Source - Triple superphosphate (0-46-0).

[2] SB = Surface broadcast, DB = Deep bands on a 12-inch spacing with Wil-Rich Air Seeder with chisel points at a depth of 8-10 inches.

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 nine 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 lb/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 lb/A of P and K, respectively; the 120-lb rate of meal, 12 and 39 lb/A of P and K, respectively. An overall application of 100 lb/A of P_2O_5 and 100 lb/A of K_2O was made in the spring of 1981. 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 nine years and the average are given in Table 1. Significant yield differences occurred in 1974, 1979, 1980, and 1981. In no case was more than 80 lb N/A needed for maximum yield. In fact, in some years lesser amounts of N were adequate--1976 - 40 lb/A, 1977 - starter only, and 1978 - 40 lb/A. The nine-year average shows maximum yield at 80 lb 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 nine-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 nine-year average again shows no difference between organic and urea N sources.

The extra 30 lb 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 nine-year average. Soil test in the fall of 1980 showed Bray exchangeable P levels averaging 13 on treatment 4 and 43 on treatment 12. For this reason additional P was applied in the spring of 1981.

Results of the first nine years of this trial show that (1) 80 lb 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, but soil test levels had decreased to 13 lb/A.

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, 1978, 1979, and 1980. 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 lb 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 lb 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. Since 1978 soil NO_3-N levels in the 0, 40, and 80 lb/A N rates have not changed much. With the 120 lb/A N rate there has been an increase in the 0-2 foot zone but a decrease in the NO_3-N in the total 4-foot profile. With the 160 lb/A N rate there has been a considerable buildup down to the 4-foot depth.

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

Fertilizer Treatments				Grain Yield									
		In addition to starter											9-year
No.		N[2]	P	1973	1974	1975	1976	1977	1978	1979	1980	1981	average
		— lb/A —		— bu/A —									
1	Starter[1]	0	0	112.5	77.3	99.4	19.9	101.8	117.9	79.6	67.4	87.6	84.8
2	"	0	0	116.3	70.7	104.5	20.1	100.6	117.4	75.0	67.9	78.8	83.5
3	"	40	0	122.1	81.7	104.7	24.2	101.4	128.2	107.9	95.8	104.0	96.7
4	"	80	0	129.8	94.0	110.9	24.4	103.3	129.3	112.2	104.0	111.4	102.1
5	"	120	0	128.2	91.2	112.5	21.2	102.5	126.7	111.0	103.6	113.2	101.1
6	"	120(SD)	0	126.5	90.4	119.8	19.6	103.1	126.4	116.3	112.0	111.2	102.8
7	"	160(SD)	0	128.9	91.9	110.7	25.6	99.3	125.7	105.8	103.2	107.6	99.9
8	"	80(F)	0	118.2	92.8	119.0	23.2	99.6	135.7	115.7	113.6	108.3	102.9
9	"	120(F)	0	128.9	90.2	125.7	21.2	103.4	128.6	115.8	106.1	112.7	103.6
10	"	80(ORG)	8	122.2	87.8	114.7	25.4	99.4	129.0	121.9	102.6	107.5	101.2
11	"	120(ORG)	12	127.7	96.9	119.2	22.0	101.0	130.7	113.1	109.6	100.2	102.3
12	"	80	30	123.6	91.8	108.9	24.7	104.2	127.8	123.5	105.4	109.2	102.1
Significance				NS	**	NS	NS	NS	NS	**	**	**	
BLSD(.05)				-	16.9	-	-	-	-	12.0	9.8	11.2	

[1] Starter (6-24-24) was applied along the row at planting time at 143 lb/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 lb at planting and 40 lb sidedressed and treatment 7 received 80 lb at planting and 80 lb sidedressed.

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

Fertilizer treatments		In addition to starter		N content of sixth leaves									
No.		N[2]	P	1973	1974	1975	1976	1977	1978	1979	1980	1981	9-year average
		- lb/A -		%									
1	Starter[1]	0	0	2.20	2.96	2.26	2.25	3.11	2.64	1.85	2.46	2.88	2.51
2	"	0	0	2.18	3.04	2.27	2.09	3.00	2.65	1.71	2.41	2.81	2.46
3	"	40	0	2.40	3.26	2.59	2.57	3.07	3.00	1.98	3.00	3.22	2.79
4	"	80	0	2.53	3.37	2.85	2.62	3.13	3.13	2.86	2.90	3.28	2.96
5	"	120	0	2.74	3.50	2.90	2.79	3.16	3.24	2.99	3.06	3.39	3.09
6	"	120(SD)	0	2.55	3.46	2.88	2.53	3.12	3.24	2.96	3.02	3.23	3.00
7	"	160(SD)	0	2.62	3.45	2.85	2.67	3.04	3.22	2.68	3.08	3.11	2.97
8	"	80 (F)	0	2.50	3.32	2.82	2.64	3.14	3.12	2.86	2.72	3.19	2.92
9	"	120 (F)	0	2.48	3.46	2.80	2.62	3.23	3.11	2.88	2.86	3.32	2.97
10	"	80(ORG)	8	2.52	3.42	2.84	2.54	3.23	3.16	3.00	2.95	3.29	2.99
11	"	120(ORG)	12	2.61	3.42	2.93	2.67	2.98	3.20	2.62	3.16	3.37	3.00
12	"	80	30	2.49	3.36	2.60	2.64	3.09	3.13	2.40	2.85	3.14	2.86
Significance				**	**	**	**	NS	**	**	**	**	
BLSD(.05)				.22	.19	.23	.16	-	.13	.59	.32	.29	

[1] Starter (6-24-24) was applied along the row at planting time at 143 lb/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 lb at planting and 40 lb sidedressed and treatment 7 received 80 lb at planting and 80 lb sidedressed.

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

Sample Depth	Treatment No.	Annual Broadcast N Rate	Year									
			1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
- ft -		- lb/A -	lb NO_3-N/A									
0-2	1	0	39	48	47	10	54	35	28	16	23	20
0-3	1	0	54	64	63	10	68	63	39	23	28	27
0-4	1	0	65	87	85	15	82	88	57	50	42	41
0-2	3	40	27	-	40	7	79	41	33	21	22	24
0-3	3	40	46	-	64	11	105	100	89	53	41	38
0-4	3	40	80	-	103	18	134	132	140	100	79	63
0-2	4	80	23	64	100	30	115	86	40	23	46	53
0-3	4	80	40	91	128	48	143	186	174	115	176	163
0-4	4	80	65	125	159	57	168	218	245	219	247	217
0-2	5	120	39	112	178	40	187	234	87	49	118	112
0-3	5	120	63	152	220	70	233	470	311	259	269	256
0-4	5	120	89	185	256	81	270	528	458	392	385	350
0-2	7	160	37	-	174	80	258	149	100	100	274	257
0-3	7	160	59	-	211	122	314	299	370	370	569	486
0-4	7	160	87	-	244	141	347	365	596	603	723	641

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

Month	Year 1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	95-year average
	inches										
April	2.61	1.09	1.37	2.76	.47	1.90	2.80	1.53	.15	1.78	2.28
May	4.40	3.80	2.59	1.53	.39	5.48	2.48	2.52	1.83	1.94	2.97
June	2.20	.98	2.40	6.84	1.63	2.72	5.52	6.30	6.69	6.68	3.94
July	6.28	5.55	3.88	2.03	1.07	3.52	2.08	2.71	2.40	3.76	3.53
August	1.72	1.76	4.79	4.39	1.76	3.20	2.63	1.15	2.94	2.67	2.93
September	.38	2.26	.72	1.61	.57	3.50	3.03	.22	2.32	.54	2.20
October	1.81	1.79	.68	1.59	.08	3.25	.08	4.26	1.23	3.28	1.62
November	1.43	.95	1.17	1.77	.14	3.13	1.25	.60	.13	.64	.95
Total	20.83	18.18	17.60	22.43	6.11	26.70	19.87	19.29	17.69	21.29	20.42

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. 1981 Operations

In 1981 the variety was Trojan TXS99. Counter was applied at 1 lb/acre (active ingredient) at planting on May 1. Lasso @ 2.5 lbs/acre plus Bladex @ 2.2 lbs/acre were applied broadcast on May 5. Silage yields were taken on September 23 and grain yields on October 20.

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

Treatment	1981 yield	1966-81 yield
Silage, low fertility	6.30	5.67
Silage, high fertility	6.86	6.09
Grain, low fertility	6.65	5.66
Grain, high fertility	6.61	5.91

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

	1981 yield	1966-81 yield
Grain, low fertility	99.32	91.49
Grain, high fertility	104.47	94.36

V. Check Yields

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

	1981 yield	1966-81 yield
Grain (0 + 0 + 0)	48.37 Bu/A	50.26 Bu/A
Silage (0 + 0 + 0)	4.32 Tons/A	3.77 Tons/A

VI. Discussion

A. In 1981 there were no significant differences in silage yields but the silage high fertility plots yielded slightly more than the low fertility plots.

B. The 16-year average yields show very little difference between silage and grain plots, but there is still a slight advantage for the higher fertility level.

SOIL TEST LAB COMPARISON

West Central Experiment Station - Morris

S. D. Evans, C. R. Schrader and W. E. Jokela

In the past few years the number of commercial laboratories testing soils in west central Minnesota has increased. In many cases the commercial laboratory recommendations differ greatly from those of the University of Minnesota Soil Testing Laboratory. In order to develop educational material for use by the extension soils specialists, trials were started at the West Central Experiment Station in 1980 on a corn-wheat rotation. Results from the 1980 trials were summarized previously (Soil Series 109).

In the fall of 1980 soil samples of the plow layer and the 0-2 foot zone (corn only) were taken from each plot except the check. The soil from the four replications was combined to make two samples (plow layer and 0-2 foot) from each treatment. The samples were dried thoroughly, mixed and subdivided and sent to the same laboratory as that treatment in 1980. Recommendations were requested for corn at a yield goal of 130 Bu/A and spring wheat at a yield goal of 65 Bu/A. Analyses requested were (1) a complete analysis on the plow layer samples and (2) a nitrate-N analysis and recommendation on the 0-2 foot samples on the treatments to be planted to wheat. After receiving the soil tests and recommendations (Tables 1 and 2), the fertilizer treatments were calculated with an adjustment for soil buildup with Lab C. With Lab C there was no indication that the 0-2 foot sample was used for the nitrogen recommendation on wheat.

General

The experiment was set up as a randomized complete block with four replications on each crop. Two blocks, each with 24 plots, are adjacent to one another and will alternate between wheat and corn. The plot size is 15 feet by 40 feet. Row spacing on the corn is 30 inches. A storm on August 3 with high winds, caused severe lodging in the wheat and corn.

Wheat

The N, P, K, and S treatments for wheat were applied broadcast by hand in a dry form on April 7. The copper was dissolved in water and sprayed to the plots the same day. All plots were then worked with a field cultivator and drug. On April 8 the plots were seeded to Era wheat @ 1 3/4 Bu/A. On May 19 bromoxynil (.25 lb/A) and MCPA ester (.25 lb/A) were applied for weed control. The upper 2 leaves were sampled prior to flowering on June 12 for nutrient analysis. On July 17 at the soft dough stage whole plant samples were taken for nutrient analysis. The plots were harvested with a plot combine on August 5. Samples of grain were saved for protein analysis.

Corn

The N, P, K and S treatments for corn were applied broadcast by hand on May 1. The copper was dissolved in water and applied to the plots the same day. All plots were then dug with a field cultivator, drug and planted to variety Trojan TXS99 @ 22,000 seeds/acre. There was no starter fertilizer used. An insecticide, Counter, was applied in the row @ 8.8 lb/A (1 lb/A active ingredient). Herbicides used were Lasso (2.5 lb/A) and Bladex (2.2 lb/A) on May 4. Early plant height and samples were taken on June 22. Leaf samples at mid-silk were collected on July 28. The plots were harvested with a plot combine on October 15. Samples of grain were saved for protein analysis.

Results and Discussion of the Wheat Trial

As shown in Table 1, the soil tests and fertilizer recommendations varied greatly with laboratory. Two commercial labs recommended sulfur and one recommended copper. There were also wide variations in N, P and K recommendations.

Upper leaf nutrient concentration differences among laboratories were found for P, Ca, Fe, Zn and Mn. In most cases Lab C had the highest concentration and Lab E the lowest concentration. The P concentration appeared to be related to the total P applied over the two-year period. Lab C received the highest Zn application in 1980 but Lab D had the highest concentration and never received Zn. Lab C had the highest Mn concentration having received an Mn application in 1980. Soft dough nutrient concentration differences between laboratories were found only for Ca and Fe (Table 4).

Table 1. Soil test results and the suggested fertilizer program for wheat in 1981.

Test	Soil Test Results[1]				
	LAB A	LAB B	LAB C	LAB D	LAB E (UM)
pH	7.8	7.6	7.7	7.8	7.8
Phosphorus (Bray 1)	16-H	16-M	15	18-H	9
($NaHCO_3$)	-	39-M	15	-	-
Potassium	132-H	151-M	130	144-H	106
Organic matter (%)	4.2	3.6-H	4.5	-	M
Calcium	3350	2720-H	4000	3200-M	-
Magnesium	555	580-VH	560	500-M	-
Sodium	16	-	31	-	-
Sulfur	5.5-M	6-L	20	18-ADQ	7
Iron	7.8-H	15-M	2.8	-	-
Manganese	6.6-VH	11-M	14.8	9-H	-
Zinc	1.01-H	2.3-M	2.8	3.0-ADQ	1.7
Copper	.38-H	0.7-L	0.8	0.8-H	-
Boron	-	1.0-M	1.1	-	-
ENR (lb/A)	-	102	-	-	-
Nitrate nitrogen (lb/A)	108(0-2 ft)	86(0-2 ft)	5	84(0-2 ft)	160(0-2 ft)
C.E.C. (meq/100 g)	27.7	18.1	25.1	-	-
Soluble salts (mmhos/cm)	.69	-	.30	-	-

Nutrient	Suggested Fertilizer Program[2]				
	LAB A	LAB B	LAB C	LAB D	LAB E (UM)
Nitrogen	44	0	95	80	0
Phosphorus (P_2O_5)	0	55	50	0	40
Potassium (K_2O)	30	105	180[3]	22	30
Sulfur	-	12	8	-	-
Zinc	-	-	-	-	-
Manganese	-	-	-	-	-
Copper	-	0.5	-	-	-
Boron	-	-	-	-	-

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

[2] All values indicate pounds of nutrient suggested per acre for a yield goal of 65 bushels of wheat per acre.

[3] Values include maintenance plus 1/2 of suggested buildup.

Table 2. Soil test results and the suggested fertilizer program for corn - 1981.

Test	Soil Test Results[1]				
	LAB A	LAB B	LAB C	LAB D	LAB E (UM)
pH	7.8	7.6	7.9	7.6	7.8
Phosphorus (Bray 1)	8.5-L	14-M	-	8.5-M	12
($NaHCO_3$)	-	39-M	10	-	-
Potassium	122-H	143-M	170	120-H	80
Organic matter (%)	3.8	3.3-H	5.3	M	M
Calcium	4550	2790-H	4500	3200-M	-
Magnesium	550	448-H	550	620-H	-
Sodium	16	-	59	-	-
Sulfur	8.5-H	6-L	12	14-ADQ	8
Iron	7.0-H	13-M	18.4	-	-
Manganese	5.0-VH	11-M	11.6	8-H	-
Zinc	.93-H	2.3-M	2.2	2.6-ADQ	1.9
Copper	.38-H	0.7-L	0.8	0.8-H	-
Boron	-	1.1-M	1.0	-	-
ENR (lb/A)	-	96	-	-	-
Nitrate nitrogen (lb/A)	-	-	7	-	-
C.E.C. (meq/100 g)	27.7	18.1	27.7	-	-
Soluble salts (mmhos/cm)	.69	-	.35	-	-

Nutrient	Suggested Fertilizer Program[2]				
	LAB A	LAB B	LAB C	LAB D	LAB E (UM)
Nitrogen	120	145	120	102	80
Phosphorus (P_2O_5)	97	75	140	77	80
Potassium (K_2O)	46	105	165[3]	65	95
Sulfur	-	15	14	-	-
Zinc	-	-	-	-	-
Manganese	-	-	-	-	-
Copper	-	1	-	-	-
Boron	-	-	-	-	-

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

[2] All values indicate pounds of nutrient suggested per acre for a yield goal of 130 bushels of corn per acre.

[3] Values include maintenance plus 1/2 of suggested buildup.

There were no significant differences in grain yield between laboratories (Table 7). Plant height, lodging, grain moisture and grain protein did not vary significantly between laboratories.

The fertilizer cost and economic returns are given in Table 8. The fertilizer cost differed $41.09 between Labs A and C. The return over fertilizer varied from $231.50 (Lab A) to $190.81 (Lab C). The check had the lowest returns.

Results and Discussion of the Corn Trial

As shown in Table 2, the soil tests again varied widely. Recommendations for N, P and K were different, but the range was not as great for wheat. Again, two laboratories recommended sulfur and one recommended copper.

Small whole plant nutrient concentration differences among laboratories were significant only for Cu (Table 6). Lab D had a significantly higher Cu concentration but had no Cu applied for the 1981 crop. However, there was an application of 2 lb/A of Cu for the 1980 crop.

Earleaf nutrient concentration differences among laboratories were significant for N, Ca, Cu and Mn. The lowest N concentration was Lab E where the N applied was lowest and the highest N concentration was Lab B where N applied was highest. The Cu concentrations were not consistent with the highest (Lab A) never receiving Cu. The Mn concentration was highest for Lab B which received Mn in 1980.

Corn grain yields did not vary significantly between laboratories. None of the other plant measurements varied significantly (.05 level) between treatments.

The fertilizer cost and economic returns are given in Table 8. Fertilizer costs varied from $43.00 (Lab D) to $76.97 (Lab C). The returns over fertilizer varied only about $18/acre.

Two-Year Summary

Analysis of the combined data for 1980 and 1981 for wheat (Table 9) shows quite a range in return over check, but all values are negative. The highest cost was Lab C and the lowest cost was Lab A. For corn all returns are positive with the greatest return from Lab E ($93.05) and the least return from Lab C ($63.58). After two years it appears that the recommendations by some labs of sulfur, micronutrients and high rates of P and K are not resulting in significantly higher yields than the University of Minnesota recommendations. On the other hand, some labs give recommendations that are close to those of the University of Minnesota.

Table 3. Effect of suggested fertilizer applications on the leaf[1] nutrient concentration of wheat.

	Nutrient								
LAB	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
A	.326	2.09	.684	.310	86	34.2	2.2	81	24.2
B	.340	2.22	.634	.287	86	31.5	2.3	76	23.8
C	.342	2.28	.761	.329	92	36.5	2.1	91	23.6
D	.336	2.23	.719	.299	87	37.1	2.3	83	22.5
E (UM)	.313	2.07	.626	.273	84	31.4	2.0	69	21.1
Check	.317	2.24	.524	.218	78	32.3	2.6	61	24.1
Significance	*	NS	**	*	**	**	NS	**	NS
BLSD (.05)	.019	--	.075	.072	6	2.5	--	15	--
CV (%)	3.5	6.4	7.8	15.0	4.6	5.1	14.6	12.5	22.3

[1] Upper 2 leaves prior to flowering.

Table 4. Effect of suggested fertilizer applications on the nutrient concentration of whole plants at soft dough stage of wheat.

LAB	Nutrient									
	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
A	1.37	.198	1.35	.176	.142	34	19.6	<0.04	28	1.4
B	1.29	.180	1.62	.204	.141	32	15.2	"	28	2.0
C	1.55	.213	1.61	.204	.152	37	21.4	"	32	2.2
D	1.35	.190	1.39	.184	.140	32	21.1	"	28	1.8
E (UM)	1.24	.171	1.44	.179	.139	27	15.1	"	27	1.9
Check	1.40	.226	1.02	.155	.132	28	20.0	"	31	1.9
Significance	NS	NS	*	*	NS	*	+	-	NS	NS
BLSD (.05)	-	-	.35	.033	-	7	-	-	-	-
CV (%)	11.63	14.5	15.5	10.7	14.3	13.5	19.2	-	19.2	54.35

Table 5. Effect of suggested fertilizer applications on the nutrient concentration in young whole plants of corn.

LAB	Nutrient								
	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%				ppm				
A	.333	3.43	.838	.627	1483	50.6	8.6	111	1.5
B	.338	3.49	.750	.582	1496	54.2	8.8	116	1.6
C	.345	3.67	.801	.576	1409	48.0	8.3	113	1.9
D	.347	3.41	.749	.627	1474	45.6	9.5	112	1.7
E (UM)	.336	3.41	.756	.632	1449	55.8	8.2	111	1.5
Check	.340	3.36	.786	.644	1415	64.1	9.4	110	1.7
Significance	NS	NS	NS	NS	NS	NS	*	NS	NS
BLSD (.05)	-	-	-	-	-	-	0.8	-	-
CV (%)	4.78	7.37	9.41	9.54	14.11	31.41	5.83	6.04	17.97

Table 6. Effect of suggested fertilizer applications on the leaf concentrations in corn.

LAB	Nutrient									
	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
A	3.07	.294	1.48	.483	.414	93	18.6	2.7	70	4.7
B	3.20	.304	1.55	.535	.390	94	18.0	2.6	77	4.7
C	3.09	.287	1.51	.475	.390	89	17.1	2.2	73	4.8
D	3.06	.287	1.43	.495	.450	90	16.6	2.5	69	4.8
E (UM)	3.02	.285	1.45	.478	.453	89	16.4	2.1	67	4.4
Check	2.70	.268	1.35	.465	.422	87	16.6	2.2	62	4.5
Significance	**	NS	+	*	NS	NS	NS	*	**	NS
BLSD (.05)	0.18	-	-	.042	-	-	-	0.5	7	-
CV (%)	3.96	5.69	5.63	5.39	12.33	4.35	7.74	12.40	6.67	4.60

Table 7. Effect of fertilizer recommendations on various plant measurements.

LAB	Corn							Wheat				
	Early Plant Height	Early Plants (10) Dry Weight	Broken Stalks at Harvest	Lodging at Harvest	Plant Population at Harvest	Corn Grain Yield	Grain Moisture	Plant Height at Harvest	Lodging at Harvest	Grain Yield	Grain Moisture	Grain Protein
	-in-	-grams-	-%-	-%-	-1000's/A-	-Bu/A-	-%-	-in-	Score[1]	-Bu/A-	-%-	-%-
A	19.3	39	2.2	30	19.1	114.1	25.8	30.8	7.0	60.5	13.6	13.8
B	18.4	37	3.1	24	19.7	123.0	27.1	31.5	7.0	65.1	13.4	13.7
C	19.0	37	2.0	26	19.0	123.2	26.1	32.0	7.2	60.6	13.8	14.1
D	19.6	36	11.2	35	18.7	117.8	25.7	31.5	7.2	60.4	13.7	14.8
E (UM)	19.7	41	4.9	31	19.2	118.3	26.7	28.5	6.5	55.8	14.0	14.2
Check	18.8	45	6.0	36	18.9	93.6	27.5	29.2	6.5	48.9	14.1	13.8
Signif.	NS	NS	NS	NS	NS	**	+	+	+	**	+	NS
BLSD (.05)	-	-	-	-	-	9.5	-	-	-	6.7	-	-
CV (%)	4.8	19.3	138.2	34.2	7.2	5.7	3.3	5.7	6.1	7.6	2.4	4.7

[1] Lodging score: 1 = No lodging, 9 = flat.

Table 8. Economic return over fertilizer costs - 1981.

LAB	Wheat			Corn		
	Value of Crop @ $4/Bu	Fertilizer Cost*	Return over Fertilizer	Value of Crop @ $3/Bu	Fertilizer Cost*	Return over Fertilizer
		$/A			$/A	
A	242.00	10.50	231.50	342.30	48.23	294.07
B	260.40	30.96	229.44	369.00	59.65	309.35
C	242.40	51.59	190.81	369.60	76.97	292.63
D	241.60	14.86	226.74	353.40	43.00	310.40
E (UM)	223.20	13.90	209.30	354.90	44.35	310.55
Check	195.60	0	195.60	289.80	0	289.80

* Values used ($/lb) were as follows: N = $0.15, P_2O_5 = $0.25, K_2O = $0.13, S = $0.18, Cu = $2.80.

Table 9. Two-year summary of yields and economic returns.

LAB	Wheat				Corn			
	Total 2-Year Yield	Total 2-Year Fertilizer Cost	Economic Return over Fertilizer	Return over Check	Total 2-Year Yield	Total 2-Year Fertilizer Cost	Economic Return over Fertilizer	Return over Check
	Bu/A	$/A	$/A	$/A	Bu/A	$/A	$/A	$/A
A	109.2	40.95	395.85	-0.55	233.00	94.68	604.32	+81.82
B	113.2	74.66	378.14	-18.26	239.80	117.85	601.65	+79.15
C	109.1	113.95	322.45	-73.95	243.60	144.72	586.08	+63.58
D	109.4	50.66	389.94	-6.46	236.50	118.27	591.23	+68.73
E (UM)	106.5	36.91	389.09	-7.31	234.00	86.45	615.55	+93.05
Check	99.1	0	396.40	-	204.50	0	522.50	-

Pesticide Plots at Rosemount

Russell S. Adams, Jr.

A new herbicide (chlorosulfuron or Glean) is considered to have promised for weed control in wheat. However, residue carryover may occur in calcareous soils. In 1981 bioassay plots were established at Rosemount on the old lime plots. The soil type was a Port Byron silt loam (Typic Hapludoll). Four rates of chemical were applied (0, 1/3, 3/4 and 1 1/2 oz/A) representing approximately one, two, and five times field rate.

The wheat was planted on May 12, herbicide applied on May 13, Preharvest weed biomass sampled on July 13, wheat harvested on July 30 and postharvest weed biomass sampled on October 2.

Yield and weed biomass data are reported in Tables 1 and 2. The data shows that wheat yields were slightly improved by either lime or herbicide and that these responses were additive. Weed growth was effectively suppressed by both lime and herbicide. Weed regrowth after harvest showed considerable recovery except in high lime and high herbicide treatments. Herbicide analysis on frozen soil samples have not been completed. However, recovery of weed growth shows that the herbicide was either being deactivated or degraded through the summer. The major preharvest weed species were soybeans, velvet leaf and giant foxtail. The major postharvest weed species were lambsquarter and stunted giant and green foxtails.

This summer, 1982, these plots will be planted to soybeans and sunflowers and residue effects followed.

Table 1. Wheat yields in chlorosulfuron treatments at Rosemount, 1981.

Lime T/A 1948	Chlorosulfuron treatments oz/A 0	1/3	3/4	1 1/2
	----------bushels/acre----------			
0	34.7	39.7	38.3	38.1
6	40.8	41.9	41.0	44.0
24	39.7	42.8	43.4	42.7

Table 2. Preharvest and postharvest biomass in wheat plots treated with chlorosulfuron to control weed growth, Rosemount, 1981.

Lime T/A 1948	Chlorosulfuron treatments oz/A 0 Pre-harvest	0 Post-harvest	1/3 Pre-harvest	1/3 Post-harvest	3/4 Pre-harvest	3/4 Post-harvest	1 1/2 Pre-harvest	1 1/2 Post-harvest
0	0.22	0.31	0.03	0.25	0.02	0.19	0.01	0.11
6	0.06	0.37	0.04	0.17	0.00	0.29	0.01	0.02
24	0.03	0.37	0.02	0.11	0.01	0.11	0.00	0.01

FERTILIZATION TRIALS OF MALTING BARLEY ON IRRIGATED SANDY SOIL IN CENTRAL MINNESOTA

Mike O'Leary and Greg Buzicky

Introduction

In recent years there has been an increase in irrigated acreage in central Minnesota. While corn, potatoes and alfalfa are the main crops grown on irrigated land, there is interest in introducing samll grains into rotations. Malting barley would be a possibility if satisfactory yields with acceptable malting characteristics, can be obtained.

Since most irrigated soils are sandy with low nitrogen content and low residual nitrate-nitrogen, it should be possible to manage the nitrogen environment for malting barley production. Therefore, the objectives of this study were:

1) to examine the response of Manker, Morex and other experimental varieties to nitrogen fertilization,
2) to examine the effect of various times of application of nitrogen fertilizer on an established malting barley variety,
3) to examine various levels of potassium and seeding rates on yield and quality of Manker barley.

Methods

The study was established at the Staples Irrigation Demonstration and Research Farm in Wadena County in central Minnesota. Soil type at the plot site was an Esterville sandy loam with a slightly acid pH, high phosphorus test and low potassium test.

The plot area was fertilized to optimum P, K, and S levels as recommended by soil tests. The seeding rate was 96 lbs/A with 10 lbs/A P_2O_5 as starter fertilizer. Weed control was obtained with Brominal + (.25 #a.i./A) at the four leaf stage and plots were sprayed for disease control in 1981. A solid set irrigation system provided 12.2" in 1979, 8.0" in 1980 and 5.9 in 1981 of water in addition to the 14", 13.5 and 13.4" of rainfall for 1979, 1980, and 1981, respectively. The nitrogen source used was ammonium nitrate for all trials.

The Nitrogen Rate by Variety trial was conducted utilizing a split plot design replicated four times with varieties as the main plot and N rates as the subplot. Nitrogen rates were 0, 45, 90 and 135 lbs/A applied 2/3 preplanting and 1/3 at tillering stage. Varieties tested included Manker and Morex for three years and Larker (1), M-32 (2), M-34 (1) and M-36 (2).

The Time of Nitrogen Application trial utilized a randomized complete block design replicated four time with nitrogen applied at a 90 lb/A rate according to four schemes of timing. The five treatments were: (1) check; (2) 90 lbs/A, preplant (P); (3) 60 lbs/A, preplant and 30 lbs/A, tillering (P + T); (4) 60 lbs/A, preplant and 30 lbs/A, early boot (P + B); (5) 40 lbs/A, preplant and 30 lbs/A, tillering and 20 lbs/A early boot (P + T + B).

The Density of Planting by Nitrogen Rate by Potassium Rate trial was set out in a factorial arrangement (2 x 2 x 2) replicated four times in a randomized complete design. Seeding rates of 96 and 144 lbs/A, nitrogen rates of 45 and 90 lbs/A, and potassium rates of 60 and 260 lbs/A were used. Nitrogen was applied as ammonium nitrate with 2/3 applied preplant and 1/3 applied at tillering. Potassium was applied preplant incorporated.

Nitrogen Rate by Variety Study

During the course of the Nitrogen Rate by Variety trial all varieties tested responded in similar fashion to increasing N rates. Interaction between these two variables was absent for all parameters

measured except for plump kernels in 1980. Two experimental varieties, M-34 and M-36, exhibited a tendency to sustain a higher plump kernel percentage than other varieties at high N rates.

Manker and Morex, the two recommended malting varieties, were tested in all years. No significant difference in grain yield or percent protein between these varieties was noted during the course of this trial (Table 2). Morex had significantly better plump than Manker in 1979 and 1980 while Manker had significantly better test weight than Morex in both these years. Differences between all varieties tested in 1979 and 1980 were due mostly to the presence of experimental varieties that were subsequently dropped in 1981. M-36, an experimental variety tested in 1980 and 1981, proved comparable to Manker or Morex for the characters measured. Varietal data for 1981 can be found in table 3. Results from previous years are given in Soil Series 107 and 109.

N rates, when averaged across varieties, proved to have major effects under the prevailing conditions. Significant increases in grain yield were observed with each increment of added nitrogen up to 90 lbs/A in all years (Table 1). In 1980 and 1981 135 lbs. N/A produced significantly higher yields than other nitrogen treatments.

Changes in grain protein between the check and the 45 lbs/A rate were variable for the three years. Significant increases in percent grain protein were produced for each addition of nitrogen above 45 lbs/A in all years. Although grain protein was increased with each rate the values associated with the high N rate were relatively low. In each year percent plump kernels displayed a tendency to decrease as N rates were increased from 45 lbs. N/A. Signifiant decreases in percent plump for N above 45 lbs/A were observed in 1979 and 1980. In 1981 a significant decrease occurred only between 45 and 90 lbs. N/A. During the duration of the study N rate had negligible effects on test weight.

Table 1. Effect of N rate on yield, test weight, percent plump, and percent protein of barley grain at Staples, MN in 1979, 1980, and 1981.

N-Rate (lbs/A)	Yield (bu/A)	Test weight (lbs/bu)	Protein (%)	Plump (%)
		1979		
0	30.8	48.2	10.9	73.7
45	51.4	48.4	10.0	74.8
90	66.2	48.0	11.2	67.0
135	69.1	47.2	12.4	60.3
BLSD (.05)	4.8	--	.4	2.5
C.V. %	13.2	2.0	4.7	4.8
		1980		
0	33.4	48.9	9.4	76.5
45	65.8	49.5	9.1	79.1
90	89.3	48.9	10.5	74.9
135	94.5	49.4	11.2	72.9
BLSD (.05)	3.5	--	.4	1.8
C.V. %	9.6	2.7	8.6	4.4
		1981		
0	28.7	46.0	8.4	73.9
45	45.0	46.7	8.9	82.8
90	62.3	46.6	10.0	79.2
135	68.0	45.9	11.6	78.5
BLSD (.05)	2.7	--	.3	2.1
C.V. %	7.2	2.0	3.6	3.4

Table 2. Yield, test weight, % plump and % protein of Manker and Morex barley grain -- Staples, MN 1979, 1980, and 1981.

	Yield (bu/A)			Test weight (lbs/bu)			Protein (%)			Plump (%)		
Variety	79	80	81	79	80	81	79	80	81	79	80	81
Morex	56.6	69.5	46.5	47.9	47.5	45.2	11.3	10.2	9.9	72.8	75.1	77.6
Manker	55.2	73.0	54.2	49.8	50.2	46.8	11.0	10.2	9.7	66.6	72.2	78.3

Table 3. Effect of variety on yield, test weight, percent protein and percent plump of barley grain at Staples, MN, 1981.

Variety	Yield (bu/A)	Test weight (lbs/bu)	Plump (%)	Protein (%)
Morex	54.2	46.8	78.3	9.7
Manker	46.5	45.2	77.6	9.9
M-36	52.3	46.8	79.9	9.6
Significance	ns	ns	ns	ns
C.V. (%)	7.2	3.4	2.0	3.6

Table 4. Effect of time nitrogen application on Manker (1979, 1980) and Morex (1981) barley yield, test weight, percent plump and percent protein of barley grain at Staples, MN.

Treatment (lbs N/A)	Yield (bu/A)	Test weight (lbs/bu)	Protein (%)	Plump (%)
1979				
check	29.6	48.4	9.7	70.1
90(P)	56.7	50.6	9.9	71.2
60(P) + 30(T)	52.5	50.5	9.9	69.2
60(P) + 30(B)	61.6	51.9	11.2	79.2
40(P) + 30(T) + 20(B)	65.2	51.2	11.2	71.4
BLSD (.05)	8.2	--	2.1	.9
C.V. %	10.8	3.4	2.9	5.6
1980				
check	25.5	49.4	8.6	64.0
90(P)	82.3	50.5	8.4	70.2
60(P) + 30(T)	84.6	50.4	9.2	65.8
60(P) + 30(B)	82.1	52.2	12.2	84.2
40(P) + 30(T) + 20(B)	88.3	51.2	10.4	71.2
BLSD (.05)	9.4	1.9	1.3	6.3
C.V. %	9.2	2.2	9.1	6.0

Table 4, continued.

Treatment (lbs N/A)	Yield (bu/A)	Test weight (lbs/bu)	Protein (%)	Plump (%)
		1981		
check	22.1	42.3	8.8	69.0
90(P)	49.3	43.2	9.6	78.0
60(P) + 30(T)	48.6	42.2	9.4	76.0
60(P) + 30(B)	48.6	44.0	10.7	78.0
40(P) + 30(T) + 20(B)	55.0	44.2	10.6	76.0
BLSD (.05)	6.1	--	.6	4.0
C.V. %	9.6	2.4	4.2	4.0

Time of Nitrogen Application Trial

Yields were not greatly affected by time of nitrogen application (Table 4). Apart from the check, which generally yielded 22-30 bu/A, few significant differences were observed. In 1979, the P + B and P + T + B methods of application produced the highest yields. In 1980, no significant differences were noted amoung the four methods although the P + T + B method had the highest yield. In 1981, the P + T + B method again produced the highest yield. Thus in each year the application of nitrogen at the preplant, tillering and boot stages gave the highest mean yield.

Test weight was not consistently affected by time of application, although an increase in test weight was observed in 1980 for the P + B and P + T + B methods over the check.

Kernel plumpness was greatly increased in two of the three years by the P + B application method. This is especially striking since the P + T + B scheme also provided nitrogen at both the planting and boot stage although at lower rates. This suggests that, under these conditions, adequate nitrogen must be available early and then followed with additional nitrogen in adequate amounts at the critical grain-filling period in order to obtain the highest percentage of plump kernels.

Protein content of the grain was greatly increased in all three years by application of nitrogen at the boot stage by treatments P + B and P + T + B. This delayed application resulted in an adequate supply of available N for grain filling, thereby increasing the protein content of the grain.

Density of Planting by Nitrogen Rate by Potassium Rate Trial

Results of this trial showed few significant differences or interactions. The high N rate (90 lbs versus 45 lbs/A) increased yield and percent protein in both years. In 1979, a significant decrease in kernel plumpness was caused by high density seeding (144 versus 96 lbs/A). No significant difference for any variables were observed due to potassium fertility levels (260 versus 60 lbs/A).

Summary

These trials were conducted in order to provide information on the production of irrigated malting barley in Minnesota, which to the present time has been limited. Due to the nature of most irrigated soils, associated growing conditions, and the dependence of a quality barley crop on favorable soil fertility conditions, various aspects of nitrogen fertilization were the main areas of investigation.

Varietal response to N rates was quite similar during the experimental period. There was a dramatic increase in yield from the application of nitrogen in all years. Furthermore, there was a trend of increased grain yield and protein as a result of increasing N rates in all years. Kernel plumpness also was greatly influenced by N rates. Highest kernel plumpness was obtained with 45 lbs/A with

successive decreases associated with higher N rates. The recommended varieties, Manker and Morex, and experimental M-36 performed in similar fashion when tested together. These varieties do not seem to be particularly well apapted to the irrigated conditions encountered in these trials.

At the optimum N rate (90 lbs/A), the P + T + B split application resulted in the highest yield. Kernel plumpness was highest for the two split treatments involving a boot stage application. Of the two schemes of application, the 40(P) + 30(T) + 20(B) produced slightly higher yields while the 60(P) + 30(B) resulted in a significantly higher percentage of plump kernels and a slightly higher protein content. No differences were obtained between medium and high seeding density or low and high potassium levels.

Personnel Engaged in Barley Research

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CORN - BEAN ROTATION

Harvey Meredith and Melvin Wiens

Yields from continuous corn on the irrigated sands have been disappointing. A study was initiated in 1981 at the Staples Station to evaluate continuous corn, corn-soybean, and corn-edible beans.

Two maturity corn varieties are planted in the study: Pioneer 3978 (85-day) and 3906 (95-day); McCall soybeans and Seafarer edible beans.

No significant differences in corn yields were noted in 1981. Corn yields averaged 151.4 bu/A.

This study will be continued. Two additional locations will be initiated in 1982.

SOUTHERN EXPERIMENT STATION - WASECA

WEATHER DATA - 1981

Month	Period	Precipitation 1981	Precipitation Normal	Avg. Air Temp. 1981	Avg. Air Temp. Normal	Growing Degree Days 1981	Growing Degree Days Normal
		-----inches------		-------°F--------			
January	1-31	0.15	.73	16.5	12.9		
February	1-28	2.54	.96	22.5	17.5		
March	1-31	0.96	1.94	35.7	28.5		
April	1-30	4.49	2.48	48.8	45.6		
May	1-10	1.95		52.0		62.0	
	11-20	0.08		53.6		81.0	
	21-31	1.57		62.1		138.5	
	Total	3.60	3.86	56.1	57.7	281.5	319
June	1-10	0.50		67.0		167.0	
	11-20	1.70		66.5		165.0	
	21-30	1.66		65.4		153.0	
	Total	3.86	4.75	66.4	67.1	485.0	519
July	1-10	0.00		72.6		223.5	
	11-20	4.65		74.4		241.5	
	21-31	1.56		66.3		179.5	
	Total	6.21	4.02	71.0	71.4	644.5	646
August	1-10	1.79		71.0		211.0	
	11-20	1.85		66.2		163.0	
	21-31	3.74		68.1		199.5	
	Total	7.38	3.60	68.4	69.7	573.5	604
September	1-30	1.46	3.45	58.6	60.3	307.0	337
October	1-31	3.24	1.89	44.4	50.3	0.0	35
November	1-30	1.24	1.25	36.8	32.9		
December	1-31	1.18	1.02	14.6	19.0		
Year	Jan-Dec	36.31	29.95	45.1	44.4	2291.5	2460
Growing Season	May-Sep	22.51	19.68	64.1	65.3	2291.5	2425

Notes:

1) Highest temp. on June 8 -- 93°
2) Highest 24-hour precipitation on August 27 -- 2.20"
3) Growing degree days were 7% below normal
4) Available soil moisture in 0-5' profile was never below 85% of field capacity
5) Last spring frost -- May 10
6) Frost on September 28

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

Waseca, 1981

G. W. Randall

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

EXPERIMENTAL PROCEDURES

Four starter fertilizer treatments and a check with no starter fertilizer (Table 1) were applied in a randomized, complete-block design with six replications on a Nicollet clay loam soil (Aquic Hapludoll). Soil test of this site averaged: pH = 5.8, Bray 1 extractable P = 54 lb/A and exchangeable K = 375 lb/A. Corn that had been moldboard plowed was the previous crop. Nitrogen as anhydrous ammonia was applied at a rate of 180 lb N/A on May 2.

Corn (Pioneer 3732) was planted on May 13 at a rate of 27700 plants/A with a 4-row John Deere 7000 Max-Emerge planter. This planter was used to apply the dry material in a 2 x 2 band and the liquid in the row with the seed. The 7-21-7, 5-12-5 and 8-20-8 were obtained from local fertilizer dealers while the 9-18-9 was obtained from Na-Churs. The 5-12-5 dry material applied at the 95-lb rate yields approximately the same amount of N + P + K as 5 gal/A of the two liquid materials. The 140-lb rate of the 8-20-8 is closer to a more conventional rate of a dry fertilizer while still using a 1:2.5:1 material. Amaze at a rate of 1 lb/A (active) was band-applied to control rootworms. Lasso (3½ qts/A) and atrazine (3 lb/A) were applied to control weeds.

Ten randomly selected plants from the outside 2 rows of these 4-row plots were sampled on June 16 for early plant growth measurements and for nutrient analysis. Leaf samples opposite and below the ear were taken at silking (July 27) for analysis. Grain yields were determined by combine harvesting the center two rows of each plot with a JD 3300 modified plot combine. Moisture and protein analyses were determined on those samples.

RESULTS

Although normal temperatures and slightly drier than normal conditions existed in the six-week period after planting, significant differences in early plant weight were noticed (Table 1). Plants were largest with the liquid materials, intermediate with the dry materials and smallest with no starter fertilizer. Differences in small plant weight did not exist between the two liquid fertilizers or between the two rates of dry fertilizer. A possible explanation for the advantage shown with the liquid materials is the effect of placement. The liquids were placed in the seed zone between the double disc openers while the dry materials were applied in a conventional 2 x 2 placement.

Small plant P was increased significantly over the control and the liquid materials by the dry materials (Table 1). No other nutrients were affected by the dry materials. Neither of the liquid materials increased the nutrient concentrations above those of the control. Perhaps this was due to a "dilution effect" with the larger plants associated with the liquid treatments.

Nutrient uptake, the product of nutrient concentration times small plant weight (dry matter), was influenced by the treatments (Table 2). The higher levels of P, K, Ca and Mg were associated with the larger dry matter accumulations found with both the liquid and dry materials with no difference between the liquid and dry materials. The liquid materials, however, did result in significantly higher Mn, Zn, Cu and B levels than the control. Uptake of Fe was not affected by the starter fertilizers.

Leaf nutrient concentrations shown in Table 3 were sufficient for optimum yields but were not influenced by any of the starter fertilizer treatments.

Table 1. Influence of starter fertilizer on the nutrient concentration in the small whole corn plants at Waseca in 1981.

Treatment Material	Rate	Small plant weight	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		g DM/plt.	----------%----------				----------ppm----------				
No Starter		2.7	.46	5.00	.46	.28	860	80	38	12.4	10.7
9-18-9 (liq)	5 gal/A	3.6	.45	4.96	.46	.27	865	82	35	11.4	10.9
7-21-7 (liq)	5 gal/A	3.7	.45	5.05	.46	.28	685	82	35	12.3	9.9
5-12-5 (dry)	95 lb/A	3.1	.51	5.10	.48	.28	675	80	36	11.5	10.6
8-20-8 (dry)	140 lb/A	3.2	.53	5.17	.48	.28	850	87	38	11.0	10.3
Significance:[1/]		**	**	NS	+	*	NS	NS	NS	NS	NS
P Level (%) :[2/]		99	99	55	92	95	64	33	79	52	25
BLSD (.05) :		0.4	.02	--	--	.01	--	--	--	--	--
CV (%) :		10.3	3.1	4.1	3.6	3.3	28.	11.	7.0	13.	13.

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

2/ Probability levels of significant difference among treatment means.

Table 2. Influence of starter fertilizer on the nutrient uptake in the small whole corn plants at Waseca in 1981.

Treatment Material	Rate	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		----------mg/plant----------								
No Starter		12.2	133	12.3	7.4	2.2	.21	.10	.033	.028
9-18-9 (liq)	5 gal/A	16.2	178	16.4	9.6	3.2	.29	.13	.040	.038
7-21-7 (liq)	5 gal/A	16.6	186	16.9	10.1	2.5	.30	.13	.045	.036
5-12-5 (dry)	95 lb/A	15.9	160	15.0	8.9	2.1	.25	.11	.036	.033
8-20-8 (dry)	140 lb/A	17.1	167	15.4	9.2	2.8	.28	.12	.035	.033
Significance:		**	**	**	**	NS	**	*	**	*
P Level (%) :		99	99	99	99	86	99	98	99	98
BLSD (.05) :		2.0	21	1.9	1.1	—	.05	.02	.007	.006
CV (%) :		11.	11.	11.	10.	29.	16.	12.	15.	14.

Table 3. Influence of starter fertilizer on the nutrient concentrations in the corn ear leaf at Waseca in 1981.

Treatment Material	Rate	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		----------%----------					----------ppm----------				
No Starter		2.8	.33	2.08	.42	.27	105	71	21	2.8	3.8
9-18-9 (liq)	5 gal/A	2.8	.34	2.01	.43	.27	106	65	19	2.8	3.8
7-21-7 (liq)	5 gal/A	2.8	.33	2.00	.43	.27	104	68	20	2.4	3.4
5-12-5 (dry)	95 lb/A	2.8	.33	2.03	.43	.27	106	67	20	2.5	3.6
8-20-8 (dry)	140 lb/A	2.8	.34	2.00	.43	.28	106	66	19	2.4	3.4
Significance:		NS	NS	NS	NS	NS	NS	NS	+	NS	NS
P Level (%) :		16	59	23	13	21	5	21	94	86	29
CV (%) :		3.1	3.3	5.9	5.0	6.1	5.6	13.	6.3	13.	21.

Reductions in final plant population have been reported when applying liquid fertilizer materials with the seed. The data shown in Table 4 indicate no effect of any treatment on plant population. Grain yield, moisture and protein were not influenced statistically by the starter fertilizer treatments. However, a trend toward higher grain protein with the starter treatments was evident for the second year in a row.

Table 4. Influence of starter fertilizer on corn population, grain yield, grain moisture and grain protein at Waseca in 1981.

Treatment		Final	Grain		
Material	Rate	population	Yield	Moisture	Protein
		x 10^{-3}	bu/A	%	%
No Starter		24.3	181.0	24.6	8.7
9-18-9 (liq)	5 gal/A	25.2	177.6	24.3	9.2
7-21-7 (liq)	5 gal/A	25.0	172.9	24.3	9.1
5-12-5 (dry)	95 lb/A	25.2	179.8	24.3	9.0
8-20-8 (dry)	140 lb/A	25.2	182.1	24.4	9.1
Significance:		NS	NS	NS	NS
P Level (%) :		71	88	37	79
CV (%) :		3.4	3.5	1.6	4.6

SUMMARY

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

SOIL TEST COMPARISON STUDY

Waseca, 1981

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

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

PROCEDURES

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

Four samples consisting of approximately 35 cores each from a 0-7" depth were taken from each site. All samples were oven-dried at 95°F, crushed and mixed thoroughly. The samples were then subdivided and sent to five laboratories which test the majority of the soil samples from Southern Minnesota. Soil analyses requested consisted of pH, OM, extractable P_1, exchangeable K, extractable S and the micronutrients generally tested by each laboratory. Based on the results from the U of M laboratory these two sites were then classified as being initially "very high" and "medium-high".

The fertilizer recommendations given by the five laboratories were then applied as five treatments in the spring of 1980 for corn. An additional check (no fertilizer) treatment was included in the randomized, complete-block design with six replications. After the 1980 crop, soil samples (3 cores/plot times 6 replications yielding 18 cores per treatment) were taken from each treatment and sent to the respective laboratory. This allows us to follow the buildup or decline of nutrients as affected by the recommendations of a particular laboratory over a continuous, long period of time.

Fertilizer amounts based on the analyses and recommendations from the fall 1980 samples were then applied to the appropriate plots and incorporated by field cultivation in the spring of 1981. The fertilizer recommendations were based on a yield goal of 160 bu/A of continuous corn. Corn (Pioneer 3732) was planted at the rate of 27700 ppA in 30" rows on May 8 with 1 lb Amaze/A and no starter fertilizer. Chemical weed control consisted of 3½ lb Lasso and 3 lb Bladex/A applied preemergence.

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

In September, 1981, 0-7" soil samples were taken from each treatment at each of the two sites and were sent to the laboratory of the respective treatment. The recommendations obtained from these samples will be used for the 1982 growing season.

RESULTS

Very high testing site

The soil test results and the accompanying recommended fertilizer program of each laboratory are shown in Table 1 for the very high testing site. Nitrogen recommendations among the laboratories were quite similar while the P and K recommendations among the labs were substantially different. Various micronutrients and S were recommended by three of the four private labs.

Table 1. Soil test results and the recommended fertilizer programs on the very high testing site at Waseca in 1981.

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

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

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

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

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

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

Grain yields were significantly affected by the fertilizer treatments (Table 2). All fertilizer recommendations resulted in higher yields than the unfertilized check. The recommendations from labs D and B produced higher yields (P=.05 level) than that from lab E (U of M). With lab D, this may have been due to the higher N rate or the Fe, Mn and Zn application, although the latter does not appear to be the reason when looking at the plant analyses. The higher K rate with lab B may have been responsible for the higher yield than with lab E. Slight differences in final population existed but was thought not to influence yield. Grain moisture among all laboratory treatments was equal and was significantly below the check.

Small, whole plant Ca, Zn and Mn concentrations were higher with the fertilizer treatments than the control (Table 3). This is primarily due to the imbalance created by N deficiency in the check treatment. Plant Zn was highest with lab B, probably a result of the 8 lb Zn/A recommendation for the 1980 crop. Plant P, K, Mg, Fe and Cu were not affected by the different fertilizer recommendations.

Earleaf N, P, Ca, Fe and B concentrations among the five laboratories were not significantly different (P=.05 level) (Table 4). The higher K rate applied with treatment B did result in higher leaf K and lower leaf Mg than lab E (U of M). The Fe + Mn + Zn recommendation of lab D resulted in higher leaf Mn than the other labs but Fe and Zn were unaffected. The Cu recommendation from lab A and the Zn recommendation of lab C did not result in significantly increased leaf Cu or Zn in those treatments.

Leaf Zn levels were highest with recommendations from labs A and B which did not recommend Zn in 1981. However, this may be carryover from the Zn recommended by these two laboratories for 1980 (8 and 6 lb Zn/A, respectively). Leaf nutrient concentrations except Cu and B appeared to be adequate from the lab E treatment which has never received any nutrient except N, P and K. Leaf Cu and B levels in general appear low.

Table 2. Effect of fertilizer recommendations on corn final population, grain yield and moisture on the very high testing site in 1981.

Lab	Fertilizer Recommendations	Final Population	Grain Yield	Grain H_2O
	lb/A[1]	ppA x 10^{-3}	bu/A	%
A	190N +35P +130K +S+Cu	24.2	171.7	20.0
B	185N +60P +160K +S	25.2	175.4	20.2
C	182N +56P +128K +Zn	25.2	173.2	20.1
D	215N +75P +110K +S+Fe+Mn+Zn	24.6	180.3	20.1
E(UM)	170N +50P +105K	23.5	167.4	20.0
Check		23.8	139.6	21.1
	Significance Level(%):[2]	95	99	99
	BLSD (.05) :	1.5	7.7	.4
	CV (%) :	4.4	4.2	1.5

[1] P and K expressed on oxide basis.

[2] Probability level of significance.

Table 3. Effect of fertilizer recommendations on small plant growth and nutrient concentrations on the very high testing site in 1981.

Lab	Small plant dry weight	Nutrient P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	g/plt.	%				ppm				
A	4.4	.38	4.95	.42	.31	524	75	55	11.7	7.0
B	4.4	.39	4.98	.43	.31	403	74	58	11.4	7.2
C	4.6	.39	4.96	.44	.32	547	81	51	11.4	6.8
D	4.6	.39	4.97	.43	.31	507	82	50	11.7	6.4
E(UM)	4.2	.38	4.98	.42	.32	490	76	47	12.1	6.2
Check	4.4	.38	4.81	.40	.30	506	63	38	12.0	7.0
Signif(%):	13	33	39	99	75	63	99	99	14	94
BLSD(.05):				.02			6	3		
CV(%) :	12.	3.4	3.8	3.7	3.7	23.	6.6	4.8	10.	8.9

Table 4. Effect of fertilizer recommendations on corn earleaf nutrient concentrations on the very high testing site in 1981.

Lab	Nutrient N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
A	3.20	.31	1.92	.46	.34	111	71	32	3.4	3.9
B	3.17	.32	2.06	.46	.33	113	75	36	3.5	3.7
C	3.19	.32	1.98	.47	.34	114	79	31	3.7	3.9
D	3.27	.32	1.99	.48	.34	116	87	28	4.1	4.0
E(UM)	3.17	.32	1.88	.48	.37	114	74	26	3.7	3.8
Check	2.60	.29	1.84	.41	.30	96	44	20	2.6	3.2
Signif(%):	99	99	96	99	97	99	99	99	99	99
BLSD(.05):	.11	.01	.16	.02	.04	5	9	3	.5	.3
CV(%) :	3.2	2.7	5.9	4.2	9.0	4.4	12.	8.9	12.	6.6

Medium-high testing site

The soil test results and the accompanying recommended fertilizer program of each laboratory are shown in Table 5 for the medium-high testing site. Nitrogen recommendations among the laboratories were quite similar while both the P and K recommendations varied substantially. Sulfur and various micronutrients were recommended by three of the four private labs.

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

	Soil Test Results[1]				
Test	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	6.5	6.9	6.8	6.5	6.5
pH (buffer)	6.7	---	---	7.0	---
Phosphorus	14 M	24 L	22	24 M	12 MH
Potassium	163 L	180 L	120	228 H	100 MH
Organic matter (%)	4.2 H	7.4	M	4.2	H
Calcium	4300 H	5600 H	---	6090 VH	---
Magnesium	577 VH	770 M	---	1038 H	---
Sulfur	6 L	14 L	25 A	8 M	7 MH
Iron	37 VH	39.4 H	8+ A	5.6 VH	---
Manganese	21 H	16.1 H	2+ A	2.1 VH	---
Zinc	1.3 M	1.9 H	1.1 A	1.7 M	1.2 H
Copper	1.0 M	0.9 M	0.4+ A	---	---
Boron	1.7 H	1.5 H	3.4 A	---	---
ENR (lb/A)	114	---	---	110 H	---
C.E.C. (meq/100g)		35.0	---		---

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

	Recommended Fertilizer Program[2]				
Nutrient	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
Nitrogen	185	185	182	200	170
Phosphorus (P_2O_5)	80	90[3]	56	90	80
Potassium (K_2O)	125	195[3]	128	110	105
Sulfur	18	16	---	---	---
Iron	---	---	---	.12[4]	---
Manganese	---	---	---	.12[4]	---
Zinc	3	---	---	.6[4]	---
Copper	---	---	---	---	---
Boron	---	---	---	---	---
Lime (T/A)	1.5	---	---	0.5	---

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

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

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

At this medium-high testing site the treatments that received fertilizer yielded significantly more than the check (Table 6). However, there were no significant yield differences among the fertilizer treatments (recommendations). Grain moisture was reduced significantly from the control by all of the fertilizer treatments with no difference among the five laboratories. Final population was not different among the treatments.

Small plant growth was increased over the check by all treatments which received fertilizer (Table 7). Plant growth was larger with all four of the private laboratory treatments compared to the public lab (E). This may have been due to the higher application rate of K over the two-year period with the private lab recommendations. Evidence of this is shown by higher K concentrations in the small plants with the private lab treatments. Calcium and Mg show an inverse relationship to K which is expected. Plant Zn responded to the lab A recommendation of 3 lb Zn/A in 1981 and 4.5 lb in 1980 but differences among labs B-E were not significant (P=.05 level). Small plant P, Fe, Mn, Cu and B

were not influenced by the five laboratory recommendations.

The five laboratories did not show significantly different leaf nutrient concentrations (P=.10 level) (Table 8). The only nutrient to be influenced compared to the no fertilizer control was N, which was increased to the same level by all recommendations. This would indicate that the high P and K rates plus the Fe, Mn and Zn recommendations were not being utilized by the plants even under these high yield conditions. Again, all nutrients except Cu and B appeared to be at or above published sufficiency levels.

Table 6. Effect of fertilizer recommendations on corn final population, grain yield and moisture on the medium-high testing site in 1981.

Lab	Fertilizer Recommendations	Final population	Grain Yield	Grain H_2O
	lb/A[1/]	ppA x 10^{-3}	bu/A	%
A	185N +80P +125K +S+Zn	25.3	181.3	27.7
B	185N +90P +195K +S	24.9	180.0	27.7
C	182N +56P +128K	24.6	176.2	27.8
D	200N +90P +110K +Fe+Mn+Zn	24.5	181.1	27.6
E(UM)	170N +80P +105K	25.2	183.2	27.4
Check		24.2	120.1	29.7
	Signif. Level (%):	32	99	99
	BLSD(.05) :		9.6	0.6
	CV (%) :	5.4	5.3	2.0

1/ P and K expressed on oxide basis.

Table 7. Effect of fertilizer recommendations on small plant growth and nutrient concentrations on the medium-high testing site in 1981.

Lab	Small plant dry weight	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	g/plt.	%				ppm				
A	3.9	.41	4.35	.57	.43	475	68	47	13.3	8.3
B	3.8	.41	4.41	.58	.43	483	71	42	12.2	8.4
C	3.9	.43	4.40	.59	.43	534	70	39	13.2	8.1
D	4.0	.42	4.32	.58	.43	522	70	43	12.9	7.3
E(UM)	3.4	.41	3.77	.63	.52	464	73	40	12.4	8.2
Check	2.2	.38	3.03	.64	.58	596	63	39	14.7	8.3
Signif.(%):	99	99	99	99	99	46	87	96	99	40
BLSD(.05) :	0.4	.02	.26	.03	.06			6	1.1	
CV(%) :	10.	3.3	6.0	4.0	10.	26.	8.8	9.8	6.9	14.

Table 8. Effect of fertilizer recommendations on corn earleaf nutrient concentrations on the medium-high testing site in 1981.

Lab	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
A	2.78	.28	1.62	.48	.41	90	49	23	2.5	4.2
B	2.88	.28	1.64	.46	.40	90	48	22	2.5	4.0
C	2.84	.28	1.56	.48	.44	88	47	21	2.4	3.9
D	2.88	.30	1.62	.47	.39	88	53	22	2.6	4.0
E(UM)	2.91	.30	1.67	.50	.41	94	55	23	2.8	3.9
Check	2.18	.28	1.52	.45	.38	87	41	24	2.7	3.6
Signif.(%):	99	85	34	80	66	13	59	34	39	69
BLSD(.05) :	.17									
CV(%) :	5.5	6.5	11.	6.7	12	10.	24.	14.	18	9.7

SUMMARY - 1981

There were substantial differences among the laboratories' fertilizer recommendations at both sites. Nitrogen recommendations were generally similar, but P and K recommendations differed greatly among the laboratories. Sulfur and various micronutrient recommendations were provided by all four private labs. Small growing plants showed some uptake response to the micronutrients and K recommended. Earleaf nutrient concentrations among the lab recommendations were generally not significantly different except for K on the medium-high testing site. Some carryover of Zn from the 1980 recommendations was observed. Grain yield differences were not observed among the 5 lab recommendations at the medium-high testing site; however, significant yield differences were found on the very high testing site.

Fertilization resulted in a slight profit ($13-19/A) on the very high testing site with no real difference among the labs with respect to profit or loss from the various recommendations (Table 9). However, fertilizer costs ranged from $77/A with lab D to $52/A with lab E. On the medium-high testing site a substantial return was gained from fertilization ($66-92/A). Also, the laboratories' recommendations resulted in fertilizer costs ranging from $58-78/A while net return varied by $26/A among the labs.

Table 9. Effect of fertilizer recommendations on yield, value, fertilizer cost and the resulting economic return on both the very high testing site and medium-high testing site at Waseca in 1981.

	Very High Testing Site				Medium-High Testing Site			
Lab	Yield	Value @$2.40/bu	Fert.[1] cost	Return[2]	Yield	Value @$2.40/bu	Fert.[1] cost	Return[2]
	bu/A	$/A			bu/A	$/A		
A	172	413	60	17	181	434	70	76
B	175	420	66	18	180	432	78	66
C	173	415	65	14	176	422	58	76
D	180	432	77	19	181	434	76	70
E(UM)	167	401	52	13	183	439	59	92
Check	140	336	0	--	120	288	0	--

[1] Using May 1, 1981 prices for each nutrient expressed as dollars/lb as follows: N, .15; P_2O_5, .25; K_2O, .13; S, .18; Mn, 1.04; Zn, .89; Cu, 2.80; B, 1.90.

[2] Return yield value @$2.40/bu - fertilizer cost - value of check treatment.

Conclusions from the 1981 study can be summarized as follows:

1. Application of high rates of P and K to soils already testing very high is not practical.

2. No direct benefit or response was obtained with the addition of S or the micronutrients even though they were recommended by some laboratories.

TWO-YEAR SUMMARY

Summarizing the 1980 and 1981 data from the very high testing site generally showed no benefit for fertilization (Table 10). This was due to fertilizer recommendations being made for a goal of 180 bu/A in 1980 while the yields obtained barely exceeded 100 bu/A due to drought conditions. The lowest total fertilizer cost was with lab E ($92/A) and this resulted in the highest return. Lab D recommended the highest fertilizer cost. Recommendations by all private labs did not pay for the fertilizer used in this study; partially because of the dry conditions.

Recommendations by all laboratories paid for the fertilizer in the medium-high testing site (Table 10). Return above the unfertilized check ranked the labs in the order E>C>A>D>B. Highest fertilizer costs were recommended by lab B with lowest costs by lab E (U of M).

Table 10. Effect of fertilizer recommendations on total corn yield, total fertilizer cost and the resulting economics on both the very high and medium-high testing site at Waseca from 1980 and 1981.

	Very High Testing Site Total Two-Year				Medium-High Testing Site Total Two-Year			
Lab	Yield	Crop Value[1]	Fert. Cost.	Return[2]	Yield	Crop Value[1]	Fert. Cost	Return[2]
	bu/A	$/A			bu/A	$/A		
A	270	707	131	-48	317	842	153	56
B	275	720	135	-39	308	816	177	6
C	279	733	121	-12	312	830	135	62
D	282	738	148	-34	310	821	163	25
E(UM)	274	722	92	6	316	838	112	93
Check	236	624	0	--	235	633	0	--

[1] Price used per bushel was $3.00 and $2.40 in 1980 and 1981, respectively.

[2] Return over two-year period = crop value - fertilizer cost - value of check treatment.

EFFECT OF SYMBOOSTER ON SOYBEAN PRODUCTION

University of Minnesota
Southern Experiment Station
Waseca, MN -- 1981

Gyles W. Randall

Symbooster is "a biostimulant consisting of enzymes" and works as "a chemistry of enzymes and micro-minerals that stimulate the bioactivity of the soil and their enhanced activity results in an improved yield", according to Agro-K Corporation, who markets the product. Claims are made that "Symbooster will increase the available form of phosphorus and potassium fertilizer making them more available to the plant to utilize for optimum growth development". They further claim that "excellent results have been posted to date on potatoes, sugar beets and soybeans".

The purpose of this study was to evaluate the effect of Symbooster on soybeans produced on a fertile, south-central Minnesota soil.

EXPERIMENTAL PROCEDURES

The soil type used was a Webster clay loam with pH=6.9, Bray No. 1 extractable P=38 lb/A (High) and exchangeable K=284 lb/A (High). Following wheat in 1980, 0+60+150 (lb $N+P_2O_5+K_2O$/A) was broadcast applied and chisel plowed in. A combination of Treflan (1 qt/A) + Amiben (5 qt/A) was applied and incorporated on May 6 to control weeds.

A randomized, complete-block design consisting of six replications and three treatments was used. Each individual plot measured 55' x 10'. Two rates of Symbooster (1 gal/A--recommended rate and 2 gal/A) were applied with a bicycle sprayer on May 19 and were field cultivated in lightly. Hodgson 78 soybeans were planted in 30" rows at a rate of about 7 beans/foot on May 22. Twenty uppermost, mature trifoliate leaves were sampled at mid-bloom on July 29 from each plot. The center two rows of each 4-row plot were harvested by a ALAMCO plot combine on October 23. Final stand and seed moisture were taken at that time.

RESULTS

Soybean seed yield, seed moisture at harvest and final population were not influenced (P=.10 level) by the Symbooster treatments (Table 1). Probability levels indicate only an 8% chance that the 0.3 bu/A difference in yield between the control and the recommended Symbooster rate was significant--even with a very low C.V. Symbooster also did not influence (P=.10 level) the soybean leaf nutrient concentrations. All nutrient concentrations were considered to be optimum for high soybean yields.

Table 1. Influence of Symbooster on soybean production and leaf nutrient content at Waseca in 1981.

Symbooster Treatment	Final Stand	Seed Yield	Nutrient[1/] P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	pl./foot	bu/A	%				ppm				
Check	6.0	44.7	.50	2.25	1.38	.49	94	160	24.6	8.2	53
1 gal/A	5.9	45.0	.51	2.23	1.37	.48	94	163	24.7	8.0	53
2 gal/A	5.9	44.8	.49	2.15	1.34	.48	96	149	23.8	8.2	52
Significance:[2/]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
P Level (%) :[3/]	32	8	42	84	28	48	25	89	28	52	61
CV (%) :	5.7	3.0	6.4	3.9	6.1	2.4	5.2	7.0	8.0	3.8	2.9

1/ Uppermost, mature trifoliate at mid-flowering.

2/ NS = not significant at the 90% level.

3/ Probability level at which difference in means would be significant.

SUMMARY

On the basis of this one-year study, Symbooster cannot be recommended for soybean production on fertile soils in south-central Minnesota.

MAXIMUM YIELD DEMONSTRATION
University of Minnesota
Southern Experiment Station
Waseca, MN -- 1981

Gyles W. Randall

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

EXPERIMENTAL PROCEDURES

The site selected was formerly a garden demonstration area which had a long history of high fertilization rates. The soil was a moderately well drained Nicollet clay loam with a 2-4% south-facing slope. Each crop system was planted in an area measuring 20' x 65'. Trickle irrigation using Chapin Watermatic Twin Wall 8 mil, 15" outlet tubing was installed at 30" spacings. Flow meters measured application rates. Water was applied from July 1 thru July 10. Tensiometers were installed at depths of 12" and 30" in all plots. Readings were taken on Monday, Wednesday and Friday at 9:00 A.M. The corn was hand planted while a Tye drill was used to plant the soybeans. The corn plots were harvested and measurements taken on the center 40' of each of the center 4 rows of each 8-row plot. Soybean yields were taken from combine harvested areas measuring 10' x 50' from the center of each plot. Additional experimental procedures are outlined in Table 1.

Table 1. Experimental procedures used in "non-limiting" environment demonstration at Waseca in 1981.

	Crop System			
Parameter	Cont. Corn	Corn after Soybeans	Soybeans after Corn	Cont. Soybeans
Tillage:	F. Chisel Spr. f. cult. (2x)	F. Chisel Spr. f. cult. (2x)	F. Chisel Spr. f. cult. (2x)	F. Chisel Spr. f. cult. (2x)
Fertilizer:	350 lb N/A -100 as AN (4/15) -100 as soybean meal (4/17) PPI -150 as Urea (6/12) No P or K	350 lb N/A -100 as AN (4/15) -100 as soybean meal (4/17) PPI -150 as Urea (6/12) No P or K	None	None
Hybrid-Variety:	Agway 849X Pioneer 3732	Agway 849X Pioneer 3732	Vickery	Vickery
Planting date:	4/17	4/17	5/19	5/19
Planting rate:	34800 ppA	34800 ppA	160000 ppA	160000 ppA
Row width:	15"	15"	6 2/3"	6 2/3"
Herbicide:	Lasso + Bladex	Lasso + Bladex	Treflan + Amiben	Treflan + Amiben
Insecticide:	Furadan (3 lb/A)	Furadan (3 lb/A)	None	None
Rainfall:		May June July August	3.60" 3.86" 6.21" 7.38"	
Irrigation:	July 2.75"	3.75"	None	None
Harvest date:	9/21 & 10/2	9/21 & 10/2	10/22	10/22
Harvest method:	Hand	Hand	Combine	Combine

The effect of a high fertilization history is shown in Table 2 from samples taken in 1980. Soil test P and K levels down to 24 inches were extremely high. Soil test Zn and S were judged to be very high and high, respectively. Soil pH was slightly acid with medium to high levels of organic matter.

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

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

RESULTS

Tensiometer values shown in Table 3 indicate sufficient soil moisture levels throughout the season. This soil has an available soil water holding capacity of over 10 inches in the 0-5' profile. With that in mind, the few occasions when values were greater than 50 centibars is of no consequence. This is especially true at the 12" level because we desire and encourage the roots to penetrate to depths of 4-5'. On only one occasion (7/29) did the 30" value equal 50 centibars or greater. Soil moisture drawdown was greatest for corn following soybeans, somewhat less for continuous corn and least for soybeans.

Nutrient concentrations in the diagnostic tissues shown in Table 4 indicate sufficient amounts of all nutrients with the possible exception of Mg in corn. The Mg levels were somewhat lower than normal probably due to the extremely high soil K levels. The Agway 849X hybrid accumulated substantially less Mg and somewhat less K and Zn than did Pioneer 3732. High soil K did not result in extremely high tissue K levels. Copper levels also appeared to be low, but this may be associated with different analytical methods used now (ICP) compared to previous methods when Cu sufficiency levels were documented.

Yields from this demonstration fell below our goals of 250 and 80 bu/A for corn and soybeans, respectively (Table 5). The highest corn yield was 222.4 bu/A with the Agway 849X variety following soybeans. When this variety followed corn, severe rootworm damage occurred and resulted in 84% of the plants lodged, 7% barren stalks, a lower final population and the lowest yield in the demonstration. Corn yield following soybeans was higher than following a previous crop of corn, although very little

difference was noted in the Pioneer 3732 hybrid. Protein levels were less than in 1980 but were not influenced by previous crop or hybrid. Final population was substantially lower than the planting rate. This was primarily due to very cold soils and delayed emergence (18-19 days) following the very early planting date (April 17). Also, strong winds in early June broke off some of the Agway 849X plants at the soil surface. Yields were taken at physiological maturity; thus, grain moisture (grain + cob) was quite high.

Table 3. Tensiometer readings from June 10 thru September 4, 1981.

		Crop System							
		Cont. Corn		C-Sb		Sb-C		Cont. Sb	
Week of[1]	Depth(in):	12"	30"	12"	30"	12"	30"	12"	30"
		centibars							
6/10		22[2]	14[3]	35	14	6	12	13	13
6/17		8	9	34	12	2	10	6	8
6/24		37	9	77	14	4	9	11	7
7/1		32	8	82	13	5	9	10	7
7/8		60	11	61	15	64	12	54	10
7/15		6	8	17	20	6	8	8	8
7/22		14	11	57	35	9	12	25	9
7/29		10	13	57	50	4	16	23	10
8/5		18	22	34	28	6	27	54	13
8/12		17	24	6	10	3	42	34	11
8/19		22	9	17	12	9	21	38	8
8/26		26	11	28	16	11	33	29	9
9/2		8	10	7	11	11	11	8	9

1/ Readings taken on Monday, Wednesday and Friday A.M.

2/ Each value is an average of 6 readings (3 dates x 2 tensiometers).

3/ Each value is an average of the 3 dates.

Table 4. Nutrient concentrations in the leaf[1] from the "non-limiting" environment demonstration at Waseca in 1981.

Crop System	Hybrid	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%					ppm				
Cont. Corn	A849X	2.95	.45	2.44	.56	.13	105	29	15	4	4
	P3732	2.92	.40	2.56	.47	.23	141	40	21	5	6
Corn-Sb	A849X	2.92	.43	2.47	.55	.13	138	39	21	4	4
	P3732	2.99	.39	2.89	.44	.22	209	49	25	6	5
Sb-C		--	.47	2.24	1.05	.32	92	55	37	3	49
Cont. Sb		--	.45	2.10	1.06	.32	93	50	32	3	50

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

Table 5. Corn and soybean production in a "non-limiting" environment at Waseca in 1981.

Crop System	Hybrid-Variety	Grain Yield	Grain Moisture	Grain Prot.	Barren Stalks	Root + Stalk Lodging	Final Popl'n
		bu/A	%	%	%	%	x 10^{-3}
Cont. Corn	A849X	170.4	40.2	9.1	7	81	26.3
" "	P3732	193.0	34.8	9.2	1	14	28.5
Corn - Sb	A849X	222.4	40.3	8.9	2	3	29.6
" "	P3732	197.3	35.6	8.9	2	6	32.2
Soybeans - C	Vickery	42.1	14.0				
Cont. Sb	Vickery	39.6	13.9				

The wet weather during 1981 resulted in increased internodal growth of the soybeans, severe lodging as early as mid-July, and relatively poor yields (Table 5). Soybean yield following corn was 2.5 bu/A better than the yield of continuous soybeans. Disease (Septoria, Brown stem rot and downy mildew) evidence began to show by late August. Brown stem rot was most prevalent with continuous beans. The conductive tissue of many plants with continuous soybeans was rotten by August 26. This resulted in average soybean size of 154 mg/seed compared to 168 mg/seed with soybeans following corn.

Total above ground plant material was weighed, separated into grain and fodder, dried and weighed to calculate dry matter production. The Agway hybrid produced 11.627 tons dry matter/A when following soybeans and in both crop systems out-produced the Pioneer hybrid (Table 6). However, the Pioneer hybrid did consistently show a higher grain:stover ratio as indicated by harvest index values of .50 and .51. Fodder N was slightly higher for continuous corn with little consistent difference between hybrids. Total N uptake (grain + fodder) was highest for the Agway 849X hybrid over both cropping systems and was well below the 350 lb N/A application rate. Total N uptake as a percent of N application ranged from 55 to 71% and indicates that our N application rate should have been sufficient.

Table 6. Total dry matter production, harvest index, fodder N and total N uptake of the corn in the "non-limiting" environment demonstration at Waseca in 1981.

Crop System	Hybrid	Total Dry Matter	Harvest Index	Fodder N	Fodder Yield	Total N Uptake
		T/A		%	T DM/A	lb/A
Cont. Corn	A849X	10.079	.40	0.84	6.060	219
" "	P3732	9.217	.50	0.84	4.650	212
Corn-Sb	A849X	11.627	.45	0.78	6.366	249
" "	P3732	9.100	.51	0.65	4.432	191

Soil samples were taken in one-foot increments to a depth of 5' from the corn plots following harvest. Nitrate-N analyses show a relatively small amount of residual N in the profile following continuous corn but a substantial carryover of NO_3-N with the corn-soybean sequence (Table 7). The lower levels following continuous corn could be due to increased immobilization and denitrification due to the high amount of corn residue (ca 5 T/A) incorporated from the previous crop. These values also indicate the N application rate of 350 lb/A was in excess of demand when corn followed soybeans.

Table 7. Residual NO_3-N left in the soil profile after harvest as influenced by cropping system.

Profile Depth	Crop System: Cont. Corn	Crop System: Corn-Sb
ft.	---------lb NO_3-N/A----------	
0-1	21	156
1-2	17	60
2-3	21	54
3-4	20	44
4-5	16	31
Total	95	345

DISCUSSION

The number of frustrations and hazards encountered in 1981 was reduced from 1980. Much of this was due to increased precipitation, thicker plastic irrigation tubing (8-mil vs 4-mil) and reduced lodging. Birds, striped gophers and squirrels were still a problem but corrective measures, i.e., shotguns, poison, a netting over the plots following tasseling and run down and under a 3' high wire fence which surrounded the plots, almost eliminated these problems.

Final population was reduced from 40000 ppA in 1980 to about 30000 ppA in 1981. This reduction was more than intended but did result in less premature death and lodging. However, I think that a higher population should have been maintained to maximize yields.

Selection of the two hybrids with a fairly large difference in relative maturity was good. Agway 849X (120-day RM) even though planted early did not reach physiological maturity until the first fall frost (September 28) while Pioneer 3732 (105-day RM) reached maturity by September 7. Growing degrees during 1981 were 7% below normal, so under these conditions a 120-day hybrid would be expected to encounter difficulty maturing before a killing frost.

Hybrid differences were also noticed in seed vigor, brittleness and in root development. Seedling emergence was slower (1-2 days) with 849X and the stands were poorer which indicated germination problems with early planting and cool soil temperatures. The high wind speeds of June 11 (70 MPH) broke off some of the Agway 849X plants while the Pioneer 3732 plants were not broken. Even though a very heavy application of Furadan (3 lb a.i./A) was used, the 849X hybrid lodged extensively when in continuous corn. Either the rootworms found this root environment to be more favorable or the root system of this hybrid was less developed.

Fodder production was quite high, especially with Agway 849X. Because all dry matter except the ears are returned to the soil, we can expect immobilization of significant fertilizer N in these plots in 1982.

FUTURE

Because of soybean diseases and poor yields, corn will be planted in all plots in 1982. The same two hybrids will be used at a planting rate of 40000 ppA. Another short season (probably about 80-day RM) will be used. Also, we would like to try some of the 25-5" or 23-7" row spacings. Nitrogen will be applied at 400 lb N/A following corn and 300 lb/A following soybeans. Other management practices will remain similar to 1981.

ACKNOWLEDGMENT

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NITROGEN INCORPORATION STUDY

Waseca, 1981

G.W. Randall, H.L. Meredith and D.K. Langer

With increasing usage of post-plant application of nitrogen (N), there has been a considerable amount of attention given to whether or not it is necessary to incorporate surface-applied N for maximum corn yield and greatest N efficiency. The purpose of this study was to determine the value of incorporating three sources of surface-applied N fertilizer by measuring corn yield and leaf and grain N concentration.

EXPERIMENTAL PROCEDURES

Thirteen treatments, involving a factorial with 3 sources of N, 2 rates of N and 2 methods of application (incorporation vs no incorporation), plus a check treatment, were replicated six times and applied to a Nicollet clay loam soil (Table 2). Within each replication the incorporation treatments served as main plots with the six source-rate treatments randomized as subplots. Each individual plot measured 10' wide (4 rows) by 55' in length.

The previous crop was corn which had been moldboard plowed immediately after receiving a broadcast application of 0+30+120 (lb $N+P_2O_5+K_2O$/A) in the fall of 1980. Prior to planting the incorporated N treatments were applied on May 11 and field cultivated in.

Corn (Pioneer 3901) was planted at 27700 plants/A with 1 lb Amaze/A on May 12. Weeds were chemically controlled with Lasso (3½ lb/A) and Atrazine (3 lb/A). The nonincorporated treatments were surface-applied on May 27.

Two soil cores/check plot were taken to a 5-foot depth and composited into 1-foot increments from each of the replications on May 6. These samples were analyzed for NO_3-N. In addition, 0-6" samples were taken from each plot in July for pH determination of the surface soil.

Leaf samples were taken from 10 random plants at silking. Population was determined from 35' of row prior to harvest. Grain yield, grain moisture and grain protein were determined on corn harvested from the center two rows of each plot with a modified JD 3300 plot combine on October 12.

RESULTS

The site selected for the study contained a moderate amount of NO_3-N in the 5-foot profile (Table 1). Most of the NO_3-N was found in the 0-2' layer with little accumulation below that depth.

Table 1. Nitrate content of the soil profile at the beginning of the study in 1981.

Depth	NO_3-N[1/]
feet	lb/A
0-1	34(7.5)
1-2	30(5.9)
2-3	16(2.1)
3-4	16(4.4)
4-5	16(2.6)
Total	112(18.2)

[1/] Each value is an average (standard error of mean) from the six check plots.

Two separate analyses of variance statistical tests were conducted on the data. The first included all treatments and indicates that significant differences (P=.01 level) in leaf N, yield, grain moisture and grain N were found (Table 2). All N treatments showed higher leaf N concentrations, grain yields and grain N concentrations when compared to the check. Final population and soil pH were not related to treatment and, thus, should not have had a bearing on any particular treatment.

Table 2. Influence of nitrogen rate, nitrogen source and incorporation on soil pH, leaf N, final population, grain yield, grain moisture and grain nitrogen at Waseca in 1981.

N Treatments								
Rate	Source[1]	Incorporation	Soil pH	Leaf N	Final Population	Grain Yield	Grain Moisture	Grain N
lb/A				%	x 10^{-3}	bu/A	-------%--------	
0	----	--	6.7	2.32	24.6	138.2	26.0	1.12
75	AN	No	6.7	2.64	25.2	167.4	25.3	1.24
75	AN	Yes	6.6	2.67	25.2	170.8	24.7	1.27
75	Urea	No	6.8	2.67	24.7	164.9	25.3	1.20
75	Urea	Yes	6.7	2.72	25.2	159.2	24.8	1.19
75	28%	No	6.6	2.47	25.4	158.2	26.1	1.22
75	28%	Yes	6.7	2.63	24.9	170.5	24.8	1.25
150	AN	No	6.6	2.75	25.2	170.6	25.0	1.24
150	AN	Yes	6.7	2.74	25.1	177.7	24.0	1.31
150	Urea	No	6.7	2.72	25.1	180.1	24.6	1.25
150	Urea	Yes	6.8	2.70	25.9	175.9	24.2	1.29
150	28%	No	6.7	2.62	25.3	167.4	25.0	1.26
150	28%	Yes	6.7	2.71	25.0	176.3	24.4	1.26
	Signif. Level(%):[2]		<1	99	22	99	99	99
	BLSD(.05)	:		.14		10.7	0.8	.08
	CV(%)	:	5.6	4.5	4.6	5.8	2.8	5.4
Individual Factors								
N Rate (lb/A)								
75			6.7	2.63	25.1	165.2	25.2	1.23
150			6.7	2.71	25.3	174.7	24.5	1.27
	Signif. Level(%):		42	99	59	99	99	99
N Source								
AN			6.6	2.70	25.2	171.6	24.8	1.27
Urea			6.7	2.70	25.2	170.0	24.7	1.23
28%			6.6	2.61	25.2	168.1	25.1	1.25
	Signif. Level(%):		93	99	4	64	96	76
	BLSD(.05)	:		.05			0.3	
Incorporation								
No			6.7	2.64	25.1	168.1	25.2	1.24
Yes			6.7	2.70	25.3	171.7	24.5	1.26
	Signif. Level(%):		2	53	29	70	88	66
					Signif. Level (%)			
Interactions								
Rate x Source		:	<1	85	37	93	26	72
Rate x Incorp.		:	78	82	32	12	54	47
Source x Incorp.		:	31	95	73	99	68	41
Rate x Source x Incorp.		:	74	6	1	24	78	51

1/ AN = 33% N, Urea = 45% N, UAN = 28% N solution.

2/ Probability level of significance.

A second analysis, with the N check plots omitted, was made to accurately estimate the source, rate and incorporation effects and their interactions. The 150-pound N rate resulted in significantly higher leaf N, grain yield and grain N and lower grain moisture than the 75-pound rate (Table 2). A comparison of N sources indicated highest leaf N with ammonium nitrate (AN) and urea (U) and lowest with UAN. Grain yield and N were not influenced by the three N sources. The incorporation of the N did not influence any of the parameters measured when averaged over N source or N rate as compared to leaving the N on the soil surface.

Significant interactions between N source, rate of application and surface application with or without incorporation were not common but had significant implications (Table 2). The significant rate x source interaction for yield was due to a 18.0 bu/A yield increase at the 150-lb N rate with U over the 75-lb rate while the AN and UAN only showed 5.1 and 7.4 bu/A increases, respectively. The significant source x incorporation interaction for leaf N indicates that leaf N was not increased by the incorporation of AN or U but was increased significantly by the incorporation of UAN. A significant source x incorporation interaction was also found in grain yield. Incorporation resulted in a slight yield decrease with U (4.9 bu), a slight increase with AN (5.2 bu) and a significant increase with UAN (10.6 bu). These data indicate that the incorporation of UAN was more important than the incorporation of either AN or U for improving N efficiency.

The weather conditions in the 10 days after application of the non-incorporated treatments are shown in Table 3. A slight rain (0.06") occurred within 12 hours after the N application with another 0.10" the following day. This dissolved the N into the surface soil. Only 0.36" of rain was recorded during the 10-day period following N application. Air temperatures were quite mild during this 10-day period. Maximum air temperature averaged 78°F and ranged from 68°F to 84°F. In the next 10-day period, measurable amounts of rain occurred in 5 days and totaled 2.00". Surface soils were saturated during half of this time in which maximum air temperatures averaged 67°F.

Table 3. Air temperature and precipitation in the 10-day period following surface application of N in 1981.

Day	Air Temperature Max	Air Temperature Min	Precipitation
	------°F-------		inches
1 (N applied)	71	55	0.06
2	79	58	0.10
3	80	47	
4	68	47	
5	82	59	
6	82	61	0.03
7	75	50	0.15
8	73	53	
9	84	58	0.02
10	82	54	

SUMMARY

The incorporation of UAN did improve yield and leaf N under these experimental conditions in 1981. Incorporation of ammonium nitrate or urea did not influence N efficiency. Leaf N was significantly less and grain moisture higher with UAN than with the other two sources.

ROTATION NITROGEN STUDY

Waseca, 1981

G. W. Randall and D. K. Langer

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 corn removed as silage in a crop sequence study.

EXPERIMENTAL PROCEDURES

Four 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) have been applied annually to corn.

The corn-wheat + alfalfa sequence was dropped in 1981 in favor of a continuous corn system where all of the corn was removed as silage the preceding year. This gives us a comparison of the N needs between grain removal only compared to total above-ground biomass removal.

In 1981, anhydrous ammonia was applied on April 25 to all corn plots. Wheat received 50 lb N/A as urea before planting. Broadcast P and K of 30 + 120 lb P_2O_5 and K_2O/A were applied in the fall of 1980 before moldboard plowing all plots. Starter fertilizer was not applied.

Each corn plot was split lengthwise and two corn hybrids (Pioneer 3732 and Pioneer 3901) were planted in 30" rows at 27700 ppA on May 1. Amaze was applied to all corn plots at 1 lb/A to control rootworms. Era wheat was planted on May 18. Each of the previous year's corn-soybean plots were split so that Corsoy was planted on half of each plot and Hodgson in the other half on May 18.

Weeds were chemically controlled along with one cultivation of the corn. A combination of 3½ qt Lasso plus 3 lb Bladex/A was applied preemergence to corn. Soybeans received 3½ qt Lasso plus 5½ qt Amiben/A applied preemergence.

Corn leaf samples were taken at silking from rows 2 and 3 (Hybrid A) and from rows 4 and 5 (Hybrid B) of each 6-row plot. Corn yields were taken by mechanically harvesting the same rows. Grain moisture and protein data were obtained on the harvested samples.

RESULTS

A significant grain yield and leaf N response to fertilizer N was shown with both hybrids regardless of the previous crop (Table 1). The Pioneer 3901 hybrid yielded slightly more than the P3732 but generally contained less leaf N. When averaging the two hybrids together grain yield response to N (200 lb N/A) ranged from 43 bu/A following soybeans to 80 bu/A following continuous corn (grain). Yield responses of 59 and 57 bu/A resulted following corn removed for silage and wheat, respectively. When no N was added yields were lowest for continuous corn (grain), intermediate following continuous corn (silage) and wheat and highest following soybeans. Yields were maximized at 160-200, 160, 120 and 120-160 lb N/A when continuous corn (grain), corn (silage), soybeans or wheat were the preceding crops, respectively. At the 200 lb/A N rate corn yields were 0, 5 and -1 bu/A higher following corn (silage), soybeans, or wheat as compared to continuous corn. This was consistent with both hybrids but was considerably different than in past years. The reason is thought to be due to the extremely favorable weather conditions in 1981 which did not provide any stress situations. Also, the hybrids used in 1981 are perhaps much more tolerant to a monoculture system than the previous hybrid (Pioneer 3780).

When no N was added, leaf N was highest following soybeans, intermediate following wheat and corn (silage), and lowest following continuous corn (grain). At the 200-lb N rate differences in leaf N were not found among the previous crop histories.

To determine if N from the 1980 application to corn carried over and affected soybean yields, soybeans from the 0 and 200 lb N/A treatments were harvested from all 5 replications. The data shown in Table 2 indicate no effect of the previous year's N treatment on soybean yields in 1981.

Table 1. Grain yield and leaf N as influenced by previous crop and N rate at Waseca in 1981.

		Previous Crop							
		Corn (grain)		Corn (silage)		Soybeans		Wheat	
N rate	Hybrid:	3901	3732	3901	3732	3901	3732	3901	3732
lb N/A		Yield (bu/A)							
0		115.3	105.9	137.0	127.3	161.7	144.6	132.3	133.9
40		152.4	144.6	163.1	157.7	178.4	169.6	169.4	168.1
80		174.5	163.1	187.2	172.4	192.6	185.9	186.8	179.6
120		193.0	171.5	192.3	176.5	206.3	188.6	197.6	175.1
160		198.3	177.2	199.3	179.3	204.8	189.7	200.9	177.5
200		200.6	181.7	201.1	181.8	205.1	187.4	205.1	175.1
		Leaf N (%)							
0		1.86	1.81	2.02	2.16	2.25	2.26	2.12	2.18
40		2.20	2.24	2.50	2.53	2.65	2.61	2.45	2.52
80		2.50	2.60	2.65	2.63	2.68	2.82	2.70	2.69
120		2.72	2.67	2.71	2.84	2.74	2.87	2.73	2.88
160		2.74	2.90	2.80	2.80	2.82	2.93	2.81	2.95
200		2.81	2.89	2.75	2.97	2.87	2.98	2.77	2.97

Table 2. Influence of N applied to corn in 1980 on the yield of soybeans in 1981.

Variety	N rate	Yield
	lb N/A	bu/A
Corsoy	0	50.0
	200	50.6
Hodgson	0	49.0
	200	47.2

NITROGEN EFFICIENCY AS AFFECTED BY RIDGE - PLANTING

Waseca, 1981

G. W. Randall and D. K. Langer

As conservation tillage systems become more popular there are numerous questions regarding proper fertilization practices. Ridge planting, a system where no preparatory tillage is done but the seeds are planted on a performed ridge, has attracted much attention in the last few years. The purpose of this study was to determine the influence of N source, N rate and method-time of N application on the N needs of continuous corn grown in a ridge-plant system so as to improve N efficiency with conservation tillage.

EXPERIMENTAL PROCEDURES

Nineteen treatments, involving a factorial with 3 method-times of application, 3 sources of N and 2 rates of N plus a check treatment, were replicated five times and applied to a Webster clay loam. All treatments were completely randomized. Each individual plot measured 10' wide (4 rows) by 60' in length.

The previous crop was corn which had been ridged in June of 1980. A N rate of 180 lb N/A had been used in 1980. In the fall of 1980, P and K were broadcast at a rate of 30 + 120 lb P_2O_5+K_2O/A. Soil tests averaged: pH = 7.6, Bray P_1 = 39 lb/A (High) and exchangeable K = 255 lb/A (High).

Corn (Pioneer 3732) was planted with a Buffalo till-planter at 26500 plants/A with 1 lb Amaze/A on May 14. No starter fertilizer was used. Weeds were chemically controlled with Lasso (3½ lb/A) + Bladex (3 lb/A) applied preemergence on May 15. All plots were cultivated and ridged on July 2.

One-third of the N treatments was applied preplant on May 14. The urea was broadcast on the surface by hand while the urea-ammonium nitrate (UAN) solution (28% N) was broadcast with a bicycle sprayer. The planting operation which removes the top of the ridge and deposits the soil in the inter-row valleys was done within 6 hours of N application and should have incorporated most of the N. Anhydrous ammonia (AA) was knifed-in between the ridges with an anhydrous tool bar equipped with coulters ahead of the knives.

Another one-third of the treatments was applied just as the corn was emerging (May 27). Application techniques were the same as at preplanting. The last one-third of the treatments was sidedress-applied at the 8-leaf stage (June 26). The urea and UAN materials were banded along each row and covered slightly with soil.

The percent of the soil surface covered by corn residue from the 1980 crop was measured at emergence by the line-intercept method.

Leaf samples were taken at silking from 10 random plants per plot. Final population was determined from 70' of row prior to harvest. Grain yield, grain moisture and grain N (protein) were determined on corn harvested from the center two rows of each plot with a modified JD 3300 plot combine on November 4.

RESULTS

Two separate analyses of variance statistical tests were conducted on the data. The first included all treatments and indicates that highly significant differences (P=.01 level) in leaf N, grain yield, grain moisture and grain N were found (Table 1). All N treatments showed significantly higher leaf N and grain yield and lower grain moisture when compared to the check. Grain protein with all of the 150-lb N treatments was higher than the check.

The second analyses, with the check treatment omitted, was made to estimate the method-time, source and rate of N effects and their interactions. When averaged over N source and N rate the sidedress (SD) time of application resulted in the highest leaf N concentrations, the emergence (EM) time of application resulted in lowest yields while N application preplant (PP) showed lowest grain moisture (Table 2). Final population and protein were unaffected by the method-time of application.

Table 1. Leaf N, final plant population, grain yield, moisture and protein as influenced method-time, source, and rate of N fertilizer applied to a ridge-plant system at Waseca in 1981.

Treatment							
Method[1] -Time	N Source[2]	N Rate	Leaf N	Final Popl'n	Grain Yield	Grain Moisture	Grain Protein
		lb N/A	%	x 10^{-3}	bu/A	%	%
PP	UAN	75	2.53	22.6	161.5	22.5	8.94
PP	"	150	2.73	24.1	171.0	21.9	9.34
PP	Urea	75	2.43	24.6	161.2	22.8	8.78
PP	"	150	2.64	24.3	173.6	22.0	9.42
PP	AA	75	2.65	24.3	158.3	23.4	8.74
PP	"	150	2.66	24.1	174.5	22.1	9.39
EM	UAN	75	2.32	23.6	149.0	24.3	8.71
EM	"	150	2.61	24.8	157.0	23.4	8.96
EM	Urea	75	2.42	23.7	160.1	23.4	8.89
EM	"	150	2.64	24.1	173.8	22.2	9.89
EM	AA	75	2.63	23.3	155.7	23.6	8.95
EM	"	150	2.72	24.0	160.0	23.7	9.48
SD	UAN	75	2.67	23.8	170.5	22.9	9.30
SD	"	150	2.78	23.9	168.2	22.7	9.56
SD	Urea	75	2.64	23.6	164.4	23.4	8.99
SD	"	150	2.77	24.3	167.5	23.4	9.15
SD	AA	75	2.60	24.1	166.8	23.9	8.74
SD	"	150	2.76	23.5	168.9	22.8	9.44
--	Check	0	1.96	24.0	122.6	25.4	8.09
Significance Level(%):		[3]	99	46	99	99	99
BLSD (.05)		:	0.14	--	12.0	0.9	0.86
CV (%)		:	4.7	4.9	6.1	3.2	6.4

[1] PP = preplant, EM = emergence, SD = sidedress at 8-leaf stage.

[2] UAN = 28% N solution, AA = anhydrous ammonia.

[3] Probability level of significance.

When averaged over method-time of application and N rate, leaf N was highest with anhydrous ammonia. Final population, grain yield, moisture and protein were not significantly affected (P=.05 level) by the source of N. The 150-lb rate resulted in highest leaf N, grain yield and protein and lowest grain moisture when averaged over method-time of application and N source.

The significant interaction between the method-time of application and N source shown in Table 2 presents a strong case for proper N management with ridge-planting. This interaction was found in leaf N, grain yield and grain moisture. Leaf N and grain yield were lowest and grain moisture highest when either UAN or AA were applied at the emergence stage as compared to urea or any of the N sources applied PP or SD. At this application time 23% of the soil surface was covered with residue from the past year's corn crop. Apparently this residue resulted in sufficient volatilization of the UAN to limit N supply to the plants. Greater amounts of residue were present at the PP stage, but the immediate incorporation of the UAN by the planting operation must have been sufficient to limit N loss. In the case of AA, the residue from the previous crop had been buried in the valley (injection zone) between the ridges by the planter 13 days before N application at the emergence stage. This allowed the residue to partly decay. When injecting into this zone retention was poor and ammonia vapors were observed escaping from the soil. When ammonia was applied prior to planting or at the sidedress stage, no ammonia losses were observed. The coulters aided the application especially at the PP stage.

Another interaction which bears further comment is the one between method-time of application and N rate and is observed for grain yield (Table 2). In examining the yield data in Table 1, grain yields are not affected by the N rate when all three sources are applied at the sidedress stage. At the other stages of application, N rate showed a definite effect. This indicates that greater efficiency was obtained with the sidedress application and that N rate, regardless of source, could have been reduced.

Table 2. Factorial analyses of leaf N, plant population, grain yield, moisture and protein as influenced by method-time, source and rate of N fertilizer applied to a ridge-plant system at Waseca in 1981.

	Leaf N	Final popl'n	Grain Yield	Grain Moisture	Grain Protein
MAIN TREATMENTS	%	x 10^{-3}	bu/A	%	%
Method-Time					
PP	2.60	24.0	166.7	22.5	9.10
EM	2.56	23.9	159.3	23.4	9.15
SD	2.70	23.9	167.7	23.2	9.20
Signif.Level(%):	99	8	99	99	18
BLSD (.05) :	.06	-	4.8	0.3	--
N Source					
UAN	2.61	23.8	162.9	22.9	9.14
Urea	2.59	24.1	166.8	22.9	9.18
AA	2.67	23.9	164.0	23.3	9.12
Signif.Level(%):	97	37	72	92	10
BLSD (.05) :	0.06	--	--	--	--
N Rate (lb/A)					
75	2.54	23.7	160.8	23.4	8.89
150	2.70	24.1	168.3	22.7	9.40
Signif.Level(%):	99	90	99	99	99
INTERACTIONS					
Meth-Time x Source					
PP UAN	2.63	23.4	166.2	22.2	9.14
PP Urea	2.54	24.4	167.4	22.4	9.10
PP AA	2.65	24.2	166.4	22.8	9.06
EM UAN	2.46	24.2	153.0	23.8	8.84
EM Urea	2.53	23.9	167.0	22.8	9.39
EM AA	2.67	23.6	157.8	23.7	9.21
SD UAN	2.73	23.8	169.4	22.8	9.43
SD Urea	2.70	23.9	166.0	23.4	9.07
SD AA	2.68	23.8	167.8	23.3	9.09
Signif.Level(%):	99	69	92	99	84
		Significance Levels(%)			
Meth-Time x Rate	50	48	94	58	26
Source x Rate	86	74	36	17	50
M-T x S x R	62	45	15	90	30

Grain N removal shown in Table 3 indicates a significant increase over the control with all N treatments. Nitrogen efficiency, as calculated from grain N removal divided by N application rate, shows the lowest values for the UAN and AA applied at emergence and highest values with the sidedress, 75-lb N rates.

The weather conditions in the 10 days after application at the emergence stage are shown in Table 4. A slight rain (0.06") occurred within 12 hours after the N application with another 0.10" the following day. Only 0.36" of rain was recorded during the 10-day period following N applications. Air temperatures were quite mild during this 10-day period. Maximum air temperature averaged 78°F and ranged from 68°F to 84°F. In the next 10-day period, measurable amounts of rain occurred in 5 days and totaled 2.00". Surface soils were saturated during half of this time in which maximum air temperatures averaged 67°F.

Table 3. Grain N removal and N efficiency as influenced by method-time, source and rate of fertilizer N applied to a ridge-planted system at Waseca in 1981.

Treatments				
Method-Time	N Source	N Rate	Grain N[1/] removal	N efficiency[2/]
		lb N/A	lb N/A	%
PP	UAN	75	110.4	47
PP	"	150	120.9	30
PP	Urea	75	107.2	42
PP	"	150	123.8	32
PP	AA	75	105.0	39
PP	"	150	124.8	33
EM	UAN	75	98.7	31
EM	"	150	106.6	21
EM	Urea	75	108.0	43
EM	"	150	130.2	36
EM	AA	75	105.8	40
EM	"	150	114.9	26
SD	UAN	75	120.2	60
SD	"	150	121.6	31
SD	Urea	75	111.8	48
SD	"	150	115.9	27
SD	AA	75	110.6	47
SD	"	150	120.9	30
	Check	0	75.4	--
	Signif.Level(%):		99	
	BLSD(.05)	:	14.6	
	CV(%)	:	10.4	

1/ Yield times grain N

2/ (Grain N removed from trt. - Grain N removed from check) ÷ N rate

Table 4. Air temperature and precipitation in the 10-day period following the emergence stage application of N in 1981.

Day	Air Temperature Max	Air Temperature Min	Precipitation
	------°F-------		inches
1 (N applied)	71	55	0.06
2	79	58	0.10
3	80	47	
4	68	47	
5	82	59	
6	82	61	0.03
7	75	50	0.15
8	73	53	
9	84	58	0.02
10	82	54	

SUMMARY

The application of UAN and anhydrous ammonia at the emergence stage resulted in reduced yields as compared to urea or any of the three N sources applied preplant (immediately before planting) or sidedress (8-leaf stage). Volatilization of the surface-applied UAN and poor retention of the ammonia in the band of incorporated residues were thought to be the primary reasons for the poorer N efficiency. Highest N efficiency was obtained with the sidedress applications of 75-lb N/A.

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CONSERVATION TILLAGE STUDY

Waseca, 1981

G. W. Randall and J. B. Swan

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

Experimental Procedures

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

Ridges are built along the corn rows for the till-plant (Ridge) treatment by cultivation in June each year. After harvest the stalks are chopped and the moldboard and chisel plow operations are performed in early November. On May 11 the moldboard and chisel plow plots were field cultivated once with the chisel plots receiving a prior disking.

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

Broadcast P and K were applied at a rate of 0+40+100 (lb $N+P_2O_5+K_2O$/A) in November, 1980. Nitrogen (180 lb N/A as ammonium nitrate) was broadcast on May 11. Amaze (1 lb/A) was applied to all plots at planting. Chemical weed control consisted of 3½ lb Lasso and 3 lb atrazine/A applied preemergence. Treatments 2, 3, 4, and 5 were cultivated on June 22. Weed control was excellent in all cultivated treatments.

Planting depth was determined by cutting off the coleoptile at the soil surface from all the plants in a 3-meter length of row in each plot 30 days after planting. The seeds were then excavated and the length of the coleoptile to the seed was measured. Early plant growth was determined by harvesting the above ground portion of 10 random plants per plot 36 days after planting. Yields were taken by combine harvesting two rows from each plot.

Statistical interpretation of the data throughout this report is based on the percent probability (significance levels) of obtaining a response. A significance level of 95 indicates that we could expect a real difference to occur 19 times out of 20 and only 1 time out of 20 due to chance. A significance level below 50 would indicate less than 50:50 odds of being real.

Results

Significant differences in final population, grain moisture, N removal in the grain and grain yield were found among the tillage treatments (Table 1). Grain protein was not affected (90% level).

Grain yield of the moldboard plow treatment (MP) was significantly higher than any of the other treatments (Table 1). The till-plant (ridge) (TP-R) treatment showed the second highest yield (5.7 bu/A less than MP) and was not significantly better than the chisel plow (CP) yield. Till planting without a ridge (TP-F) did not yield as well as either the TP-R or CP treatments but was 29 bu/A better than no tillage.

Starter fertilizer did improve grain yield when averaged over all treatments (Table 1). All tillage treatments except TP-F responded to starter fertilizer in 1981; thus, the tillage x starter fertilizer interaction was not significant. No explanation can be given for the lack of response with TP-F.

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

Grain moisture, an indication of maturity, was lowest with the TP-R treatment but was not significantly different than the MP and CP treatments (Table 1). The TP-F treatment was intermediate and showed significantly less moisture than the NT treatment. Slightly less moisture was associated with the addition of starter fertilizer.

Nitrogen removal in the grain (product of grain N times yield) was closely related to yield because grain protein (N) levels were not affected by the tillage treatments (Table 1). Highest N removal occurred with the MP system, intermediate removal with the TP-R, CP and TP-F systems and lowest removal with the NT system. This would indicate sufficient N was applied so that N unavailability with the very reduced tillage systems (NT and TP-F) was overcome. Higher N removal and grain N were associated with the starter fertilizer.

Table 1. Influence of tillage methods and starter fertilizer on continuous corn production at Waseca in 1981.

Treatment			Grain			
Tillage	Starter[2] fert.	Final popl'n	Moist.	Protein	N Removal	Yield
		x 10^{-3}	--------%--------		lb/A	bu/A
No tillage[1]	S		28.0	8.47	86.5	134.7
No tillage	NS		29.8	8.61	82.3	126.3
Fall plow, f.cult.[1]	S		25.3	8.73	117.7	178.0
Fall plow, f.cult.	NS		25.7	8.44	108.6	169.8
Fall chisel, d., f.cult.[1]	S		25.3	8.50	108.2	167.6
Fall chisel, d., f.cult.	NS		26.2	8.11	100.0	162.8
Till plant (Ridge)	S		25.4	8.53	110.8	171.6
Till plant (Ridge)	NS		25.4	7.98	99.5	164.9
Till plant (Flat)	S		27.2	8.69	105.0	159.8
Till plant (Flat)	NS		26.4	8.17	98.8	159.5
Individual Factors						
Tillage						
No tillage		20.8	28.9	8.54	84.4	130.5
Fall plow		23.5	25.5	8.59	113.2	173.9
Fall chisel		23.1	25.7	8.31	104.1	165.2
Till plant (Ridge)		23.0	25.4	8.26	105.2	168.2
Till plant (Flat)		21.9	26.8	8.43	101.9	159.6
Signif.Level(%):[3]		98	99	75	99	99
BLSD(.05) :		1.7	0.6	--	5.2	5.3
Starter fertilizer						
Starter			26.2	8.58	105.6	162.3
No starter			26.7	8.26	97.8	156.6
Signif.Level(%):[3]			93	94	99	98
Till x SF IA						
Signif.Level(%):[3]			95	33	10	28
CV(%) :		4.7	2.8	6.0	7.5	4.1

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

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

[3] Probability level of significance.

Surface residue measured just after planting showed the highest amounts with the NT (3.86 T DM/A) and TP-F (2.92 T DM/A) systems (Table 2). Much less but equal amounts of residue were associated with the FC (0.90) and TP-R (0.72) treatments. Fall plow had significantly less residue (0.34 T DM/A). These levels were somewhat less than in 1980 and were associated with the smaller 1980 crop. Percent surface residue measurements agreed quite closely to the weight measurements.

Planting depth averaged significantly deeper with the MP than either of the TP systems while the FC and NT systems were intermediate (Table 2). The variability in the seeding depth as measured by standard deviation (S) and shown by the range in depths indicates least variability with the MP system and greatest with the TP-R system. Seed placement ranged between 1.8" and 2.6" with the MP

system and between 0.8 and 2.6" with the TP-R system. This emphasizes the need for careful adjustment of the till planter; otherwise stand losses can be encountered with shallow seed placement.

Table 2. Influence of tillage methods for continuous corn on surface residue and seedling depth at Waseca in 1981.

Treatment	Surface Residue		Planting Depth		
			Average	S	Range
	T DM/A	%	mm		
No tillage	3.86	89	47.1	5.8	31-57
Fall plow	.34	6	53.4	4.8	46-67
Fall chisel	.90	25	46.4	6.1	27-58
Till plant (Ridge)	.72	14	41.3	7.6	21-65
Till plant (Flat)	2.92	54	41.0	6.2	26-67
Signif.Level(%):	99	99	99		
BLSD(.05) :	.35	8	7.1		
CV(%) :	14.	14.	9.6		

Soil temperature at the 3" depth was measured prior to planting by thermocouples placed randomly in the MP system and placed directly in the center of the ridge and in the center of the valleys in the TP-R system. Temperatures over the 9-day period prior to planting were essentially identical for the MP (57.3°F) and TP-R ridges (56.9°F) (Table 3). The valleys, however, averaged 4°F cooler than the ridge, which shows the advantage for planting on ridges in the TP system.

Table 3. Soil temperature average (3") prior to planting as influenced by tillage practice at Waseca in 1981.

Treatment-Position	Day							
	4/27	4/28	4/29	4/30	5/1	5/2	5/5	Avg.
	°F[1/]							
Fall plow	65.4	52.6	57.5	53.2	59.9	57.9	54.7	57.3
T-P (Ridge) Top	64.5	51.4	58.0	52.0	59.9	57.4	55.2	56.9
T-P (Ridge) Valley	57.2	51.8	53.8	50.1	52.8	52.6	53.2	53.1

1/ Average of daily maximum and minimum.

The rate of seedling emergence was determined by counting the number of plants that had spiked thru in 100-feet of row/plot each day from the 10th to the 25th day following planting. Emergence, as a percent of final stand, shown in Table 4 indicates the most rapid germination and growth with the MP treatment and followed closely (1 day) by the TP-R and CP treatments. Slowest emergence occurred with the NT system. The TP-F system was somewhat faster than the NT system but lagged behind the others.

Table 4. Influence of tillage methods on the emergence progress of continuous corn at Waseca in 1981.

Treatment	Days Post Planting											
	10	11	12	13	14	15	16	17	18	20	21	25
	% emerged											
No tillage	0	0	0	0	0	4	31	56	73	91	96	100
Fall plow	20	64	81	87	90	91	94	94	94	99	99	100
Fall chisel	2	26	58	71	76	82	86	88	89	97	99	100
T-P (Ridge)	3	21	66	79	94	95	98	99	99	99	99	100
T-P (Flat)	0	2	12	20	36	57	78	86	88	94	98	100

Early plant growth (EPG) measurements shown in Table 5 indicate substantial differences among the tillage treatments. Plant growth by mid-June showed significantly larger plants with the MP system, intermediate growth (75% of the MP) with the CP and TP-R systems, smaller plants (47% of MP) with the TP-F system and smallest plants (32% of the MP) with the NT system. Starter fertilizer significantly improved early growth when averaged over all tillage systems. The correlation between EPG and grain yield was highly significant with starter fertilizer (+.824) and no starter treatments (+.873). A curve linear relationship resulted in both cases.

Because of apparent stress symptoms and stunting with the reduced tillage systems, plant height of 10 plants/plot was taken on July 10 and August 3 (Table 5). Plants grown on MP tillage were significantly taller than all others on July 10. Intermediate height was shown with the CP and TP-R systems. Plants were somewhat taller with the TP-F system as compared to NT. By August 3 differences in plant height were much less evident. Heights of all tillage systems except NT were equal and were significantly greater than the NT. A height response to starter fertilizer averaged over tillage treatments was not shown for either date but the significant tillage x starter fertilizer interaction on July 10 indicates the height response to starter for the NT system.

Table 5. Influence of tillage methods and starter fertilizer for continuous corn on small whole plant growth and plant height at Waseca in 1981.

Treatment		Early plant growth	Plant Height	
Tillage	Starter fert.		10 July	3 August
		g/plant	-------inches-------	
No tillage	S	2.52	57	114
No tillage	NS	1.75	53	113
Fall plow	S	6.85	76	118
Fall plow	NS	6.52	76	119
Fall chisel	S	5.00	69	118
Fall chisel	NS	4.95	70	116
Till plant (Ridge)	S	5.15	69	119
Till plant (Ridge)	NS	4.75	69	118
Till plant (Flat)	S	3.20	62	117
Till plant (Flat)	NS	3.12	63	117
Individual Factors				
Tillage				
No tillage		2.14	55	114
Fall plow		6.69	76	119
Fall chisel		4.98	69	117
Till plant (Ridge)		4.95	69	118
Till plant (Flat)		3.16	62	117
Signif.Level(%):		99	99	99
BLSD(.05) :		0.98	3	3
Starter fertilizer				
S		4.54	66	118
NS		4.22	66	117
Signif.Level(%):		99	79	87
Till x SF IA				
Signif.Level(%):		78	99	74
CV(%) :		7.4	1.9	1.2

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

Table 6. Influence of tillage methods and starter fertilizer for continuous corn on small whole plant nutrient concentrations at Waseca in 1981.

Treatment		Nutrient								
Tillage	Starter fert.	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%				ppm				
No tillage	S	.48	4.77	.41	.26	271	51	34	9.4	7.5
No tillage	NS	.44	4.74	.37	.26	208	44	34	9.6	8.2
Fall plow	S	.47	5.01	.44	.24	366	52	40	9.2	8.4
Fall plow	NS	.42	4.77	.41	.27	293	49	37	9.5	8.3
Fall chisel	S	.45	4.69	.42	.27	322	58	36	10.3	8.2
Fall chisel	NS	.41	4.70	.41	.26	318	54	36	9.5	8.0
Till plant (Ridge)	S	.44	4.49	.45	.32	382	51	39	11.4	7.2
Till plant (Ridge)	NS	.43	4.28	.44	.34	362	45	41	10.8	8.1
Till plant (Flat)	S	.43	4.57	.46	.33	293	46	36	11.6	7.0
Till plant (Flat)	NS	.40	4.30	.43	.33	308	43	36	10.4	9.1
Individual Factors										
Tillage										
No tillage		.46	4.76	.39	.26	240	48	35	9.5	7.8
Fall plow		.44	4.89	.42	.26	329	50	38	9.4	8.4
Fall chisel		.43	4.70	.42	.26	320	56	36	9.9	8.1
Till plant (Ridge)		.43	4.38	.44	.33	372	48	40	11.2	7.6
Till plant (Flat)		.41	4.44	.44	.33	301	44	36	11.0	8.0
Signif.Level(%):		90	90	74	99	98	35	86	65	22
BLSD(.05) :					.06	74				
Starter fertilizer										
S		.45	4.70	.44	.28	327	52	37	10.4	7.7
NS		.42	4.56	.41	.29	298	47	37	10.0	8.3
Signif.Level(%):		99	95	98	64	91	96	13	85	99
Till x SF IA										
Signif.Level(%):		90	40	11	12	62	6	16	61	96
CV(%) :		3.6	4.7	7.0	11.	16.	13.	10.	9.0	9.1

Nutrient uptake by the small plants was calculated by multiplying the nutrient concentrations (Table 6) by the EPG found in Table 5. The differences in uptake values among the tillage treatments are closely associated with the respective EPG values (Table 7). Uptake of all elements was significantly affected by the tillage treatments. Generally, uptake was greatest with MP system, intermediate with the CP and TP-R systems and least with the TP-F and NT systems. Starter fertilizer resulted in significantly higher uptake of P, K, Ca, Fe, Mn, Zn and Cu.

Table 7. Influence of tillage methods and starter fertilizer for continuous corn on small whole plant nutrient uptake at Waseca in 1981.

Treatment		Nutrient								
Tillage	Starter fert.	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		------mg/plant-------				----------mg/10 plants----------				
No tillage	S	12	121	10	6	6.9	1.29	.86	.23	.19
No tillage	NS	8	83	6	5	3.6	.77	.60	.17	.14
Fall plow	S	32	344	30	17	25.1	3.51	2.71	.63	.58
Fall plow	NS	27	312	27	17	19.0	3.13	2.44	.62	.54
Fall chisel	S	23	234	21	13	16.4	2.90	1.84	.50	.42
Fall chisel	NS	21	233	20	13	16.0	2.64	1.81	.46	.40
Till plant (Ridge)	S	23	233	23	16	19.8	2.54	2.04	.58	.37
Till plant (Ridge)	NS	21	202	21	17	16.8	2.09	1.95	.51	.38
Till plant (Flat)	S	14	145	15	11	9.1	1.45	1.16	.36	.23
Till plant (Flat)	NS	12	134	13	10	9.5	1.32	1.14	.32	.28
Individual Factors										
Tillage										
No tillage		10	102	8	6	5.2	1.03	.73	.20	.17
Fall plow		30	328	28	17	22.1	3.32	2.58	.62	.56
Fall chisel		22	234	20	13	16.2	2.77	1.83	.48	.41
Till plant (Ridge)		22	218	22	16	18.4	2.31	1.99	.54	.38
Till plant (Flat)		13	140	14	11	9.3	1.39	1.15	.34	.26
Signif.Level(%):		99	99	99	99	99	99	99	99	99
BLSD(.05) :		5	52	4	4	5.2	.53	.49	.06	.12
Starter fertilizer										
S		21	215	20	13	15.5	2.34	1.72	.46	.36
NS		18	193	17	12	13.0	1.99	1.59	.42	.35
Signif.Level(%):		99	99	99	48	99	99	92	99	30
Till x SF IA										
Signif.Level(%):		75	61	31	23	83	17	31	20	92
CV(%) :		9.3	10.	11.	15.	19.	17.	14.	11.	10.

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

Table 8. Influence of tillage methods and starter fertilizer for continuous corn on the nutrient concentration in the earleaf at Waseca in 1981.

Treatment		Nutrient									
Tillage	Starter fert.	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%					ppm				
No tillage	S	2.9	.32	1.90	.41	.27	100	33	20	4.4	4.1
No tillage	NS	3.0	.32	1.89	.45	.34	121	38	21	5.3	4.0
Fall plow	S	2.7	.32	2.29	.46	.25	94	44	18	4.9	3.5
Fall plow	NS	2.8	.30	2.08	.49	.31	91	44	18	4.3	3.8
Fall chisel	S	2.8	.30	1.97	.48	.32	91	47	21	4.6	3.6
Fall chisel	NS	2.9	.30	1.87	.52	.33	130	48	21	3.6	3.6
Till plant (Ridge)	S	2.8	.31	1.96	.49	.35	101	38	20	4.8	3.4
Till plant (Ridge)	NS	2.8	.32	2.01	.48	.36	100	36	21	4.8	3.8
Till plant (Flat)	S	2.9	.29	1.69	.48	.35	112	44	24	4.4	3.7
Till plant (Flat)	NS	2.9	.30	1.91	.48	.36	94	44	21	4.8	3.2
Individual Factors											
Tillage											
No tillage		2.9	.32	1.89	.43	.30	111	36	21	4.9	4.0
Fall plow		2.7	.31	2.18	.48	.28	93	44	18	4.6	3.6
Fall chisel		2.8	.30	1.92	.50	.32	110	47	21	4.1	3.6
Till plant (Ridge)		2.8	.32	1.99	.48	.35	100	37	20	4.8	3.6
Till plant (Flat)		2.9	.30	1.80	.48	.35	103	44	22	4.6	3.4
Signif.Level(%):		91	41	84	88	77	32	43	95	60	82
BLSD(.05) :									3		
Starter fertilizer											
S		2.8	.31	1.96	.46	.31	100	41	21	4.6	3.6
NS		2.9	.31	1.95	.48	.34	107	42	20	4.6	3.7
Signif.Level(%):		88	11	18	93	97	66	57	18	24	14
Till x SF IA											
Signif.Level(%):		71	57	94	57	47	79	44	80	70	50
CV(%) :		3.7	4.1	6.8	6.7	13.	23.	11.	9.2	21.	14.

SUMMARY

A field experiment was established in 1975 to evaluate five tillage systems (no tillage, moldboard plow, chisel plow, till-plant (ridge) and till-plant (flat) on continuous corn on a Webster clay loam. Beginning in 1979 all plots were split to evaluate the effect of starter fertilizer with these tillage treatments. Grain yields with the moldboard plow were significantly higher than with any of the other systems. The chisel plow and till-plant (ridge) systems yielded slightly less (8.7 and 5.7 bu/A, respectively). Lowest yields were obtained with no tillage. Starter fertilizer did improve yields when averaged over all treatments.

SEVEN-YEAR YIELD SUMMARY

Grain yields have been obtained from the five tillage systems where starter fertilizer was used from 1975-1981 (Table 9). The 7-year average yield shows a 4.8 bu/A yield advantage for the moldboard plow over the till-plant (ridge) system. Most of this difference could be attributed to the 17 bushel advantage in 1980 for moldboard plowing. The chisel plow and till-plant (flat) systems showed intermediate yields while lowest yields were obtained with no tillage. Weed control has been excellent in all treatments except no tillage. However, postemergence herbicides were applied to no tillage in 1979 and 1980 and did provide better weed control.

Three-year data indicate some advantage for the use of starter fertilizer with the chisel plow (8 bu/A), till-plant (ridge) (6 bu/A) and no tillage systems (6 bu/A). No reason can be given for the obvious difference in response to starter fertilizer between the no tillage and till-plant (flat) systems when both treatments represent the most severely reduced tillage systems.

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

Treatment		Grain	
Tillage	Starter fert.	1979-81 Avg. Yield	1975-81 Avg. Yield
		----------bu/A----------	
No tillage	S	141.0	127.8
No tillage	NS	134.7	
Fall plow	S	169.6	151.6
Fall plow	NS	170.2	
Fall chisel	S	161.1	141.6
Fall chisel	NS	152.8	
Till plant (Ridge)	S	159.9	146.8
Till plant (Ridge)	NS	154.0	
Till plant (Flat)	S	153.1	142.8
Till plant (Flat)	NS	154.6	

USE OF DWELL (TERRAZOLE) AND N-SERVE AS NITRIFICATION INHIBITORS WITH FALL VS. SPRING NITROGEN APPLICATION FOR CORN PRODUCTION IN SOUTHERN MN.

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

The use of nitrification inhibitors on fine textured soils of southern Minnesota has gained considerable attention over the last several years. There are several chemicals known which are capable of delaying the rate of nitrification, but there is only one currently on the market (N-Serve -Dow Chemical, U.S.A.). An experimental chemical Dwell (Terrazole-Olin Corporation) has shown nitrification inhibition characteristics and was evaluated under field conditions along with N-Serve at the Southern Experiment Station at Waseca, MN in 1981. The objectives of the trail were to evaluate the use of nitrification inhibitors with different nitrogen rates, nitrogen forms, in fall vs. spring nitrogen application programs.

Experimental Procedures

An experiment consisting of 35 treatments, with six replication was arranged in a randomized complete block design and established at the Southern Experiment Station. Twelve treatments were applied on September 16th, 1980 and consisted of a factorial arrangement of two nitrogen rates (75 and 150 # N/A), two nitrogen forms (urea and anhydrous ammonia),and three inhibitor treatments (none, N-Serve, and Dwell). Sixteen spring treatments were applied on May 1st 1981 and consisted of a factorial arrangement of two nitrogen rates (75 and 150 # N/A), three nitrogen forms (urea, anhydrous ammonia and 28% solution), and three nitrification inhibitor treatments (none, N-Serve, and Dwell). Four sidedress treatments were applied at the 8-leaf stage of corn growth on June 17th. Anhydrous ammonia was used at the 75 # N/A with three inhibitors (none, N-Serve, and Dwell), and 150 #N/A without an inhibitor. A control treatment receiving no fertilizer N was also included.

Fall treatment: Urea was broadcast and the respective nitrification inhibitor treatments made as a separate spray application over the soil surface followed by immediate incorporation. The anhydrous ammonia treatments were injected at a depth of 6-8 inches utilizing 30" knife spacing. N-Serve applications were made by addition of the product directly into the anhydrous tank so that both products were applied simultaneously. Dwell applications were made simultaneously with the use of a dual-tube anhydrous shank and a separate pressurized system for the application of the Dwell.

Spring treatment: Urea and anhydrous ammonia were applied in a similar manner as the fall treatments. N-Serve and Dwell was, however, injected into the anhydrous ammonia at a position after the nitrolater and before the manifold utilizing a separate pumping system. Applications of 28% N solution were sprayed onto the plots with a separate spray application for the nitrification inhibitor treatments and again followed by immediate incorporation. The 8-leaf sidedress applications were made with anhydrous ammonia and the inhibitor applied in a similar manner to the early spring application. All nitrification inhibitors were applied at 0.5 # a.i./A. Corn (Pioneer 3732) was planted into the experimental area in 30" rows at a seeding rate of approximately 27,000 seeds/A. Leaf samples were collected from opposite and below the ear at silking, dried, and Kjeldahl nitrogen determined. Dry matter production was determined by harvesting 15' of row from each plot at physiological maturity separating the sample into ears and stover. Subsamples were collected for moisture determination and Kjeldahl nitrogen analysis. Corn grain yields were determined by machine harvesting the center two rows from each plot (55') and expressing the yield at 15.5% moisture.

General Results

The corn grain yields were excellent at Waseca in 1981. The growing season was characterized by being relatively dry early with more than adequate moisture during mid to late summer. This can at least partially explain many of the results, and the apparent conclusion that nitrogen losses at Waseca in 1981 were not severe. Corn grain yields were significantly increased up through the highest rate of nitrogen application (150 # N/A). Time of N application (Fall vs. spring) and use of nitrification inhibitors had relatively little influence on grain yields. Anhydrous ammonia did on the average provide higher yields than urea application. Total nitrogen removal was influenced by all four variables tested. Nitrogen removal was increased when the nitrogen rate was increased to 150# N/A and when anhydrous ammonia was used vs urea. Applications of nitrogen in the spring resulted in higher amounts of N taken up, while N-Serve application also increased total N removal. Most of the total N removal increase that was associated with N-Serve was due to a higher amount of nitrogen in the stover. Overall, no large differences were observed between nitrogen management varialbes (except N rate) thus reflecting the comment that nitrogen losses due to leaching and/or denitrification were minimal during 1980-81 season.

Table 1. Influence of nitrogen form, nitrogen rates, nitrification inhibitors and timing of nitrogen application on leaf N content, grain yield, dry matter production, grain N content and nitrogen removal of corn - Waseca, 1981.

Treatments						Dry Matter Production			N-Conc.		N-Removal		
N Rate	N Form	Time[1/]	Inhib.	Leaf N	Grain Yield	Grain	Stover	Total	Grain	Stover	Grain	Stover	Total
#/A				%	bu/A	--------T/A--------			-----%-----		-------lbs/A--------		
Check	-		-	2.02	124.9	2.94	3.73	6.67	0.98	0.48	58.5	35.8	94.2
75	Urea	F	-	2.43	151.9	3.80	4.36	8.16	1.00	0.40	76.6	35.3	111.9
75	Urea	F	N-S	2.32	153.1	3.70	4.41	8.12	1.13	0.48	83.8	42.7	126.5
75	Urea	F	Dwell	2.37	149.5	3.59	4.24	7.83	1.01	0.45	72.6	37.9	110.6
75	AA	F	-	2.52	162.6	4.11	4.38	8.49	1.09	0.45	89.3	39.7	129.1
75	AA	F	N-S	2.23	162.4	3.99	4.43	8.43	1.10	0.56	88.3	49.8	138.2
75	AA	F	Dwell	2.49	169.8	4.09	4.67	8.76	1.14	0.53	93.5	49.9	143.5
150	Urea	F	-	2.55	171.9	4.39	4.84	9.23	1.20	0.57	105.0	55.1	160.1
150	Urea	F	N-S	2.52	162.3	4.30	4.90	9.20	1.23	0.66	105.6	64.7	170.4
150	Urea	F	Dwell	2.46	173.5	4.40	4.94	9.34	1.17	0.62	103.0	61.5	164.6
150	AA	F	-	2.44	171.4	4.27	4.80	9.06	1.19	0.56	101.0	53.1	154.1
150	AA	F	NS	2.62	180.0	4.32	4.82	9.14	1.22	0.68	105.4	65.7	171.2
150	AA	F	Dwell	2.72	179.4	4.58	4.84	9.42	1.24	0.63	113.9	61.3	175.2
75	Urea	S	-	2.27	154.9	3.99	4.57	8.51	1.14	0.53	90.3	48.6	139.0
75	Urea	S	N-S	2.27	159.6	3.87	4.56	8.43	1.15	0.51	88.7	46.6	135.3
75	Urea	S	Dwell	2.19	144.1	3.71	4.34	8.05	1.06	0.51	78.7	44.6	123.3
75	AA	S	-	2.52	158.7	3.94	4.55	8.49	1.11	0.49	87.7	45.1	132.7
75	AA	S	N-S	2.49	167.9	4.10	4.85	8.96	1.14	0.55	94.0	53.6	147.6
75	AA	S	Dwell	2.23	157.9	3.72	4.37	8.10	1.08	0.50	81.4	44.0	125.4
75	28%	S	-	2.54	165.0	4.21	4.88	9.09	1.16	0.55	97.8	53.7	151.5
75	28%	S	N-S	2.45	168.7	4.18	4.76	8.94	1.11	0.57	93.3	54.1	147.5
75	28%	S	Dwell	2.49	162.7	3.99	4.75	8.75	1.18	0.47	94.5	45.2	139.6
150	Urea	S	-	2.54	174.9	4.39	5.12	9.01	1.25	0.61	109.6	62.4	172.0
150	Urea	S	N-S	2.51	180.3	4.34	5.05	9.39	1.24	0.66	107.1	66.4	173.5
150	Urea	S	Dwell	2.57	169.5	4.17	4.90	9.07	1.23	0.62	102.1	61.4	163.5
150	AA	S	-	2.63	176.4	4.33	4.72	9.05	1.20	0.62	104.1	58.5	162.7
150	AA	S	N-S	2.61	180.0	4.54	4.70	9.24	1.26	0.66	114.2	62.0	176.3
150	AA	S	Dwell	2.83	172.9	4.55	5.01	9.56	1.21	0.66	110.3	65.5	175.7
150	28%	S	-	2.62	182.2	4.36	4.95	9.31	1.24	0.64	107.6	63.7	171.4
150	28%	S	N-S	2.36	176.4	4.32	4.92	9.24	1.26	0.63	109.0	61.6	170.5
150	28%	S	Dwell	2.61	169.8	4.28	4.87	9.15	1.17	0.64	100.1	60.6	160.7
75	AA	8-L	-	2.75	166.7	4.03	4.48	8.51	1.10	0.60	88.9	53.7	142.6
75	AA	8-L	N-S	2.76	167.9	3.98	4.41	8.39	1.13	0.59	90.1	51.9	142.0
75	AA	8-L	Dwell	2.72	166.0	4.11	4.50	8.61	1.15	0.59	94.5	53.1	147.6
150	AA	8-L	-	2.72	176.6	4.40	4.62	9.01	1.23	0.63	108.2	57.9	166.1
Significance				**	**	**	**	**	**	**	**	**	**
BLSD(.05)				0.20	11.5	0.35	0.41	0.69	0.08	0.10	10.5	11.1	18.4

Table 1 continued on next page 1/ F= fall S = Spring 8-L = leaf

Table 1 (continued)

	Leaf N	Grain Yield	Dry Matter Production Grain	Stover	Total	N-Conc. Grain	Stover	N-Removal Grain	Stover	Total
	%	bu/A	-------T/A---------			------%------		------lbs/A----------		
Factorial Arrangement (Nitrogen Rate X Nitrogen Form X Inhibitors X Time treatments)										
N-Rate #/A										
75	2.36	157.7	3.88	4.78	8.36	1.10	0.50	85.4	44.8	130.2
150	2.58	174.4	4.38	4.89	9.27	1.12	0.63	106.8	61.5	168.3
Significance	**	**	**	**	**	**	**	**	**	**
BLSD (.05)	0.08	4.4	0.13	0.15	0.26	0.03	0.04	4.2	4.1	7.4
N-Form										
Urea	2.42	162.1	4.05	4.69	8.74	1.15	0.55	93.6	52.3	145.9
A.A.	2.53	170.0	4.21	4.68	8.89	1.17	0.58	98.6	54.0	152.6
Significance	**	**	**	NS	NS	NS	+	**	NS	*
BLSD (.05)	0.08	4.4	0.13	-	-	-	0.02	4.2	-	5.7
Inhibitor										
None	2.49	165.3	4.14	4.67	8.81	1.15	0.53	95.4	49.7	145.2
N-Serve	2.45	168.2	4.14	4.72	8.86	1.18	0.59	98.4	56.4	154.9
Dwell	2.48	164.6	4.10	4.66	8.77	1.14	0.56	94.5	53.3	147.7
Significance	NS	NS	NS	NS	NS	**	**	NS	**	*
BLSD(.05)	-	-	-	-	-	0.03	0.03	-	3.8	7.2
Time										
Fall	2.47	165.6	4.12	4.64	8.76	1.14	0.55	94.9	51.4	146.3
Spring	2.47	166.4	4.13	4.72	8.86	1.17	0.58	97.4	54.9	152.2
Significance	NS	NS	NS	NS	NS	*	+	NS	*	*
BLSD(.05)	-	-	-	-	-	0.02	0.02	-	3.2	5.7
Factorial Arrangement (N-Rate X Time X Anhydrous Ammonia)										
N-Rate #/A										
75	2.60	162.7	4.03	4.47	8.50	1.10	0.51	88.6	46.2	134.8
150	2.59	174.8	4.33	4.71	9.04	1.21	0.60	104.4	56.5	161.0
Significance	NS	**	**	+	*	**	**	**	**	**
BLSD(.05)	-	11.6	0.23	0.22	0.41	0.06	0.08	7.0	8.3	12.6
Time										
Fall	2.48	167.0	4.19	4.59	8.78	1.14	0.50	95.2	46.4	141.6
Spring	2.57	167.6	4.13	4.63	8.77	1.16	0.55	95.9	51.8	147.7
8-Leaf	2.73	171.7	4.21	4.55	8.76	1.17	0.61	98.5	55.8	154.3
Significance	**	NS	NS	NS	NS	NS	*	NS	+	NS
BLSD(.05)	0.13	-	-	-	-	-	0.07	-	7.0	-
Factorial Arrangement (Inhibitor X Time at 75 # N/A)										
Inhibitor										
None	2.60	162.7	4.03	4.47	8.50	1.10	0.51	88.6	46.2	134.8
N-Serve	2.58	166.1	4.03	4.56	8.59	1.13	0.57	90.8	51.8	142.6
Dwell	2.48	164.6	3.98	4.52	8.49	1.12	0.54	89.8	49.0	138.8
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD (.05)	-	-	-	-	-	-	-	-	-	-
Time										
Fall	2.41	165.0	4.06	4.50	8.56	1.11	0.52	90.4	46.5	136.9
Spring	2.42	161.5	3.92	4.59	8.52	1.11	0.52	87.7	47.5	135.2
8-Leaf	2.74	166.9	4.04	4.47	8.51	1.13	0.59	91.2	52.9	144.1
Significance	**	NS	NS	NS	NS	NS	*	NS	+	NS
BLSD(.05)	0.12	-	-	-	-	-	0.06	-	5.8	-

THE INFLUENCE OF EROSION CLASS AND SLOPE STEEPNESS ON THE PRODUCTIVITY OF MT. CARROLL SILT LOAM SOILS

Clifton Halsey

Objective

To determine the effect of past erosion on the yield of corn grown on Mt. Carroll silt loam soils.

Problem

It is generally assumed that the removal of topsoil by erosion reduces the productivity of the remaining soil. Soil scientists realize that the proportion of productivity lost depends on the quality of the productivity-related characteristics of the remaining soil.

Research with well-drained deep loam soils has shown that where the original surface soil is mechanically removed, crop productivity can be restored with additional fertilizer. Economic research regarding the effects of erosion on projected long-term productivity has shown generally that farmers can expect only very minor increases in farm income from using soil conserving practices. Yield estimates used in these income computations have been based primarily on the subjective judgment of soil scientists. There has been very little, if any, recent research on this problem on the erosive sloping soils in southeastern Minnesota. The question still persists, "What is the effect of erosion on the crop productivity of Minnesota's soils?".

Procedure

Field research is being conducted on Mt. Carroll silt loam soils in typical farm fields in Olmsted County; 1981 was the first year of the study.

Three different suitable fields will be located each of five successive years in Olmsted County with the aid of SCS soil scientist, George Poch, and the permission of the farmers. Each field is to have three adjacent classes of erosion - slight, moderate and severe, as defined below.

Soil cores of the sites are taken during the spring to locate three plots classed as having none to slight, moderate, and severe erosion. The plots are about 100 feet x 100 feet in size. None to slight erosion is defined as sites having a depth greater than 30 inches to the bottom of the B2 horizon. Moderate erosion includes sites having a depth between 20 and 30 inches to the bottom of the B2 horizon. Severely eroded sites will have a depth of less than 20 inches to the bottom of the B2 horizon. The depth of profile development is related to the slope steepness and distinguishing between the effect of accelerated erosion and the effect of slope steepness on productivity is very difficult and perhaps impossible. Three cores, 5 feet deep, will be taken from each yield plot and divided into the following incremental samples: Ap horizon, bottom of the Ap to 20 inches deep, 20 to 30 inches deep, 30 to 40 inches deep, 40 to 50 inches deep, and 50 to 60 inches deep. They will be stored in plastic bags for later analysis. (The 1981 cores were divided by horizons.)

Detailed cropping and management history are obtained for each field to determine possible sources of variation in results.

The following analyses will be made of the core increments:

chemical: organic carbon, available phosphorus, exchangeable potassium, available zinc, and pH

physical: particle size, available water-holding capacity, mechanical resistance, and available water during planting the middle of June and at tasseling.

Samples of the crops are harvested from each plot and weighed; moisture content of these samples and yields are determined.

Statistical analysis will determine the relationship of crop yield to the erosion class and to other measured characteristics of the soil. The 1981 data have not been statistically analyzed.

Results and Discussion - First Year

The corn yields and plant populations for each plot and the averages for each erosion class are shown in Table 1. Variations in weediness, lodging and plant populations are likely causes of the variation in yields. Field Behnken-2 was contoured with tight turns in the slightly eroded plot. Lodging and an apparent overlapping of rows confused harvesting in the Behnken-2 moderately eroded plot. The general moisture conditions during the growing season were good.

The average depths of the lower boundaries of the horizons are given in Table 2. The plots fitted quite well with the established criterion for associating erosion with depth to the bottom of the B2 horizon, as defined previously in "Procedure". The Behnken-2 field has a more deeply developed profile.

Extractable phosphorus in parts per million for three horizons as plot averages and horizon averages are in Table 3. Analyses of the Ap horizons reflect applications of commercial fertilizer. Phosphorus content of the subsoil is generally high.

Exchangeable potassium analyses are shown in Table 4. Potassium levels in the Ap horizon ranged between medium and high because of applications of commercial fertilizer. Levels in the subsoil were mostly medium to medium-high.

Available zinc was mostly in the lower medium range as shown in Table 5.

Available moisture capacities of the horizons in the erosion classes are listed in Table 6. They are quite uniform.

Soil acidities as pH are given in Table 7. The pH of the Ap horizons reflects the liming history of the fields. The pH of the B2 and the C1 horizons of the slight and moderate erosion classes average around 5.8 to 6.0. Limy till lies a little below 5 feet from the surface. Two cores struck the till within 4 to 5 feet of the surface.

Organic carbon percentages are contained in Table 8. There seems to be a difference among the three fields in this order: Ohm-1>, Behnken-2>, Behnken-1. The difference may be due to long term management or to native vegetation. The differences between erosion classes may be attributable to accelerated erosion and slope steepness.

Particle size data are in Table 9. The figures are the averages of the three fields for each horizon within each erosion class. The textures appear quite uniform throughout the profiles.

Summary and Conclusions

Information on which statements are based regarding the effect of erosion on crop productivity in Minnesota is not very solid. Locating suitable sites for comparing erosion classes is difficult. Distinguishing between accelerated erosion and soil formation factors as influences on depths of soil to the bottom of the B2 horizon may be impossible. Using portions of farm fields as plots produces considerable variation in yields. Adequate moisture during the entire growing season may minimize yield differences among erosion classes.

The Mt. Carroll subsoils appear to have medium to high quantities of extractable phosphorus and moderate amounts of exchangeable potassium. Surface supplies of zinc border on insufficient for corn.

Available moisture throughout the profile is quite high. The soils are acid unless limed. Organic carbon ranges between 1 and over 2 percent, depending on the site and the position on the landscape or amount of erosion. The soil texture is a quite uniform silt loam throughout the profile.

More attention needs to be given to locating fields having uniform management to reduce yield variation. Data should be collected which indicates the available moisture status of the soil. Years of moisture stress may result in yield differences between erosion classes.

Table 1. Corn stands and yields - 1981 fields.

Erosion Class	Plants Per Acre			
	Behnken-1	Behnken-2	Ohm-1	Average
slight	17,050	18,000	26,600	20,700
moderate	18,100	23,050	25,000	22,050
severe	17,900	20,000	25,300	21,067
	Bushels Per Acre			
	Behnken-1	Behnken-2	Ohm-1	Average
slight	138.4	112.2	176.4	142.3
moderate	123.2	129.9	163.6	138.9
severe	135.3	115.8	163.4	138.2

Table 2. Average horizon lower boundary depths - 1981 fields (inches).

Erosion Class	Horizon	Plot Averages			3-Plot Averages
		Behnken-1	Behnken-2	Ohm-1	
slight	Ap	9.3	8.0	9.0	8.8
	B21	17.3	23.3	18.7	19.8
	B22, 23	34.0	35.7	29.3	33.0
	B3	44.7	48.0	39.0	43.9
	C1	55.3	60.0	49.0	58.4
moderate	Ap	8.7	7.0	8.0	7.9
	B21	18.7	16.7	16.7	17.4
	B22	26.7	26.7	24.0	25.8
	B3, 23	36.0	38.3	32.0	35.4
	C1	44.0	60.0	54.3	52.8
severe	Ap	6.0	6.7	7.0	6.6
	B2	17.7	20.7	17.7	18.7
	B3	25.3	38.3	28.7	30.8
	C1	34.0	60.0	47.7	47.2
	C2	44.0		52.0	48.0

Table 3. Extractable phosphorus - 1981 fields (parts per million).

Erosion Class	Horizon	Plot Averages			3-Plot Averages
		Behnken-1	Behnken-2	Ohm-1	
slight	Ap	14.0	18.2	32.3	21.5
	B21	13.2	27.3	9.3	16.6
	C1	18.8	30.2	16.0	21.7
moderate	Ap	15.7	19.7	19.7	18.4
	B21	15.3	23.0	13.5	17.3
	C1	19.0	28.3	18.7	22.0
severe	Ap	29.7	19.8	25.8	25.1
	B21	21.2	13.0	14.8	16.3
	C1	20.2	16.0	12.8	16.3

Table 4. Exchangeable potassium - 1981 fields (parts per million).

Erosion Class	Horizon	Plot Averages Behnken-1	Behnken-2	Ohm-1	3-Plot Averages
slight	Ap	112.3	153.3	115.8	127.1
	B21	68.5	118.8	81.0	89.4
	C1	59.0	107.2	70.2	78.8
moderate	Ap	107.5	122.3	112.2	114.0
	B21	80.2	99.0	91.7	90.3
	C1	63.2	85.7	76.2	75.0
severe	Ap	160.2	89.0	85.8	111.7
	B21	86.8	89.7	79.7	85.4
	C1	66.3	64.0	48.5	59.6

Table 5. Available zinc in the Ap horizon - 1981 fields.

Erosion Class	Plot Averages Behnken-1	Behnken-2	Ohm-1	3-Plot Average
slight	0.57	0.83	0.77	0.72
moderate	0.40	0.73	0.43	0.52
severe	0.50	0.63	0.37	0.50

Table 6. Available moisture capacity - 1981 fields.

Erosion Class	Horizon	difference between 1/3 bar & 15 bar, percent of oven-dry weight; Field Behnken-1	Behnken-2	Ohm-1	3-Plot Averages
slight	Ap	19.1	14.4	13.3	15.6
	B21	18.1	17.4	19.1	18.2
	B22	17.6	19.9	18.6	18.7
	C1	18.2	17.8	18.7	18.2
moderate	Ap	17.3	12.6	14.2	14.7
	B21	17.2	16.6	17.6	17.1
	B22	17.5	19.0	19.0	18.5
	C1	17.0	18.5	16.8	17.4
severe	Ap	15.3	10.9	15.8	14.0
	B21	17.0	14.1	19.3	16.8
	B22	12.6	17.4	19.7	16.6
	C1	16.9	17.8	19.4	17.9

Table 7. pH (water) - 1981 fields.

Erosion Class	Horizon	Plot Averages Behnken-1	Behnken-2	Ohm-1	3-Plot Averages
slight	Ap	7.0	6.0	6.2	6.4
	B21	7.1	6.0	6.2	6.4
	B22	6.7	5.4	5.8	6.0
	C1	6.2	5.7	6.0	6.0
moderate	Ap	7.1	6.1	6.8	6.7
	B21	6.8	5.8	6.4	6.3
	B22	6.0	5.4	6.0	5.8
	C1	5.9	5.7	5.8	5.8
	C2			7.4	
severe	Ap	7.1	6.8	6.5	6.8
	B21	6.9	6.2	6.5	6.5
	B22	6.6	5.8		6.2
	C1, 2	6.1	6.1	7.6	6.6

Table 8. Percent organic carbon in the Ap horizon - 1981 fields.

Erosion Class	Plot Averages Behnken-1	Behnken-2	Ohm-1	3-Plot Averages	(O.M.%)
none to slight	1.40	1.60	2.23	1.74	3.0
moderate	1.23	1.33	1.67	1.41	2.4
severe	1.03	1.10	1.57	1.23	2.1

Table 9. Particle size data - 1981 fields (average percent).

Erosion Class	Horizon	Sand v.f. sand	total	Silt fine	total	Clay	Texture Class
slight	Ap	5.7	7.2	32.7	71.4	21.7	silt loam
	B21	6.8	8.0	31.5	68.2	23.8	silt loam
	B22	9.6	10.1	24.3	64.4	25.4	silt loam
	C1	15.7	17.4	20.6	62.4	20.2	silt loam
moderate	Ap	4.9	6.3	31.9	70.0	23.7	silt loam
	B21	6.7	7.8	27.2	65.0	27.2	silty clay loam
	B22	10.0	10.8	27.7	66.6	22.6	silt loam
	C1	15.0	16.6	19.3	64.9	18.5	silt loam
severe	Ap	7.0	8.6	26.8	66.6	24.7	silt loam
	B21	9.0	11.0	23.6	63.1	25.9	silt loam
	B22	13.1	21.9	19.0	55.1	23.0	silt loam
	C1	16.1	16.8	19.2	66.2	17.0	silt loam

SOYBEAN CANOPY AND RESIDUE DATA COLLECTION

Jeffrey St. Ores and Clifton Halsey

Soil scientists and conservationists use the Universal Soil Loss Equation (USLE) to estimate the amount of soil removed from fields by sheet and rill erosion. The estimates are expressed as long-term annual average losses in tons per acre. The cover and management factor (C factor) is one of six major factors in the equation.

C factors may be derived from tables in Predicting Rainfall Erosion Losses, U.S.D.A. Agriculture Handbook 537, by W.H. Wischmeier and D.D. Smith (1978). But dates when crop canopies protect 10, 50, and 75 percent of the soil surface must be known for such derivations. The percent of ground protected at maximum canopy, the date when maximum canopy is achieved and the percent of ground covered by residues after harvest must also be known.

Two of the variables, presumably affecting time to achieve various canopy levels, are row spacing and time of planting. Additionally, soybeans do not maintain maximum canopy through harvest. The Wischmeier tables assume they do. Soybean leaf residues are also known to disintegrate rapidly after leaf fall.

More knowledge of dates when various canopy levels are achieved, amount of canopy decline in the latter part of the growing season, and the amount of residue protection afforded the soil from leaf fall to tillage would be useful and reduce the amount of "guesstimation" that becomes a part of estimating soil losses. Increased confidence in the USLE would also occur.

Procedures

A five-year project was started in 1981 to gather the type of information discussed above (Table 1). County extension agents in nine counties collected data from 20 fields (Table 2). The agents were asked to use the line-transect method in MN Extension Folder 477, Estimating the Effects of Crop Residue Mulches on Soil Erosion by Water, to estimate the percent of soil surface covered by canopy or residues. Plant populations were estimated at the 10 percent canopy level by counts in a representative portion of the field. Yield information was provided by the farmers.

General Results

The following data are very preliminary. No statistical analyses were performed on the 1981 data. The average planting date was May 22 with plantings ranging from May 11th to June 5th. Row widths were tabulated in 3 groupings; 8 fields had rows between 6 and 14 inches apart. Nine fields had 30-inch spacings and 3 fields had 36- to 38-inch spacings. Plant populations ranged from 82,000 to 286,000 plants per acre when estimated at 10 percent canopy.

Generally, fields with wide row spacing required more days to achieve various canopy percentages than fields with narrower spacings (Table 3). This trend was most noticeable in fields planted between May 19 and May 25 (data not shown).

Fields planted between May 10 and May 18, in general, required more days to achieve the various canopy levels than fields planted later (Tables 4a and 4b). This trend was most noticeable with narrow row spacings. Average dates when various canopy levels were reached are shown in Tables 5a and 5b.

Maximum percent of ground protected by canopy ranged from 85 to 100 percent. By harvest time, canopy levels generally had decreased to an average of 30 percent canopy and ranged from 0 to 95 percent canopy. The percent of ground covered by surface residue at harvest averaged 55 percent and ranged from 20 to 100 percent.

The average soybean yield was 41 bushels per acre.

Fall tillage, where done, decreased the percentage of ground covered by residue by 70 to 90 percent. Percent of ground covered after tillage averaged 10 percent and ranged from 2 to 35 percent.

Table 1. Information gathered.

Row spacing
Plant population
Planting date
Canopy and residue cover (measured as percent soil surface protected from raindrops)
Canopy heights
Yield
Type and date of fall tillage

Table 2. Participating counties.

Varietal maturity zone	County	Number of Fields
Southern	Steele	2
	Waseca	3
South Central	Goodhue	3
	Lincoln	1
	Lyon	1
	Pipestone	4
	Renville	3
	Swift	1
Central	Grant	1

Table 3. Average number of days to different canopy levels

Row width (in)	Percent of soil surface protected by canopy 10	50	75	Maximum	Number of Fields sampled
	- - -days after planting- - - -				
6-7	17.6	37.4	45	53	5
12-14	25	43.7	52	60	3
30	24	51	67	80	9
36-38	31	52	55	72	3

Table 4a. Average number of days to different canopy levels on fields with 6-14 inch rows.

Planting date (1981)	Percent of soil surface protected by canopy 10	50	75	Maximum	Number of Fields sampled
	- - - -days after planting- - - -				
5/10-5/18	29	48	55	62	2
5/19-5/25	17.5	36	44	53	5
5/26-6/5	-	-	-	-	-

Table 4b. Average number of days to different canopy levels on fields with 30-36 inch rows.

Planting date (1981)	Percent of soil surface protected by canopy 10	50	75	Maximum	Number of Fields sampled
	- - - -days after planting- - - -				
5/10-5/18	35	53	67	73	3
5/19-5/25	27	52	68	82	5
5/26-6/5	19	42	55	72	4

Table 5a. Average dates on which fields with 6-14 inch rows achieved various canopy levels.

Planting date	Percent of soil surface protected by canopy 10	50	75	Maximum
	- - - - -Date (1981)- - - -			
5/10-1/18	6/9	6/28	7/6	7/12
5/19-5/25	6/7	6/28	7/4	7/18
5/26-6/5	--	--	--	--

Table 5b. Average dates on which fields with 30-36 inch rows achieved various canopy levels.

Planting date	Percent of soil surface protected by canopy 10	50	75	Maximum
- - - - - - - - - Date (1981)- - - - - - - -				
5/11-5/18	6/18	7/7	7/21	8/3
5/19-5/25	6/17	7/12	7/26	8/11
5/26-6/5	6/20	7/14	7/29	8/10

COMPARISON OF THREE PHOSPHORUS SOIL TEST PROCEDURES TO WHEAT AND SOYBEAN YIELDS

W.E. Jokela, W.E. Fenster, M. O'Leary, G. Buzicky and C.J. Overdahl

Seven experiments were established in Western Minnesota in 1981 to evaluate three P soil tests and their relationship to response from P additions. Wheat was grown on six sites and soybeans on the other.

The three soil tests were Bray No. 1 1:10 ratio of soil to reagent, Bray No. 1 1:50 ratio and Olsen's bicarbonate test. The Bray No. 1 tests are affected by high soil pH while Olsen's test is largely indepent of pH. The Olsen tests were run by the North Dakota State University Laboratory. At four of the locations starter and no starter comparisons were made in addition to the four broadcast P treatments.

Table 2 gives yields of wheat and soybeans plus initial soil tests. There were no significant yield increases due to P treatment. There was no significant increase in percent P in whole plants for wheat but a significant increase in leaf P on soybeans only at the 10 percent level of confidence.

Table 3 shows plant analysis P and soil test P differences from P additions. The latter according to the three soil test procedures.

The Bray 1:10 ratios tests on these soils with pH above 7.6 appear much too low with the high crops yields, especially when it is apparent that no yield increase was obtained from P treatments.

No correlation with yield was run since no yield increase was obtained. This study will be continued for an additional two years.

Table 1. Soil type, county, and rates of starter fertilizer where used.

	Heineke	Klassen	Morris Sta.	Mehrkens W	Mehrkens S	Eckman	Klenz
County	Swift	Swift	Stevens	Pennington	Pennington	Marshall	Martin
Soil Type	Colvin	Colvin	Doland	Clearwater	Glyndon	Fargo	Webster
Texture	SiCL	SiCL	SiL	Loam	Loam	SiC	CL
Starter Fertilizer[1]							
N	-	-	0	15	15	18	-
P_2O_5	-	-	30	30	30	46	-
K_2O	-	-	0	30	30	0	-

[1]Adequate N and K applied across all plots.

Table 2. Wheat and soybean yields from four phosphate levels broadcast plus starter and no starter at seven locations and corresponding initial P soil test using three methods. 1981.

lbs. P_2O_5/A Broadcast	Heineke	Klassen	Morris Sta.	Mehrkens W.	Mehrkens S.	Eckman	Klenz[1]
	bu/acre						
0	58	47	63	68	47	57	49
30	56	51	64	63	48	61	51
60	58	46	64	62	49	63	51
90	59	49	64	69	50	60	52
significance	ns	ns	ns	*	ns	ns	ns
starter	-	-	64	65	48	62	-
no starter	-	-	64	66	49	59	-
P test lbs/acre (spring)							
Bray 1:10	6	4	15	22	2	9	18
Bray 1:50	19	14	21	33	7	30	36
Olsen's	26	17	11	16	19	16	15
K test lbs/acre	280	421	219	223	170	556	293
pH	7.8	8.0	7.8	7.9	8.0	7.8	7.7
Zn ppm	.4	.3	.3	.4	.6	-	.6

[1]soybeans

Table 3. Plant analysis of entire wheat plant at soft dough stage and uppermost leaves of soybeans and relationship to P treatment and fall soil test. 1981.

lbs. P_2O_5/A Broadcast	Heineke	Klassen	Morris Sta.	Mehrkens W.	Mehrkens S.	Eckman	Klenz
	% P						
0	.17	.15	.16	.16	.19	.16	.35
30	.18	.17	.18	.18	.19	.19	.41
60	.20	.15	.18	.19	.19	.19	.40
90	.18	.17	.20	.18	.20	.17	.40
significance	ns	ns	ns	ns	ns	ns	+
			Bray's 1:10 lbs/A P				
0	5	6	10	2	17	15	13
30	7	4	18	2	21	8	18
60	9	7	23	2	23	5	21
90	7	5	33	4	21	10	27
			Bray's 1:50 lbs/A P				
0	15	15	12	8	24	30	33
30	20	14	23	5	25	22	36
60	33	15	25	9	28	26	39
90	35	15	33	11	25	27	46
			Olsen's lbs/A P				
0	9	16	5	16	9	11	10
30	8	17	22	17	11	13	12
60	17	17	25	21	12	20	14
90	22	18	22	24	13	18	19

MICRONUTRIENTS AND RELATIONSHIP TO MICRONUTRIENT SOIL TESTS

W. E. Fenster and C. J. Overdahl

Even though micronutrients for agriculture have been in use for a long time, little or no research has been done to relate soil tests of these elements to their response in the field. Experimental work was initiated with corn at five locations in the spring of 1981. Sulfur and magnesium was also included as a variable at these sites.

The "missing element" technique was used whereby a series of plots each having one of the nutrients omitted and compared to a treatment with all elements included. This design prevented other nutrients from being limiting factors if there was possible interaction. Only one rate of each element was used. Since most of the added nutrients were in the sulfate form the sulfur comparisons were established by themselves on an adjacent area. A boron trial, in addition to being included in the main experiment, was established on an adjacent area in order to have four levels of boron compared. Nitrogen, phosphorus and potassium were applied at or above adequate amounts. All plots were replicated four times.

Yields and plant analysis

Since the results are only for one year no conclusions are drawn. Tables 1 through 5 show the 1981 results. No significant yield increases were obtained but it is apparent that nutrient content in the leaves are increased by treatments (Tables 1 and 3).

Soil test comparisons

There has been fine cooperation of private laboratories in testing soils from these plots. The Harris Laboratory at Lincoln, Nebraska, the A & L Laboratories at Omaha, Nebraska and Minnesota Valley Testing at New Ulm, Minnesota, have run soil analysis from all plots which will contribute a large volume of useful data.

Although many comparisons of treatments vs. yield, plant analysis and soil tests were made in 1981 it is desirable to delay recommendations until a three year study has been completed.

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To the three laboratories making the many tests goes a grateful thanks.

Table 1. Corn yields, plant boron, and soil test boron from four levels of boron applications. 1981.

lbs B/A	yield bu/A[1]	ppm B[1] ear leaf	soil test - ppm[1] hot H_2O
	Jokela Farm - Goodhue Co. non-irrigated Mt. Carroll silt loam		
0	170	4.3	.60
1	178	4.6	
2	175	4.6	
4	174	6.8	
significance	ns	ns	
	Kingston Farm - Dakota Co. - irrigated loamy sand		
0	155	7.0	.25
1	159	8.1	
2	147	11.8	
4	160	18.2	
significance	ns	**	
BLSD (.05)		3.5	
C.V.		21.9	
	Geiger Farm - Morrison Co. irrigated loamy sand		
0	92	4.1	.09
1	87	6.7	
2	90	10.9	
4	90	13.7	
significance	ns	**	
BLSD (.05)		3.4	
C.V.		24.8	

[1]average of 4 replications

Table 2. Corn yields[1] and soil tests at five locations comparing complete treatments of micronutrients plus magnesium to plots using missing element techniques. 1981.

Treatment[2] omitted (-) or added (+)	Martin Yield	Martin Soil Test	Goodhue Yield	Goodhue Soil Test	Dakota[3] Yield	Dakota[3] Soil Test	Morrison[3] Yield	Morrison[3] Soil Test	Pope[3] Yield	Pope[3] Soil Test
none	179	-	173	-	156	-	84	-	129	-
- Mg	181	881	169	580	160	312	85	195	125	567
- Zn	181	0.8	175	2.1	159	1.0	93	1.0	124	1.8
- Fe	182	20	174	55	151	41	89	23	127	54
- Mn	180	41	174	31	159	21	85	6	126	36
- B	178	1.04	177	.60	152	.25	91	.09	126	.51
- Cu	178	1.31	170	.75	157	.46	90	.23	132	1.01
+ complete includes S	184	-	169	-	156	-	89	-	129	-
Significance	ns		ns		ns		ns		ns	

[1]average of 4 replications
[2]pounds per acre of nutrient added Mg = 50, Zn = 10, Fe = 10, Mn = 10, B = 1, Cu = 5.
[3]irrigated sandy loams, Martin and Goodhue Co. plots on non-irrigated fine textured soils.

Table 3. Plant analysis[1] from micronutrient and magnesium treatments. 1981.

Treatment omitted (-) added (+)	Martin -	Martin +	Goodhue -	Goodhue +	Dakota -	Dakota +	Morrison -	Morrison +	Pope -	Pope +
	(ppm except Mg which is %)									
- Mg	.58	.58	.36	.38	.27	.27	.20	.21	.32	.33
- Zn	21	24	35	40	29	34	23	26	25	24
- Fe	93	97	113	109	120	117	221	218	335	330
- Mn	56	61	59	60	76	71	45	38	48	49
- B	4.9	4.6	6.1	6.7	4.9	9.2	4.9	8.0	4.2	4.2
- Cu	3.0	3.4	10.7	6.4	10.3	10.2	8.4	9.3	3.8	3.9

[1]average of 4 replications from leaf opposite and below ear at silking time.

Table 4. Corn yields[1], plant sulfur, and soil test sulfur with and without sulfur treatments. 1981.

Sulfur Treatment	Martin Yield	Martin Soil Test[2] ppm	Martin Plant Test ppm	Goodhue Yield	Goodhue Soil Test ppm	Goodhue Plant Test ppm	Dakota[3] Yield	Dakota[3] Soil Test ppm	Dakota[3] Plant Test ppm	Pope[3] Yield	Pope[3] Soil Test ppm	Pope[3] Plant Test ppm
none	183	16	.23	181	16	.24	151	6	.24	121	14	.24
50#/A	180	-	.29	179	-	.27	154	-	.25	118	-	.23
Significance	ns			ns			ns			ns		

[1]average of 4 replications
[2]sulfur soil test U of M lab, spring 1981
[3]irrigated sandy loams, Martin and Goodhue County are non-irrigated fine textured soils.

Table 5. Initial soil tests[1] 0 to 6" samples.

	pH	P	K	S	Mg	Texture	OM
Martin	7.2	34	220	16	881	clay loam	H
Goodhue	6.3	63	417	16	580	silt loam	M
Dakota	5.8	70	192	6	312	loamy sand	M
Morrison	6.3	35	190	-	195	loamy sand	L
Pope	5.6	23	152	14	567	sandy loam	M

[1]average of 4 replications.

COPPER FERTILIZATION OF BARLEY ON AN ORGANIC SOIL

Roseau County - 1981

W. E. Jokela and M. O'Leary

Barley has responded to copper fertilization on organic soils in northern Minnesota. But questions remain as to the most effective form and method of application. This study was initiated in response to these questions.

Experimental Procedures

This experiment was conducted on the Habstritt farm in Roseau County, on a site consisting of 1½ to 2 feet of peat over clay mineral soil. Soil analysis of the 0 to 6 inch depth was:

pH	P	K	Cu	Mn
	---lb/A---		--ppm (DTPA)--	
7.0	83	248	1.3	75.6

The five treatments listed in Table 1, were arranged in a randomized complete block design with four replications. Broadcast treatments were applied and incorporated with two passes of a double disk drill on May 13. The row treatment was applied with a drill and Manker barley seeded on May 26. All plots received 40-40-120 (N-P_2O_5-K_2O) broadcast. Forage harvest was taken on July 21 at heading and grain harvest on August 19.

Results and Discussion

Grain yields and forage yields, uptake, and analyses are shown in Table 1 and 2. Highly significant responses of grain and forage yield, as well as content and uptake of several elements, was observed. All copper treatments increased yield, with broadcast solution greater than broadcast dry or row application. Difference in elemental content of forage appear to be primarily due to dilution with the higher yields on the fertilized treatments. Copper concentration in the forage was not significantly increased by application of copper. Variability was very high.

Table 1. Effect of copper treatment on barley grain yield and forage yield and uptake. Roseau Co. (Habstritt). 1981.

Treatment[1] lb Cu/A as $CuSO_4$	Grain Yield Bu/A	Forage (at heading) Dry Matter lb/A	Uptake lbs/A Zn	Mn	Cu
0	9.4	1826	.061	.094	.002
6 row	28.0	2635	.087	.128	.003
6 bdcst sol	40.0	3351	.094	.147	.014
12 bdcst sol	44.9	3597	.109	.148	.006
12 bdcst dry	35.7	2827	.096	.121	.012
Significance	**	**	**	**	ns
BLSD (.05)	7.2	558	.022	.034	-
C.V.	16.0	13.3	15.9	16.4	108.6

[1]Row treatment was applied with the drill. Broadcast treatments were applied either in solution (sol) or as $CuSO_4$ crystals (dry).

Table 2. Effect of copper treatment on elemental analysis of forage. Roseau County (Habstritt). 1981.

Elemental Analysis of Forage (at heading)

Treatment[1] lb Cu/A as $CuSO_4$	%				ppm						
	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
0	.46	4.02	.80	.38	24	92	1551	51	34	1.2	8.4
6 row	.39	3.24	.81	.38	22	88	1135	48	34	1.3	6.5
6 bdcst sol	.36	2.73	.83	.40	26	76	1151	44	29	3.8	5.5
12 bdcst sol	.34	2.98	.76	.38	20	71	1532	41	30	1.8	5.0
12 bdcst dry	.39	3.36	.67	.35	20	83	1386	43	34	4.4	4.1
Significance	**	**	ns	ns	ns	**	ns	*	ns	ns	*
BLSD (.05)	.05	.39	-	-	-	10	-	7	-	-	3.0
C.V.	8.6	8.1	11.7	8.5	20.7	8.1	28.0	8.9	11.6	102.0	29.7

[1]Row treatment was applied with the drill. Broadcast treatments were applied either in solution (sol) or as $CuSO_4$ crystals (dry).

HIGH PHOSPHORUS AND POTASSIUM RATES FOR CONTINUOUS CORN

1981

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

EXPERIMENTAL PROCEDURES

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

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

Trt. No.	Application Year (Fall) 1973,'76,'79	1974,'75,'77,'78,'80
	----------lb P_2O_5 + K_2O/A----------	
1	0 + 0	0 + 0
2	0 + 100	0 + 100
3	50 + 100	50 + 100
4	100 + 100	100 + 100
5	150 + 100	0 + 100
6	100 + 0	100 + 0
7	100 + 50	100 + 50
8	100 + 150	100 + 0
9[1]	150[2] + 100	0 + 100[3][5]
10[1]	100 + 150[2]	100 + 0[4][6]

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

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

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

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

[5] 0 + 100 was applied at all locations in 1980.

[6] 100 + 0 was applied at all locations in 1980.

The P and K materials were broadcast on cornstalks and plowed down at all locations in the fall of 1980. Phosphorus was applied as CSP (0-46-0) and K as muriate of potash (0-0-60). Zinc was applied at a rate of 10 lb Zn/A as $ZnSO_4$ prior to plowing at Lamberton. 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.

At Lamberton each of the plots were split with the west half planted to corn and the east half to soybeans. Vickery soybeans were planted in 30-inch rows on April 27 at a rate of 9 seeds/foot. Weeds were controlled with Treflan (3/4#) and Amiben (2#). Plant tissue samples were not taken. Soybeans were combine harvested on September 28.

Weather conditions during 1981 were quite favorable for early planting. However, at Lamberton the soils were so dry that germination was poor, emergence was erratic and weed control was not adequate. Areas in each plot were marked for harvest at about the 8-leaf stage and were hand weeded to optimize corn yields.

Table 2. Experimental procedures for the high P and K rate study on continuous corn at the three branch stations in 1981.

Variable	Lamberton	Morris	Waseca
Planting date	4/24	4/28	5/8
Row spacing	30"	30"	30"
Planting rate	26,000	22,000	30,800
Hybrid	Pioneer 3732	Pioneer 3901	Pioneer 3732
Nitrogen rate	150#	125#	200#
Herbicide	2½# Lasso + 1½# Bladex/A (Bdct)	2½# Lasso + 2 1/5# Bladex/A (Bdct)	3½# Lasso + 3# Bladex/A (Bdct)
Insecticide	1# Counter/A	1.3# Counter/A	1# Counter/A
Harvest date	10/20	10/19	10/31

RESULTS AND DISCUSSION

Soil samples were taken at the end of the 1981 growing season. Responses to the treatments were quite similar to those obtained in 1980 except at Lamberton where P values were more than twice as high as in 1980. Soil test P was affected significantly at all three locations (Table 3). There appeared to be an almost linear response to P application rates. Soil test P was always lowest with treatments 1 and 2, which received no P. Intermediate P levels were found with treatment 3 (50 lb P_2O_5 annually) and treatment 5 (150 lb P_2O_5 every third year). Highest soil test P values were associated with the annual 100 lb P_2O_5 treatments at all locations. Use of the 1:50 soil to Bray P_1 solution ratio on the calcareous Aastad soil at Morris indicates high amounts of extractable P in this soil; over twice that indicated by the 1:10 ratio.

Soil test K was influenced (P=.05) by the K treatments at all locations (Table 3). The response to the annual K applications was not as pronounced as with P. But, a linear increase in soil test K was generally shown with the increased K application rates. Soil pH was not related to the P and K treatments.

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

Treatment No.	Treatment 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	5.5	7.6	6.1	62	12	28	23	269	330	211
2	0 + 100	5.6	7.7	6.0	54	11	26	18	341	427	254
3	50 + 100	6.0	7.6	5.9	65	32	66	45	301	386	254
4	100 + 100	5.6	7.6	6.0	98	62	112	71	327	421	260
5	0 + 100	5.8	7.6	6.1	76	29	61	46	330	383	268
6	100 + 0	5.6	7.6	6.1	112	65	128	64	257	335	214
7	100 + 50	5.7	7.6	6.1	88	51	108	68	290	339	237
8	100 + 0	5.6	7.5	5.9	101	62	123	62	301	343	240
9	0 + 100	6.0	7.6	6.2	51	30	61	27	292	339	230
10	100 + 0	5.6	7.6	6.1	68	16	40	43	282	332	237
Signif. Level (%):	[3/]	54	NS	46	99	**	**	99	96	**	99
BLSD (.05)	:				22	7	17	10	63	36	32
CV (%)	:	5.9	20.	3.1	20.	16.	17.	16.	12.	7.1	8.3

1/ Samples were taken in October before the 1981 treatments were applied.

2/ Rates applied in fall of 1980 for 1981 crop.

3/ **, *, and + are significant at the 99, 95 and 90% levels, respectively; NS = not significant at the 90% level. Numeric values for Lamberton and Waseca indicate probability level of statistical significance.

Approximately 8, 7 and 5 weeks after planting at Lamberton, Morris and Waseca, respectively, ten plants randomly selected from each plot were measured, harvested, dried and weighed to determine

early plant growth. Early plant weight and height were increased significantly (P=.01) by the treatments at Morris and Waseca (Table 4). Although a definite trend toward increased plant weight appeared with P additions at Lamberton, significant (P=.05) effects were not noted due to the variability. Both plant weight and height were generally lowest with the check treatment (no. 1) and the 0 P_2O_5 treatment (no. 2) indicating that the growth response was due primarily to P. Early weight was increased by the 50 and 100 lb P_2O_5 rates over the 0 P_2O_5 rate (no. 2) by 20 and 29% at Lamberton, 38 and 56% at Morris, and 22 and 40% at Waseca, respectively. Potassium generally did not affect either early plant weight or height.

Table 4. Early plant growth as influenced by high P and K rates at the three experimental sites in 1981.

Treatment		Weight			Height		
No.	Description	La	Mo	Wa	La	Mo	Wa
	lb P_2O_5+K_2O/A	g/dry plant			-------inches-------		
1	0 + 0	12.1	6.1	3.2	40.8	23.0	24.4
2	0 + 100	11.4	6.9	3.7	40.0	24.1	24.0
3	50 + 100	13.7	9.5	4.5	39.0	28.1	26.0
4	100 + 100	14.7	10.8	5.2	43.7	29.8	27.0
5	0 + 100	13.2	9.9	4.0	42.1	28.0	26.2
6	100 + 0	13.9	10.4	4.9	42.9	28.0	26.5
7	100 + 50	14.0	10.0	4.7	39.2	28.1	26.9
8	100 + 0	13.7	11.4	5.0	42.6	31.0	27.0
9	0 + 100	12.2	10.2	3.6	38.8	27.2	24.5
10	100 + 0	13.5	9.0	4.5	43.3	27.0	26.2
Signif. Level(%):		83	**	99	96	**	99
BLSD (.05)	:		1.8	0.5	4.4	1.8	0.9
CV (%)	:	12.	13.	8.7	6.0	4.9	2.6

The small plants from Morris and Waseca were chemically analyzed with the results shown in Table 5. Because of the poor stand and erratic emergence, the plants from Lamberton were not analyzed. Concentrations of P, K, Ca, Mg, Mn and Cu were affected significantly (P=.10) by the treatments at both 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, Mn and Cu concentrations were depressed and B increased with increasing P rates at Morris while Cu was depressed at Waseca. The high Fe and Mn concentrations at Morris are probably due to soil splash into the whorls.

Analysis of the leaf opposite and below the ear at silking indicated significant effects of the P and K treatments at both locations (Table 6). Leaf P was increased by the higher P treatments while K was increased linearly (P=.01) with increasing rates of K. Leaf Ca and Mg were reduced by the K treatments. Leaf Zn concentrations were reduced by the P treatments at both Morris and Waseca.

Planting populations were thinned to uniform stands at Lamberton and Waseca in 1981. A slight difference in final plant population was found at Morris (Table 7). Grain moisture an indication of maturity at harvest was affected inconsistently by the treatments at Lamberton and Waseca (Table 8) but was reduced by the P treatments at Morris.

The influence of the eight years of P and K application on silage and grain yields is given in Table 8. Silage yields were not increased significantly (P=.10) by the P and K treatments at Morris or Waseca. However, a definite trend toward higher silage yields did appear with the 50 and 100-lb P treatments. Grain yields were affected significantly (P=.01 level) at the Morris and Waseca locations. The response at Morris was associated with a P_2O_5 rate of 50 lb with no additional response to the 100-lb rate. A response to K was not seen at Morris. At Waseca, a definite response was obtained with the 50-lb P_2O_5 rate with slightly higher but not significant (P=.10 level) increases when 100 lb of P_2O_5 was applied. Also, a trend toward slightly higher yields with the K additions was observed at Waseca but was not statistically significant.

Soybean yields were not influenced by the P and K treatments at Lamberton (Table 9). The significance value of 15 indicates that in only 15 times out of 100 could these differences be duplicated under these experimental conditions.

Table 5. Effect of high P and K rates on the nutrient concentrations in the small whole plants at the two experimental sites in 1981.

Treatment No.	Description	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb P_2O_5+K_2O/A	%				ppm				
						Morris				
1	0 + 0	.32	3.47	.62	.60	2173	140	53	9.4	1.4
2	0 + 100	.31	4.45	.53	.49	2064	129	60	9.1	1.7
3	50 + 100	.38	4.41	.54	.49	1410	111	48	8.4	2.3
4	100 + 100	.42	4.46	.56	.48	1192	112	42	8.1	2.6
5	0 + 100	.38	4.23	.54	.51	1250	121	44	9.1	2.6
6	100 + 0	.41	3.04	.70	.69	1143	119	43	8.5	2.6
7	100 + 50	.41	3.86	.64	.54	1627	126	41	8.6	2.2
8	100 + 0	.42	4.01	.58	.58	930	99	42	7.5	2.8
9	0 + 100	.38	3.53	.60	.62	1294	121	45	9.0	2.3
10	100 + 0	.36	3.82	.59	.56	1375	120	45	9.4	2.4
	Significance:	**	**	**	**	**	**	**	**	**
	BLSD (.05) :	.04	.27	.06	.05	511	13	9	1.0	0.6
	CV (%) :	7.1	5.2	7.5	6.7	24.	7.4	12.	7.3	18.
						Waseca				
1	0 + 0	.38	3.48	.54	.52	283	66	53	15.1	7.4
2	0 + 100	.37	4.52	.44	.35	354	56	52	16.0	7.8
3	50 + 100	.40	4.62	.46	.36	306	62	49	14.3	7.4
4	100 + 100	.46	4.58	.49	.36	326	61	48	14.3	7.3
5	0 + 100	.40	4.56	.48	.38	343	62	48	13.4	6.4
6	100 + 0	.45	3.34	.59	.52	336	69	46	13.0	6.8
7	100 + 50	.45	4.04	.53	.42	386	65	50	12.4	7.8
8	100 + 0	.44	4.06	.52	.44	314	66	52	12.3	6.9
9	0 + 100	.39	4.28	.48	.41	330	60	50	16.0	7.3
10	100 + 0	.43	3.85	.53	.44	374	68	49	12.9	7.2
	Signif.Level(%):	99	99	99	99	72	98	76	98	22
	BLSD (.05) :	.02	.30	.04	.05		9	8	2.7	
	CV (%) :	4.0	5.4	5.4	8.7	16	7.9	7.3	12.	15.

Table 6. Effect of high P and K rates on the nutrient concentrations in the corn leaf at the two experimental sites in 1981.

Treatment No.	Treatment Description	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb P_2O_5+K_2O/A	----------%----------				----------ppm----------				
						Morris				
1	0 + 0	.24	1.46	.48	.54	102	83	28	4.5	6.6
2	0 + 100	.24	1.78	.42	.41	102	76	31	4.5	5.6
3	50 + 100	.28	1.70	.50	.46	98	79	22	3.9	4.9
4	100 + 100	.29	1.74	.51	.47	98	78	20	3.9	5.8
5	0 + 100	.28	1.73	.46	.46	96	76	23	3.9	5.9
6	100 + 0	.29	1.38	.56	.61	100	87	20	4.2	6.9
7	100 + 50	.28	1.59	.53	.53	99	83	20	4.2	7.3
8	100 + 0	.29	1.56	.53	.54	96	74	20	3.9	6.4
9	0 + 100	.27	1.41	.53	.61	98	85	23	4.0	6.1
10	100 + 0	.26	1.57	.50	.52	98	83	23	4.3	5.5
	Significance:	**	**	**	**	NS	**	**	*	NS
	BLSD (.05) :	.02	.11	.05	.05		8	3	0.5	
	CV (%) :	5.2	5.1	6.5	6.6	24.	6.	9.5	7.4	18.
						Waseca				
1	0 + 0	.29	1.49	.49	.50	106	76	30	5.1	4.0
2	0 + 100	.28	1.90	.46	.39	104	66	29	5.2	4.2
3	50 + 100	.31	1.97	.47	.39	109	67	26	4.8	4.1
4	100 + 100	.33	1.94	.50	.38	111	66	22	4.2	4.0
5	0 + 100	.31	1.79	.50	.41	109	66	24	4.3	4.0
6	100 + 0	.32	1.38	.54	.51	106	75	22	3.5	3.9
7	100 + 50	.33	1.76	.49	.44	110	68	23	4.5	4.1
8	100 + 0	.31	1.63	.54	.47	110	75	24	4.1	4.0
9	0 + 100	.28	1.82	.49	.43	101	61	25	4.3	5.0
10	100 + 0	.31	1.67	.51	.47	107	64	25	4.8	4.2
	Signif.Level(%):	99	99	99	99	75	37	99	99	22
	BLSD (.05) :	.02	.19	.04	.04			4	.9	
	CV(%) :	4.2	7.9	4.6	6.8	5.0	17.	12.	13.	19.

Table 7. Population and grain moisture at harvest as influenced by high P and K rates in 1981.

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	20.6	19.2	27.6	22.5	22.0	22.4
2	0 + 100	21.4	18.7	28.7	23.5	22.1	23.0
3	50 + 100	20.6	20.3	27.6	22.5	20.4	22.2
4	100 + 100	21.1	21.4	28.0	22.4	20.2	22.0
5	0 + 100	21.0	20.1	28.1	23.5	20.5	22.2
6	100 + 0	20.6	19.9	27.2	22.2	19.2	22.0
7	100 + 50	20.0	20.3	27.9	23.2	19.7	22.5
8	100 + 0	20.8	20.6	28.2	21.8	19.6	22.3
9	0 + 100	20.4	20.4	28.4	23.8	20.0	22.5
10	100 + 0	20.3	19.7	28.5	21.4	20.7	22.2
	Signif. Level(%):	10	**	63	94	**	99
	BLSD (.05) :		1.0			1.1	0.4
	CV (%) :	5.8	3.4	3.0	4.7	3.8	1.3

Table 8. Corn, silage and grain yields as influenced by high P and K rates in Minnesota in 1981.

Treatment		Silage Yield			Grain Yield		
No.	Description	La	Mo	Wa	La	Mo	Wa
	lb P_2O_5+K_2O/A	------T DM/A-------			---------bu/A---------		
1	0 + 0	ND[1/]	6.91	8.63	110.8	120.5	182.9
2	0 + 100		7.06	8.93	111.6	115.2	181.2
3	50 + 100		7.03	9.54	113.9	130.5	190.4
4	100 + 100		7.56	9.05	117.1	136.1	195.7
5	0 + 100		7.74	9.32	111.2	132.0	185.7
6	100 + 0		7.33	9.09	114.6	130.1	188.2
7	100 + 50		7.18	9.31	104.7	132.1	199.3
8	100 + 0		7.68	9.24	113.4	129.4	194.6
9	0 + 100		7.58	9.31	108.8	128.3	193.5
10	100 + 0		7.90	9.46	111.5	129.8	194.1
Signif. Level(%):			NS	52	80	**	99
BLSD (.05)	:					11.1	7.8
CV (%)	:		6.8	5.9	5.0	5.3	2.8

[1/] ND = Not Determined. Silage yields not taken because of erratic stands and growth due to poor emergence.

Table 9. Soybean yields at Lamberton as influenced by high P and K rates in 1981.

Treatment		
No.	Description	Yield
	lb P_2O_5+K_2O/A	bu/A
1	0 + 0	47.7
2	0 + 100	46.0
3	50 + 100	49.5
4	100 + 100	48.6
5	0 + 100	45.9
6	100 + 0	44.5
7	100 + 50	46.5
8	100 + 0	45.5
9	0 + 100	44.6
10	100 + 0	46.3
Significance Level (%):		15
CV (%)	:	9.8

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Nitrogen Fertilization and Use of a Nitrification Inhibitor for Corn Production in Southeastern Minnesota - 1981[1]

W.E. Jokela, G.L. Malzer, and M. O'Leary

This study was established to evaluate nitrogen management practices on the well-drained silt loam soils of southeastern Minnesota. Specifically, the objectives were: 1) to determine optimum nitrogen rates for corn production on these soils, 2) to determine if a nitrification inhibitor results in improved N use efficiency or increased yields, 3) to investigate the influence of nitrate-N in the soil profile on N fertilizer response.

Experimental Procedures

Two sites were selected, one on a Seaton silt loam (2.1% O.M.) on the Edwin Graner farm in Wabasha County and the other on a Mount Carroll silt loam (4.2% O.M.) on the Paul Voxland farm in Goodhue County. Treatments at each site consisted of three N rates - 60, 120 (140 in Goodhue Co.), and 180 lbs/A, each applied as anhydrous ammonia with and without a nitrification inhibitor (N-Serve at ½ lb a.i./A), plus a no nitrogen check. Earleaf samples were taken at silking and grain was harvested at physiological maturity. Selected treatments were sampled to five feet in one-foot increments for nitrate analysis prior to planting and after harvest.

At the Wabasha County location corn (Pioneer 3732 variety) was planted on May 8 in 38 inch rows at a population of 24,000 plants/A. 18 lbs N/A was applied to all treatments in the starter. The field had been in corn the previous year and in alfalfa the year before that. No manure had been spread for several years. Tillage was moldboard plowing with two diskings. At the Goodhue County site corn (Pioneer 3906 variety) was planted on May 9 in 30 inch rows at 24,000 plants/A. All treatments received 12 lbs N/A in the starter. The field had been cropped to corn for the five previous years, and no manure had been spread for at least three years. Corn was grown under a till plant system.

Results and Discussion

Results are shown in Table 1.

No significant yield response to N fertilizer or nitrification inhibitor occurred at either location, although there was a trend toward higher yields with applied N. Percent N in the earleaf at silking and, at the Wabasha Co. site, %N in the grain were increased by both N rate and nitrification inhibitor.

The lack of response may be a result of the relatively high nitrate-N levels in the soil profile (Table 2 and 3). The amount of nitrate-N in the 5-foot profile in the spring ranged from about 90 to 140 lbs/A. These levels were depleted by the end of the season at the Wabasha location, suggesting utilization of profile nitrates by the growing crop. Since there was no yield response to N fertilizer, a response to a nitrification inhibitor would not be expected.

[1]This project was supported in part by funds from the Minnesota Plant Food and Chemical Association.

Table 1. Response of corn to N rate and nitrification inhibitor. Wabasha and Goodhue County. 1981.

		Wabasha Co.				Goodhue Co.			
N Rate lbs./A	Inhib[1]	Grain Yield bu/A	Grain %N	Grain N Uptake lb/A	Leaf %N	Grain Yield bu/A	Grain %N	Grain Yield bu/A	Leaf %N
0	-	164.0	1.19	92.7	2.69	156.6	1.38	102.4	2.59
60	-	171.1	1.23	99.8	2.86	169.2	1.48	118.1	2.97
60	+	170.6	1.26	101.6	2.95	168.4	1.48	117.5	3.17
120 (140)	-	179.0	1.24	105.0	2.80	161.1	1.46	111.5	2.95
120 (140)	+	172.9	1.34	109.5	2.91	162.6	1.47	112.8	2.99
180	-	176.2	1.26	105.1	2.83	163.6	1.52	117.3	2.88
180	+	180.0	1.25	106.2	3.00	167.2	1.40	110.8	2.87
signif.		ns	ns	*	+	ns	ns	ns	**
BLSD (.05)		-	.07	11.0	.21	-	-	-	.22
C.V.		5.0	3.6	7.1	4.9	6.4	5.6	8.0	4.8
N Rate									
60		170.8	1.24	100.7	2.90	168.8	1.48	117.8	3.07
120 (140)		176.0	1.29	107.3	2.85	161.9	1.46	112.1	2.87
180		178.1	1.25	105.6	2.92	165.4	1.46	114.1	2.87
signif.		ns	+	ns	ns	ns	ns	ns	*
BLSD (.05)		-	.04	-	-	-	-	-	.16
Inhibitor									
-		175.4	1.24	103.3	2.83	164.6	1.48	115.6	2.93
+		174.5	1.28	105.8	2.95	166.1	1.45	113.7	3.01
signif.		ns	*	ns	*	ns	ns	ns	ns
BLSD (.05)		-	.03	-	.11	-	-	-	-
Factorial N* I									
signif.		ns	*	ns	ns	ns	ns	ns	ns
BLSD (.05)		-	.06	-	-	-	-	-	-
C.V.		5.0	3.1	8.6	4.7	6.8	5.6	8.5	4.7

[1]Inhibitor is "N-Serve" at ½ lb a.i./A.

Table 2. Nitrate-N in the soil profile. Wabasha Co. 1981

Depth (ft)	N Rate (lb/A), +/- Nit. Inhib.							
	0-		60-		60+		120-	
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
	NO_3-N (lb/A)							
0 - 1	70	8	52	12	45	18	-	15
1 - 2	30	5	43	9	32	22	-	14
2 - 3	25	3	37	4	22	12	-	11
3 - 4	10	4	11	8	12	13	-	10
4 - 5	5	5	4	10	5	9	-	10
0 - 5	140	25	147	43	116	74	-	60

Table 3. Nitrate-N in the soil profile. Goodhue Co. 1981

Depth (ft.)	N Rate (lb/A), +/- Nit. Inhib.							
	0-		60-		60+		140-	
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
	NO_3-N (lb/A)							
0 - 1	25	18	-	14	22	19	20	41
1 - 2	38	6	-	10	24	8	35	62
2 - 3	32	7	-	12	16	10	33	46
3 - 4	24	15	-	17	14	15	27	26
4 - 5	18	24	-	16	16	19	27	24
0 - 5	137	70	-	69	92	71	142	199

CORN TILLAGE RESIDUE MANAGEMENT, LANCASTER, 1981

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The driftless soils area has the greatest county average estimated soil losses from cropland in Minnesota, ranging from 4.0 to 6.6 t/ac/yr in the six counties involved. Typical soils of the region, such as Fayette-Dubuque, Seaton, and associated soils, are highly erodible, form dense crusts if unprotected from raindrop impact, and consequently, have low final infiltration rates and high runoff from the intense storm events common to the region. New and improved tillage practices are increasingly being relied upon to meet environmental goals under more intense cropping systems. These systems modify the soil and water losses as well as the kind and concentration of materials in the runoff. A more complete understanding of these tillage systems will allow a more accurate prediction of their effect on the environment; will permit the maximization of the benefits of the tillage systems for production; and will permit them to be more effectively incorporated into the overall farming systems of the region.

Experimental Procedures

The experimental site is located at the Lancaster Experimental Farm on a Rozetta silt loam. Five tillage treatments are replicated four times (Table 1). Each treatment plot is split into normal and mulched subtreatments. On the slot plant and till-plant plots an additional subtreatment (bare) is established by removing all residue prior to planting. On mulched subtreatments, corn residue additions are made following planting to obtain approximately 100 percent cover. Plots are approximately 90 to 100 feet in width and 80 foot in length. Row width is 38 inches, which is typical of the region. In 1981, corn (Pioneer 3747) was planted May 6 following tillage on May 5 and 6. A slot-planter was used to plant the conventional and chisel treatments as well as the slot-plant treatment. Attachable wings were bolted on the slot-planter to convert it to a till-planter which was then used on the till-plant plots and guard area. An AC Model 77 tool bar planter attached to a Ford tractor was used to plant the wheel track treatment.

Nitrogen (200 lbs/Ac as urea) was applied prior to tillage. Chemical weed control was used as follows: 2 lbs/Ac Aatrex, 2 qts/Ac Lasso, and 1 qt/Ac Banvel +24-D were applied May 7. On June 6, 1.5 lbs/Ac Aatrex and oil was applied post-emergence due to the very low rainfall in May (0.85 inches) and subsequent lack of effect of the preemergence herbicide. Two hundred lbs/Ac of 6-24-24 was applied as starter. Corn earleaf tissue samples were collected at silking. The plow, chisel, and Buffalo till treatments were cultivated on June 28 when corn was approximately 24 inches tall.

Mulch rates, corn emergence rate, plant height, planting depth, and growth measurements were made on designated portions of each plot. Random roughness measurements were made in Rep 2 on May 8 in wheel track plant, till plant, chisel, and conventional plots. Additional measurements were made on May 14 and June 16 to evaluate changes over time.

Ten plot frames (40-inch x 40-inch) were emplaced on May 8 and covered to protect the surface. Infiltration measurements were made on the wheel track (mulch and normal), conventional (mulch and normal) and slot plant (mulch) on June 1-4.

Neutron probe measurements were made June 22 and 29, July 6, 17, and 27, and August 4, 11, and 17. Surface soil moisture measurements were made on the same dates. Periodic bulk density measurements were made on the 1-3 inch depth.

Yields were determined by hand harvesting duplicate 60-foot samples from each subplot.

Results

Significant differences (Table 1 and 2) in grain yield, population and early growth occurred between tillage treatments. Yields from conventional and chisel plow tillage treatments were significantly greater than till-plant bare and slot plant normal treatments. Associated reductions in final population of about 3000 plants/acre on the latter treatments would largely explain the observed yield reductions.

The treatments with the lowest early growth also had lowest populations indicating less favorable conditions for germination and growth on these treatments (till plant bare and slot plant normal).

Table 1. Effect of tillage and mulch treatments on corn early growth, plant height, population at harvest, and yield.

Treatment		Dry Matter	Percent	Early Growth	Inches Plant Height at		Population at	Yield	Date 50% Plants Silked
Tillage	Residue	T/Ac[2]	Cover	gms/10 Plants	57 days	62 days	Harvest	Bu/Ac[1]	July
Till plant	Normal	3.5	46	9.0a	38	50	21,100 ab	156.6 ab	20.5
	Bare		7	5.8b	36	48	19,170 b	151.1 b	20
Slot plant	Normal	3.9	55	5.5b	37	51	19,240 b	151.3 b	21
	Bare		7	7.3ab	41	53	21,270 a	154.9 ab	20.7
Fall Chisel[3]		1.2	11	7.8ab	42	59	22,850 a	166.5 a	19.5
Conventional[4]			Trace	9.8a	42	60	22,650 a	167.6 a	19.5
Wheeltrack plant			Trace	9.5a	43	61	22,240 a	157.0 ab	19.7
Significance Level				*			*	*	

[1] Values not followed by same letter are significantly different at 5 percent level by Duncan's New Multiple Range Test.

[2] Rep 3 only.

[3] Fall chisel, spring disk.

[4] Spring plow-disk 2x.

*5 percent level of significance

Table 2. ANOVA for corn yields.

Source	df	ss	ms	f
Blocks	3	222.0500	74.0167	1.22
TMT	6	1072.8521	178.8087	2.94*
Error	18	1093.265	60.7369	

*5 percent level of significance

Normal till-plant, conventional, and wheel track planting treatments had significantly greater early growth than till-plant bare and slot plant normal treatments measured at the 5-leaf stage. Plant height measured July 2 and 7 at 57 and 62 days after planting was greatest on the wheeltrack, conventional and chisel treatments and somewhat less (5 to 10 inches less) on the till-plant and slot plant treatment. The till-plant treatment was planted flat as ridges were not prepared in 1980; this resulted in the till-plant treatment being planted essentially level or in a slight depression and not in a ridge as normally practiced. Fifty percent silking was delayed about 1 day on the non-plow treatments which is a much smaller difference than that measured in emergence.

Significant differences in planting depth were measured (Table 3). Planting depth was significantly greater on wheeltrack and conventional treatments, and was significantly less on the till-plant treatment.

Table 3. Planting Depth Measurements

Treatment	Planting Depth --------mm------- Avg	Sx	Range	2/3 Seeds between depths of
Till plant	30.25c[1]	10.39	14-55	19.8-40.6mm
Slot plant	37.50bc	11.30	20-60	26.2-48.8mm
Chisel	61.0a	9.10	50-80	51.8-70.0mm
Conventional	64.75a	12.21	45-85	52.5-77.0mm
Wheeltrack plant	44.50b	17.48	17-85	27.2-62.1mm

Significance level *

[1] See Table 1.

The percent of emergence is given as a function of time in Table 4 for the 5 tillage systems. The rate of emergence of wheeltrack, conventional, and chisel treatments was essentially the same from 17 days after planting to complete emergence; slot-plant was delayed about 3 days; and till-plant was delayed about 2 days. For the heavily (100% cover) mulched treatments, emergence was delayed approximately 6 days. The average temperature for May (Table 5) was 1.2°F below the station normal which tended to further delay the emergence of the 100 percent cover mulch treatment. This rate of mulch is clearly excessive for the climatic conditions encountered and the treatment will be modified to keep residues out of the row and decreased levels of residue will be applied.

Table 4. Influence of tillage method and mulch rate on percent emergence.

Treatment		Days after planting date of May 6 - - - - percent emerged- - - -									
Tillage	Cover	15 (May 21)	17	20	21	23	26	27	29	30	33 (June 8)
Till plant	Normal	3	28	66	75	83	94	99	100	100	100
	Bare	4	42	69	75	86	91	99	100	100	100
	100% Mulch	0	0	1	4	37	58	81	89	97	100
Slot plant	Normal	0	16	49	62	85	93	99	100	100	100
	Bare	0	22	69	80	89	95	100	100	100	100
	100% Mulch	0	0	1	4	22	64	83	91	94	100
Chisel	Normal	3	52	83	89	95	98	100	100	100	100
	100% Mulch	0	0	2	6	32	61	84	89	95	100
Conventional	Normal	4	55	86	93	97	100	100	100	100	100
	100% Mulch	0	0	2	8	48	83	92	95	99	100
Wheeltrack plant	Normal	14	55	84	90	96	100	100	100	100	100
	100% Mulch	0	0	2	4	19	48	67	79	91	100

Table 5. 1981 Weather Summary, Lancaster Experimental Farm.

Month	Precipitation inches		Growing* degree days		Temperature			
	Total	Departure	1981	Departure	Avg Max	Avg Min	Avg	Departure
April	4.22	0.95	-	-	63.2	39.7	51.4	4.5
May	0.85	-2.40	310	10	68.3	45.0	56.6	-1.2
June	4.28	-0.39	534	16	78.6	56.8	67.7	0.6
July	2.91	-1.38	646	- 7	81.6	60.8	71.2	0
August	11.35	6.62	600	12	79.6	58.9	69.2	0.7
September	3.54	0	360	12	71.3	49.9	60.6	-0.2
October	2.98	0.90	-	-	59.1	38.2	48.6	-1.8
Apr-Oct	30.13	+4.30	2450	43				

*50°F base temperature
Last day in spring with minimum temperature of 32°F = May 12 at 32°F.
First day in fall with minimum temperature of 32° or less = October 2 at 29°F

Significant differences were found between tillage treatments with respect to %K in earleaf samples. The moldboard plowed treatments (conventional and wheeltrack plant) had significantly greater %K in the earleaf sample than did till-plant (Table 6). This occurred even though all of the plots tested high (250 to 300) to very high (300+ lbs/K/Ac) in K except for 1 wheeltrack plant plot which tested 247 lbs/Ac K. These results are in accord with other Wisconsin research showing reduced uptake of potassium with non-plow systems. All plant concentrations measured appear to be sufficient for optimum yields.

Table 6. Influence of tillage method on nutrient concentration in earleaf at Lancaster, 1981.

Treatment	Nutrient						
	%				ppm		
	N	P	K	Ca	Mg	Mn	Zn
Till plant	3.34	0.33	2.26b[1]	0.67	0.37	59	26
Slot plant	3.21	0.32	2.36ab	0.60	0.34	53	25
Chisel	3.28	0.33	2.41ab	0.62	0.35	54	24
Conventional	3.31	0.34	2.45a	0.58	0.32	55	26
Wheeltrack plant	3.12	0.32	2.53a	0.58	0.33	54	25
Significance level	NS	NS	*	NS	NS	NS	NS

*5% level of significance.
[1]See Table 1

Large differences in final infiltration rates were measured on the conventional tillage treatment (Table 7); when mulch was present, the final infiltration rate was more than doubled compared to the bare treatment. The results with the wheeltrack treatment were less spectacular. Runoff began in the shortest time after water application started on the slot plant treatment, even though the treatment was heavily mulched. The relatively flat shape of the runoff curve for the bare WTP treatment occurred because there was runoff from only the downslope half of the bare wheeltrack treatment for much of the run since the ridge acted as a dam retaining water behind it. Once the ponded area filled with water, runoff occurred from the entire area. These results illustrate the dual requirement of both 1) a porous surface with high saturated hydraulic conductivity, and 2) a protective mulch cover in order to have rapid infiltration. Residue cover by itself does not guarantee a high final infiltration rate.

Table 7. 1981 Lancaster infiltration rate measurements.

Treatment Tillage	Mulch	Application Rate in/hr	H_2O Applied Before Runoff inches	Infiltration Rate X minutes after runoff commences 2.5min	7.5min	15min	25min	35min	45min	55min
				- - - - - - - - -inches/hour- - - - - - - - -						
Wheeltrack (E)	Bare	4.48	0.67	3.76	3.04	2.98	2.38	1.72	1.12	1.00
(W)	Bare	4.48	0.82	3.16	2.44	2.32	1.60	0.94	1.06	0.94
(E)	Mulch	4.56	0.61	3.12	2.40	2.28	2.04	1.56	1.68	1.68
(W)	Mulch	4.32	0.86	3.48	3.48	2.52	1.62	1.62	1.20	1.20
Conventional (107)	Bare	4.32	0.79	3.12	2.16	1.56	1.20	0.96	0.72	0.84
(108)	Bare	4.40	0.88	3.20	2.48	1.76	1.28	1.28	0.98	1.10
(105)	Mulch	5.28	1.23	4.32	3.60	3.12	2.88	2.52	2.52	2.52
(106)	Mulch	4.72	2.20	4.22	3.77	3.46	3.46	3.28	3.29	2.92
Slot Plant (109)	Mulch	4.48	0.37	3.64	2.92	2.08	1.96	1.84	1.84	1.84
(110)	Mulch	4.80	0.48	3.60	2.88	2.28	1.68	1.50	1.02	1.08

Summary

Three-year results at Lancaster with continuous corn show nearly equal average yields from conventional, chisel, slot plant, and till plant treatments (Table 8).

Thus, farmers in the region can choose between a variety of tillage options which have yields comparable with conventional tillage, but which are superior in soil and water conservation and offer some savings in time, labor, and fuel compared to conventional tillage methods.

Table 8. Continuous corn tillage results at Lancaster, Wisconsin, 1979-1981.

Tillage Treatment	Yield Bu/Ac 1979	1980	1981	Average
Till plant*	162	157	157	159
Slot plant	163	146	151	153
Chisel	160	150	167	159
Conventional	169	159	168	165

*planted flat in 1979 and 1981.

FERTILIZATION OF GRASSES GROWN FOR SEED PRODUCTION

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Research with cool season grasses during 1981 included: 1) a nitrogen source comparison study on mineral soils, 2) a nitrogen rate study on peat, and 3) a copper study on peat. Five trials with Kentucky bluegrass and timothy were conducted on growers' fields in Roseau and Lake of the Woods counties. Effects of fertilization were determined by measuring the yield and by chemical analysis of grass tissue and the soil.

A. WEATHER CONDITIONS DURING THE 1980/81 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 1980 to July 1981, 26.09 inches of precipitation (5.1 inches above normal) was received at Roseau, while the average air temperature was slightly below normal. During August, September and October, nearly 11 inches of rainfall was received which replenished the soil moisture that had been exhausted during the extreme drought of 1979/80. From November to April, the temperature was nearly 3° above normal and the precipitation was about 2 inches below normal. May was cooler than usual with about normal rainfall. June was very wet and very cool. Over 2.5 inches of rainfall was received during July with the average air temperature being 4.4°F below normal.

Table 1. Precipitation and temperature data for the 1980/81 growing season as measured at Roseau Weather Station (KRWB Radio)*.

	Precipitation (inches)		Air Temperature (°F)		
Period	Total	Departure from Normal	Average	Departure from Normal	GDD T_b=40°F
1980 Aug.	5.19	+1.97	61.7	-3.2	673
Sept.	4.12	+1.51	51.9	-2.7	357
Oct.	1.66	+0.44	38.2	-6.3	100
1980 Nov. to 1981 Apr.	2.85	-2.14	19.6	+2.8	109
1981 May	2.79	+0.34	50.0	-1.9	310
June	6.85	+3.43	56.8	-5.0	504
July	2.63	-0.82	62.8	-4.4	707
Total	26.09	+5.10			2760
Average			36.6	-0.6	
Normal (1941-1970)	20.99		37.2		

* Calculated from Climatological Data, Minnesota, Vol. 86 and 87, 1980 and 1981, U.S. Dept. of Commerce.

B. NITROGEN SOURCE COMPARISON

Two field experiments were conducted with Park Kentucky bluegrass and Climax timothy to evaluate the effectiveness of anhydrous ammonia, urea and ammonium nitrate as sources of nitrogen. The soils contained about 9 lb/acre of nitrate-N in the top six inches of soil which is the main rooting zone of the two grass species. The soils were calcareous with pH values above 7.5 (Table 2).

Prepared for presentation at the Grass Seed Institute, Baudette, MN, March 17, 1982.

The objectives of this investigation were: 1) to determine effectiveness of different nitrogen sources, and 2) to determine sod injury from the knives of ammonia applicator.

All dry fertilizer materials were applied on October 21, 1980. Urea (46-0-0) and ammonium nitrate (34-0-0) were applied to 10 x 40 foot plot areas with a 5-foot Gandy spreader. A 0+40+40 fertilizer treatment was made across all plots. Anhydrous ammonia (82-0-0) was applied with commercial applicators with the knives set 15 inches apart to 24 x 40 foot plot areas. Anhydrous ammonia was applied during the later part of October 1980. All nitrogen treatments were replicated six times.

Park Kentucky bluegrass produced high seed yield and showed significant response to the application of 120 lb of nitrogen per acre (Table 3). Moderate lodging occurred in the plots receiving nitrogen treatments. The highest seed yield was produced with the solid nitrogen fertilizers, ammonium nitrate and urea. While anhydrous ammonia resulted in highest N concentration of tissue, it produced nearly 200 lb/acre less seed than the solid N sources. Knifing did not significantly affect the yield, as shown by the urea vs. urea + knife treatments (606 vs. 505 lb/acre). These data are consistent with results obtained with Park K. bluegrass at this location in 1979.

Climax timothy showed significant response to the application of 90 lb of nitrogen per acre (Table 4). The highest yield was produced with anhydrous ammonia. Although the knives of AA applicator caused some ripping of timothy sod, the damage was not sufficient to affect seed yield.

Table 2. Soil test results of samples collected from 0-3 and 3-6 inch depths.+

Location	Sampling Depth (inches)	Texture	pH	Extractable P pp2m	Exchangeable K pp2m	DTPA Extractable Cu ppm
Helmstetter Bros.	0-3	SIL	7.6	46	83	
Park K. bluegrass	3-6	SIL	7.7	33	70	
Erickson	0-3	SIL	7.8	28#	240	
Climax timothy	3-6	SIL	7.9	17	132	
Kveen	0-3	P	6.7	29	282	
Park K. bluegrass (N-Rate trial)	3-6	P	6.5	27	83	
Kveen	0-3	P	6.7	45	221	0.5
Park K. bluegrass (Copper trial)	3-6	P	6.5	24	93	0.5

+ samples collected on October 21-22, 1980.

1:50 soil/solution ratio.

Table 3. Effect of nitrogen treatments on seed yield and N concentration in tissue of Park Kentucky bluegrass, Helmstetter Bros. farm, Lake of the Woods County, 1981.

Treatment	Seed Yield lb/acre	N Percent in Dry Matter
Check	301 a	2.03 a
Urea + Knife	505 bc	2.98 b
Urea	606 d	2.78 b
Ammonium Nitrate	627 d	2.93 b
Anhydrous Ammonia	427 b	3.37 c
Significance	**	**
BLSD (0.05)	73	0.25
C.V., %	14	8

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 4. Effect of nitrogen treatments on seed yield and N concentration in tissue of Climax timothy, Douglas Erickson farm, Roseau County, 1981.

Treatment	Seed Yield lb/acre	N Percent in Dry Matter
Check	280 a	2.76 a
Ammonium Nitrate + Knife	445 bc	3.77 b
Ammonium Nitrate	421 b	4.05 c
Urea	390 b	3.64 b
Anhydrous Ammonia	494 c	4.09 c
Significance	**	**
BLSD (0.05)	56	0.23
C.V., %	12	6

Nitrogen materials were applied at a rate of 90 lb N/acre; 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 1980 to investigate the effectiveness of different rates of nitrogen. Five N rates were used: 0, 20, 40, 60, 80 lb/acre,and the treatments were replicated four times. All plots received uniform 0+40+40 lb/acre phosphate and potash treatment. Fertilizer materials were applied with a Gandy spreader on October 22,1980. The soil contained 14 lb/acre of nitrate-N in the top six inches.

Very high seed yield was produced at this location even without nitrogen (Table 5). Moderate to severe lodging of the grass was noted prior to harvest. Some lodging had occurred even in the check plots.

Table 5. Effect of fertilization on seed yield and N concentration in tissue of Park Kentucky bluegrass on peat, Gus Kveen farm, Roseau County, 1981.

Nitrogen Rate lb/acre	Seed Yield lb/acre	N Percent in Dry Matter
0	549 a	3.23
20	612 abcd	3.77
40	594 abc	3.75
60	566 ab	3.88
80	690 d	4.09
Significance	+	ns
BLSD (0.10)	92	
C.V., %	11	11

Ammonium nitrate (34-0-0) was applied on October 22, 1980; all plots received 0+40+40 lb/acre of P_2O_5 and K_2O.

D. COPPER STUDY ON PEAT

A field experiment with Newport Kentucky bluegrass on peat was established in the fall of 1978. The soil contained 1.6 ppm DTPA extractable copper in the top 3 inches, indicating a relative low availability of this micronutrient (Table 6, Treatment: None). Originally, the copper treatments included two sources (copper sulfate and copper chelate), single application made either in fall of 1978 or spring of 1979 (residual treatment), and an annual application (made either in fall or spring). The treatments were arranged in a split-plot design with the time of application as main

plots, and the subplots consisting of residual and annual treatments. All treatments were replicated four times. Copper sulfate and copper chelate were dissolved in water and sprayed on 10 x 20 ft. plot areas. The entire field received 30+40+40 lb/acre of plant nutrients (N, P_2O_5 and K_2O) in fall. The application of all annual treatments (either fall or spring) was made at one time on May 12.

No lodging occurred in the experimental area. Relatively low seed yield (138 to 174 lb/acre) of Newport K. bluegrass was produced at this location and copper had no beneficial effect (Table 7). Copper concentration in bluegrass tissue from check plots was 2.14 ppm, considered a low level; annual application of copper sulfate (44 lb/acre of actual Cu applied during 3 years) increased it to 210 ppm. The application of copper sulfate increased DTPA extractable copper content in the soil to 36-47 ppm compared with 1.6 ppm found in the samples from check plots (Table 6).

A copper trial with Park Kentucky bluegrass was established in the spring of 1981. An extremely low extractable Cu level (0.5 ppm) was indicated by soil test (Table 2). Fertilization with copper had no beneficial effect on the yield (Table 8). Copper concentration in the tissue was increased from 3.4 ppm in control to 11.4 ppm by the application of 50 lb/acre of copper sulfate.

Table 6. DTPA extractable copper content in the soil collected from 0-3 and 3-6 inch depths+, Newport Kentucky bluegrass, Gus Kveen farm, Roseau County, 1981.

Copper Treatment	Sampling Depth (inches)	DTPA Extractable Cu ppm
None	0-3	1.6
	3-6	1.1
50 lb/A Copper Sulfate - Residual[1)]	0-3	46.9
	3-6	2.1
50 lb/A Copper Sulfate - Annual	0-3	36.4
	3-6	1.9
6 lb/A Copper Chelate - Residual[1)]	0-3	2.2
	3-6	1.3
6 lb/A Copper Chelate - Annual	0-3	3.3
	3-6	0.6

+ samples collected on May 12, 1981.

1) residual treatments were made once in spring 1979.

Table 7. Seed yield and copper concentration in tissue of Newport Kentucky bluegrass as affected by copper application, Gus Kveen farm, Roseau County, 1981.

Copper Treatment	Seed Yield lb/acre	Copper, ppm in Dry Matter
None	138	2.14 a
50 lb/acre Copper Sulfate - Residual[1)]	156	8.60 a
50 lb/acre Copper Sulfate - Annual[2)]	174	210.21 b
6 lb/acre Copper Chelate - Residual[1)]	142	3.85 a
6 lb/acre Copper Chelate - Annual[2)]	172	14.54 a
Significance	ns	**
BLSD (0.05)		36.06
C.V., %		53

1) Residual treatments were made once in spring 1979.

2) Annual treatments were made on May 12, 1981.

Table 8. Seed yield and copper concentration in tissue of Park Kentucky bluegrass as affected by copper application, Gus Kveen farm, Roseau County, 1981.

Copper Treatment	Seed Yield lb/acre	Copper, ppm in Dry Matter
None	581	3.41 a
50 lb/A Copper Sulfate	579	11.43 b
6 lb/A Copper Chelate	501	5.89 a
Significance	ns	*
BLSD (0.05)		4.70
C.V., %	10	39

All plots received 20+40+40 lb/acre of N, P_2O_5, K_2O.

ACKNOWLEDGMENTS

Grateful acknowledgments are made to the following cooperators and University personnel for their valuable assistance during 1981 in obtaining the information pertaining to grass seed production: Messrs. Everett and George Helmstetter, Lake of the Woods County; Gustav Kveen, Mike Higgins, Douglas Erickson, Roseau County; Dr. Laddie Elling, Messrs. Mike O'Leary, Donn Vellekson, Jeffrey Schmidt, University of Minnesota.

NITROGEN FERTILIZATION OF SUGARBEETS IN WEST-CENTRAL MINNESOTA , 1981

G. L. Malzer, Gregory C. Buzicky and Larry Smith

The goal of the sugarbeet grower is to manage the crop in such a way as to produce maximum recoverable sugar. One of the most influential and potentially manageable factors involved in recoverable sugar production is the nitrogen status of the soil.

Research was continued in 1981 as part of a study that was initiated in 1976 in West-Central Minnesota to investigate nitrogen management of sugarbeets. The primary objectives were a) to correlate residual soil nitrate levels to optimum nitrogen fertilization; b) to determine the optimum sampling depth for correlation of soil nitrate-nitrogen levels to sugar yields; c) to demonstrate and calibrate the relationship of soil nitrate-nitrogen levels and fertilizer nitrogen rates to recoverable sugar content.

Method: Two sites were selected in West-Central Minnesota in 1981. These were located on the Harold Peterson farm in Chippewa county and the Paul Brutlag farm in Grant county. Soil test results (0-6") for the two sites are given in Table 1. The soil was also sampled to a depth of two feet in the spring and subsoil samples were collected in the previous fall for nitrate-nitrogen (NO_3-N) analysis (Table 2).

Each site received nitrogen treatments of 0,40,80,120, and 160 lbs/A applied as anhydrous ammonia before planting. Treatments were replicated four times, however one replication was abandoned at the Brutlag site due to vandalism. Experimental design was a randomized complete block.

The plots were planted on April 9 with Maribo Monova. Emergence was good at both sites but temperatures of 22°F on May 10 caused considerable stand reduction and consequently the stands were hand-thinned to a relatively low, uniform population of 115 plants/100' row at the Peterson site and 100 plant/100' row at the Brutlag site. Weed control was accomplished by hand weeding while control of Cercospora leaf spot was attempted by spraying, however the disease was so severe that spraying was ineffective. This was especially evident at the Peterson site. Beets were harvested with a modified one row lifter on October 1 and 2 and tare samples were process by the American Crystal tare laboratory at East Grand Forks.

Results and Discussion: Beet yields at both sites were good despite severe Cercospora damage. There was no yield response to nitrogen fertilizer at either site (Tables 3 and 4). This can be explained by the high NO_3-N concentrations in the upper two feet at the Peterson site and high NO_3-N levels in the upper five feet at the Brutlag site.

All sugar parameters were adversely effected by N fertilizer at the Brutlag site although only gross sugar and recoverable sugar proved significant (Table 3). Impurity parameter were not influenced by N application. A minimal response to nitrogen fertilizers at this site was anticipated due to the excessive buildup (329 lbs/A) of NO_3-N.

At the Peterson site, sugar yields and concentrations were significantly adversely effected by N fertilizer (Table 4). The large amount of NO_3-N in the top 2 feet of soil, plus the mineralized N, provided enough nitrogen so that there was no response to fertilizer N with respect to yield. However, sugar yields and concentrations were effected by N fertilizer. Increased fertilizer applications decreased all sugar parameters and also increased the Na concentrations and impurity index significantly.

Table 1. Some of the chemical properties of the soil (0-9") at the two sites.

Site	Texture	O.M.	pH	P	K	Zn
				--lbs/A---		ppm
Peterson	Clay	6.0	7.9	17	397	3.1
Brutlag	Clay	4.0	7.0	68	232	0.9

Table 2. Soil NO_3-N concentrations at the two sites by depth.

	Increment						
Site	0-1'	1-2'	2-3'	3-4'	4-5'	0-2'	3-5'
Peterson	------197-----		9	5	5	197	19
Brutlag	82	58	73	82	82	140	329

Table 3. Yield parameters of sugarbeets as effected by N fertilization Paul Brutlag farm (Grant Co.), 1981.

Treatment	Yield	Gross Sugar	Rec. Sugar	Percent Sugar	Percent Rec.Sugar	Yield Sugar	Impurities Na	K	Amino N	Impurity Index
	T/A	---lbs/A-----		-------%---------		lbs/T	--------ppm-------			
Check	22.5	6046	4553	13.4	75.0	201	1220	1990	1370	1664
40 lbs/A	20.4	5175	3890	12.7	74.8	190	1170	1913	1283	1678
80 lbs/A	21.9	5224	3785	12.3	71.7	179	1373	2127	1320	1884
120 lbs/A	20.7	4973	3640	12.0	73.0	176	1077	2053	1310	1803
160 lbs/A	20.5	4721	3311	11.5	70.2	162	1270	1903	1437	1986
Sig.	NS	*	+	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)	-	788	699	-	-	-	-	-	-	-
C.V.	5.2	7.5	12.1	6.4	5.1	10.2	16.6	11.0	10.0	13.8

Table 4. Yield parameters of sugarbeets as effected by N fertilization, Harold Peterson Farm (Chippewa Co.,) 1981.

Treatment	Yield	Gross Sugar	Rec. Sugar	Percent Sugar	Percent Rec.Sugar	Yield Sugar	Impurities Na	K	Amino N	Impurity Index
	T/A	-------lbs/A----		----------%----------		----------ppm--------				
Check	21.5	5575	4256	13.0	76.3	198	1188	2605	1028	1579
40 lbs.N/A	23.0	5359	3895	11.6	72.6	169	1498	2438	1042	1827
80 " "	22.1	5157	3790	11.7	73.3	172	1180	2430	1102	1782
120 " "	22.4	4816	3316	10.7	68.5	147	1415	2555	1168	2099
160	22.5	4738	3290	10.5	69.1	146	1408	2570	1065	2060
Sig.	NS	+	*	**	**	**	**	NS	NS	**
BLSD(.05)	-	576	615	.98	3.4	21.1	200	-	-	238
C.V.	5.1	7.8	10.2	5.6	3.2	8.4	9.3	9.3	7.4	8.3

NITROGEN FERTILIZATION OF SUGARBEETS IN WEST-CENTRAL MINNESOTA 1976-1981

G. L. Malzer, Gregory C. Buzicky, Larry Smith, Jerome Lensing, Bob Schoper, Orville Gunderson, William Fenster

The ultimate goal of the sugarbeet growers is to manage sugarbeets in such a way as to produce the highest yield with the highest percent surgar and lowest impurity level. To do this, the grower utilizes a vast array of management options such as tillage, varieties, plant population, herbicides, fungicides, and fertilizer. Other factors such as mositure and temperature are not manageable, but very important in determining sugar yield. Since sugarbeet roots increase sugar storage only afer a deficiency of one of several primary growth factors, it is obvious that control of one of these factors is important in determining maximum recoverable sugar yields. The most influential and manageable factor is the nitrogen status of the soil.

Research was initiated in West-Central Minnesota in 1976 to investigate nitrogen management of sugarbeets. The primary objectives were a) to correlate residual soil nitrate levels to optimum nitrogen fertilization; b) to determine the optimum sampling depth for correlation of soil nitrate-nitrogen levels to sugar yield; c) to demonstrate and calibrate the relationship of soil nitrate-nitrogen levels and fertilizer nitrogen rates to recoverable sugar content.

Methods:

Nitrogen correlation studies were begun in 1976 and continued through 1981. Thirty-eight plot sites, with a total of 131 replicated treatments, were harvested during this study with several other sites chosen but subsequently abandonded due to various complications. These sites were located in seven west-central Minnesota counties: Renville (11), Chippewa (12), Kandiyohi (1), Swift (4), Stevens (1), Grant (8), and Traverse (1). The plots were located on representative soils of the area and located on growers' fields with a single exception. Besides the nitrogen correlation study, a number of other studies were instituted or incorporated into the correlation study (these results have been previously reported).

Experimental designs consisted of the Latin Square, randomzied complete block, and paired comparison. Nitrogen fertilization rates ranged from 0 to 200 lbs/A with nitrogen applied in late fall or early spring. Sites were fertilized to optimum levels for other nutrients. Varieties, population, weed and disease control varied depending upon the grower or year. However, plots were thinned by hand to optimum uniform populations and hand-weeded if necessary.

Soil samples were taken to a depth of five feet in one foot increments (before fertilization) from all but seven sites. These samples were analyzed for nitrate-nitrogen at the University of Minnesota. Time of harvest varied with each year, usually occurring in late September or early October. Beets were lifted with a four-row lifter, a modified one-row lifter, or by hand. Subsamples were collected from the harvest area and processed at the Min-Dak Farmers Cooperative and American Crystal lab at Moorhead, the American Crystal lab at East Grand Forks, or the tare lab at NDSU.

Data were compiled and analyzed with the facilities of the St. Paul Computer Center at the University of Minnesota using the Statistical Analysis System (SAS) developed by North Carolina University.

Results and Discussions

A variety of growing and management conditions occurred during the course of this six-year study. The independent variables chosen, for modeling purposes only, were nitrate-nitrogen levels. Recoverable sugar was chosen as the dependent variable since it is a result of yield, gross sugar and purity.

Table 1 contains the mean nitrate values, at various depths, encountered during the course of the study. Graphs 1 and 2 show the distribution of nitrates in the 0-2' and 2-5' increments, respectively. As seen in the graphs, the majority of sites had less than 100 lbs NO_3-N/A in the top 2' and little build-up in the 3-5' increment. The distribution of nitrate-nitrogen plus fertilizer nitrogen of the 131 treatments is shown in Graph 3. A good distribution between 40 and 300 lbsN/A+ NO_3-N/A was achieved during this study.

Analysis of scatter diagrams of nitrogen levels versus recoverable sugar demonstrated a quadratic curve. Therefore, regression analysis was conducted utilizing forty nitrate- derived variables. Table 2 lists the best one, two, and three variable models resulting from the regression analysis. Corresponding equations are listed in Table 3. Additionally, a model equation using a soil nitrate and fertilizer nitrogen variable is listed. Equations 2 and 4 are represented in Graph 4 and Equation 3 is represented in Graph 5 and 6.

It is interesting to note that Equation 2 predicts an optimum soil nitrate level of 85.7 lbs/A in the top 2' with a 112 lb/A credit to mineralization (4155/ 37.2 = 111.7). Equation 3 predicts an optimum of 96 lbs NO_3-N/A and credits 99 lbs/A to mineralization (3722/37.7 = 98.7). Inspection of Equation 4 (Graph 4), which incorporates both soil nitrate plus fertilizer nitrogen, shows an optimum level of 155 lbs/A. Equation 3, represented in Graph 5 and 6, incorporates soil nitrates to a depth of three feet. As shown in Graph 6, nitrates at the 2-3' increment contribute positively to recoverable sugar yield at levels up to 34.3 lbs/A regardless of the 0-2' nitrate-nitrogen levels. Amounts greater than 34 lbs/A result in a decrease in recoverable sugar yield. This decrease is substantial past approximately 65 lb/A.

A number of conclusions can be drawn from the analysis of data compiled in this study:

1) Soil sampling to a depth of 2' is a good tool for monitoring the residual NO_3-N in the profile and predicting the effect of the residual nitrates on recoverable sugar yield.

2) Applying fertilizer nitrogen such that the 0-2' NO_3-N + fertilizer equals 155 lbs/A, provides the optimum chances for top recoverable sugar yields.

3) The optimum nitrogen status indicated by the data is 90 lbs/A NO_3-N/A distributed in the top two feet with an additional 65 lbs/A applied as fertilizer nitrogen.

4) If the 0-2 ' NO_3N test plus fertilizer nitrogen is greater than 155, chances are greater that a decrease in recoverable sugar yield will result.

5) Sampling to a depth of greater than 3' did not provide a good correlation with recoverable sugar yield.

6) Sampling to a depth of 3' does a better job of predicting optimum recoverable sugar yields if the samples is divided into 0-2' and 2-3' increments.

7) If nitrate-nitrogen at the 2-3' increment is greater than 35 lbs/A, recoverable sugar yields will probably decrease. Substantial build-ups greater than 65 lbs/A can result in substantial decreases in recoverable sugar yields.

8) Nitrates at depths greater than 2' are not as available as nitrates in the 0-2' increment.

Table 1. Mean values of soil NO_3-N at various increments during six-year period.

	0-1*	1-2*	2-3**	3-4**	4-5**	0-2***	3-5**	0-5
	lbs NO_3-N/A							
$\bar{x}$	50.5	36.2	30.5	31.4	22.0	95.0	85.1	178.9

* N = 25 sites
** N = 30 sites
*** N = 38 sites

Table 2. The variables involved in the best one, two, and three variable models for predicting recoverable sugar.

	Variable	R^2	C.V.	Sig
1.	$(0\text{-}2'\ NO_3\text{-}N)^2$	.26	14.6	**
2.	$(0\text{-}2'\ NO_3\text{-}N)$, $(0\text{-}2'\ NO_3\text{-}N)^2$	.40	13.3	**
3.	$(0\text{-}3'\ NO_3\text{-}N)$, $(0\text{-}2'\ NO_3\text{-}N)^2$, $(.3(2'\text{-}3'\ NO_3\text{-}N))^2$	.65	10.1	**
4.	$(0\text{-}2'\ NO_3\text{-}N + \text{Fert. N})$, $(0\text{-}2'\ NO_3\text{-}N + \text{Fert. N})^2$	.25	14.8	**

Table 3. Model equations for predicting recoverable sugar yields (RS) using nitrate-nitrogen values.

1) $RS = 5845.5 - 0.04643\ (0\text{-}2')^2$

2) $RS = 4155 + 37.2\ (0\text{-}2') - .2069\ (0\text{-}2')^2$

3) $RS = 3733 + 37.7\ (0\text{-}3') - .19546\ (0\text{-}2')^2 - 6.1\ (.3\ (2' - 3'))^2$

4) $RS = 4225 + 20.3\ (0\text{-}2' + \text{Fert. N}) - .0655\ (0\text{-}2' + \text{Fert. N})^2$

9) Optimum soil nitrate and fertilizer applications only maximize the probability of top recoverable sugar yield. Actual recoverable sugar yield is influenced by a wide variety of environmental conditons and management options.

10) Excessive fertilizer application increases the possibility for lower recoverable sugar yields by creating a greater chance of surpassing the optimum N fertility status.

11) Do not base fertilizer nitrogen application rates only on yield goal. Optimum growing conditions invariably provide optimum mineralization of organic matter to usable inorganic nitrogen.

Based on the data from this six-year study, the following fertilizer nitrogen recommendations can be made for sugarbeets in West Central Minnesota:

1) If the 0-2' nitrate test is greater than 80 lbs/A, then subtract from 155 to obtain the fertilizer rate;

Example: test = 100 lbs NO_3-N/A, (0-2')
155 - 100 = 55 lbs N/A

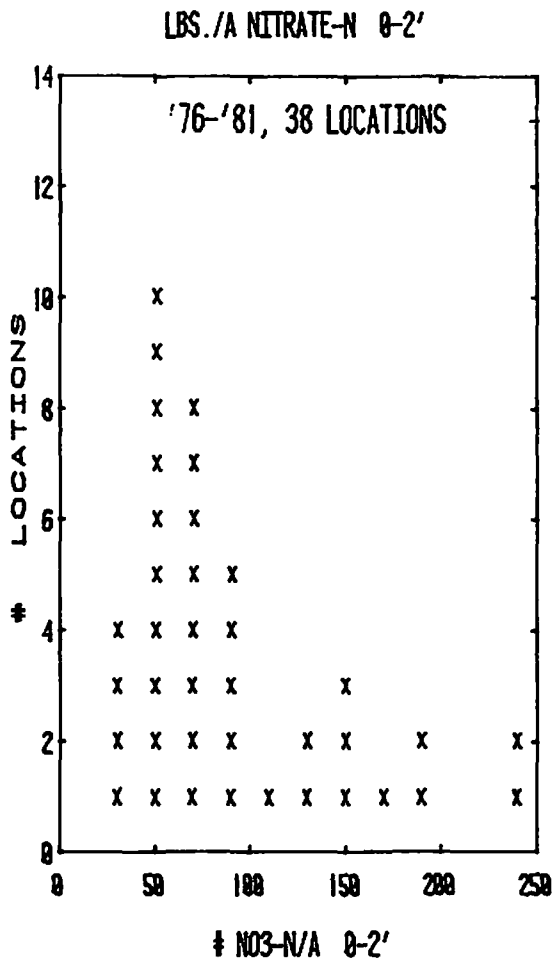
2) To avoid excessive fertilizer application, if the 0-2' nitrate test is less than 80 NO_3-N/A, subtract from 135 to obtain the fertilizer rate;

Example: test 50 = lbs NO_3-N/A, (0-2')
135 - 50 = 85 lbs N/A

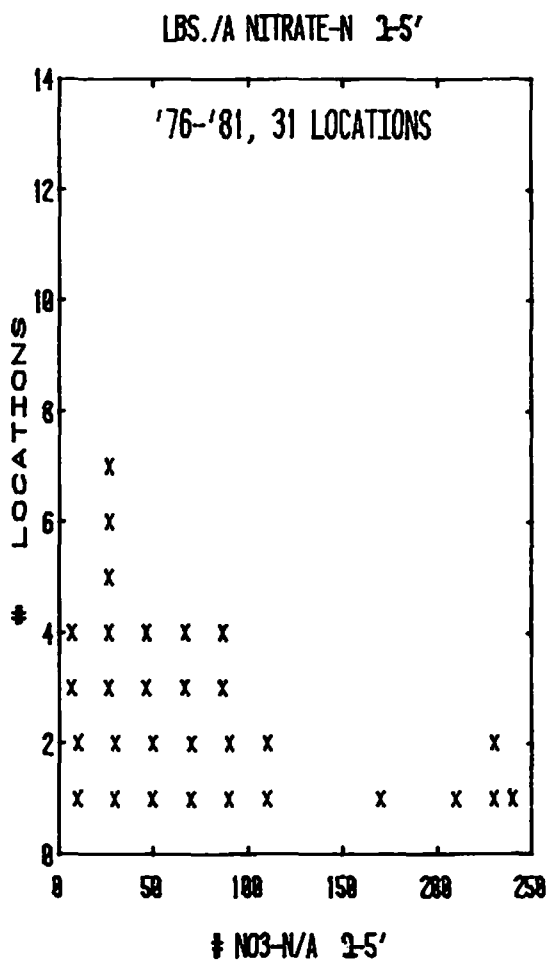
3) If a build-up of nitrates is suspected, a nitrate test should be made on the 2-3' increment. If the 2-3' nitrate test is greater than 35 lbs/A, reduce N application by 10 lb/A; if the 2-3' nitrate test is greater than 65 lbs-A, reduce N application by 20 lbs/A.

Of 33 trials conducted during the last six years, these fertilizer nitrogen recommendation would have predicted the top recoverable yields at 22 sites. Seven times the recommendations would have been less than necessary for top recoverable sugar yield and only four times would the recommendations been excessive. These recommendations, therefore, create the optimum nitrogen status and tend to prevent excessive fertilization.

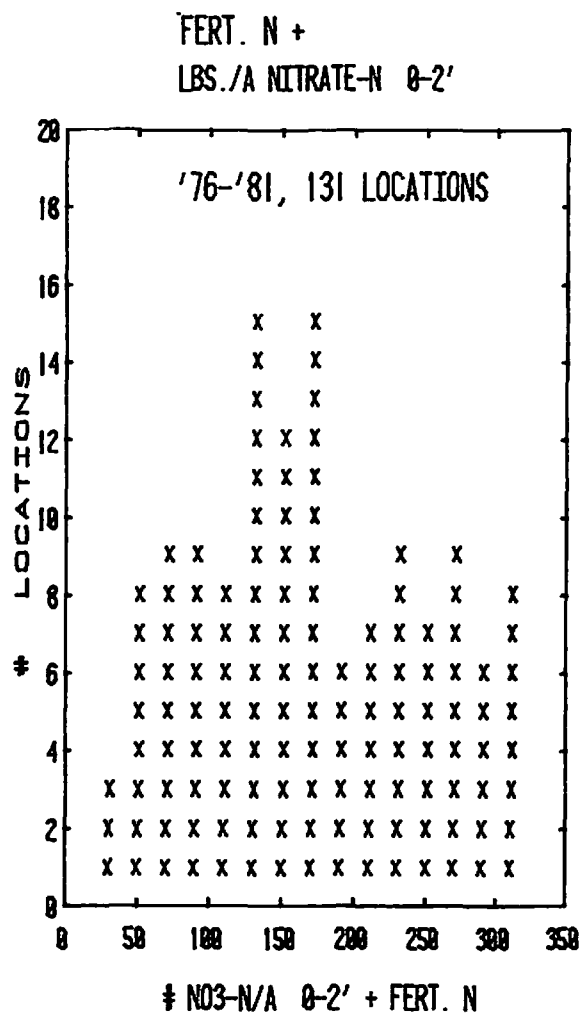
Acknowledgement is made to Dr. Bill Fenster, Orville Gunderson, Bob Schoper, Jerome Lensing, and Dr. Larry Smith for invaluable contributions to this study. Also, special thanks is extended to the sugarbeet growers of West Central Minnesota who contributed land, equipment, and time to this project. Finally, appreciation is made known to the Sugarbeet Research and Education Board for their funding of this project.



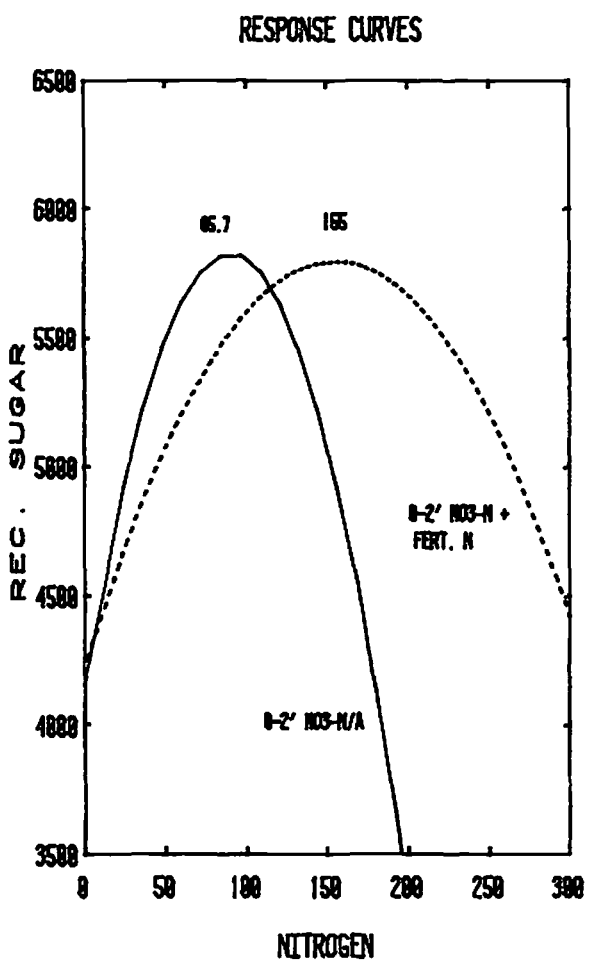
Graph 1. Distribution of nitrates, 0-2', encountered for 38 locations, 1976-1981.



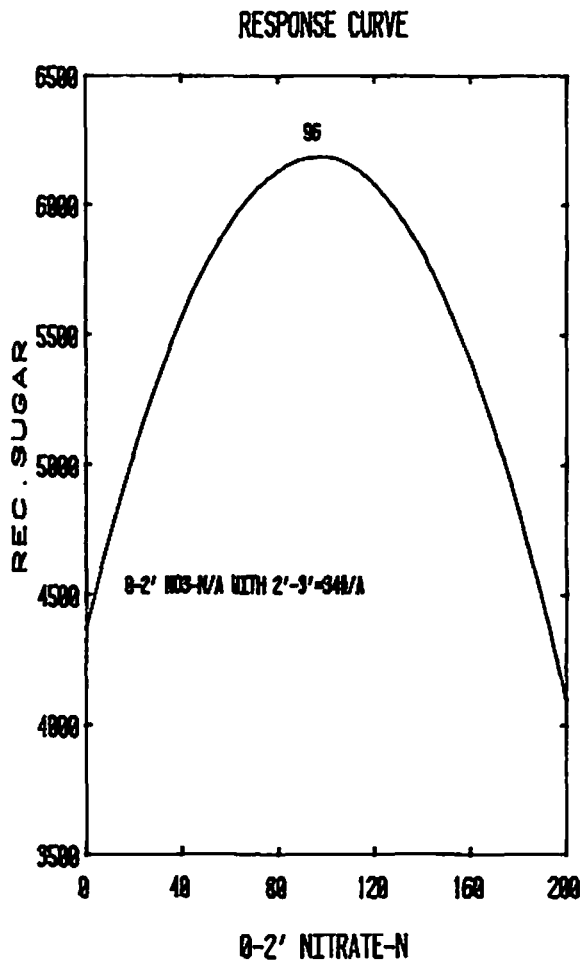
Graph 2. Distribution of nitrates, 2-5', encountered for 31 locations, 1976-1981.



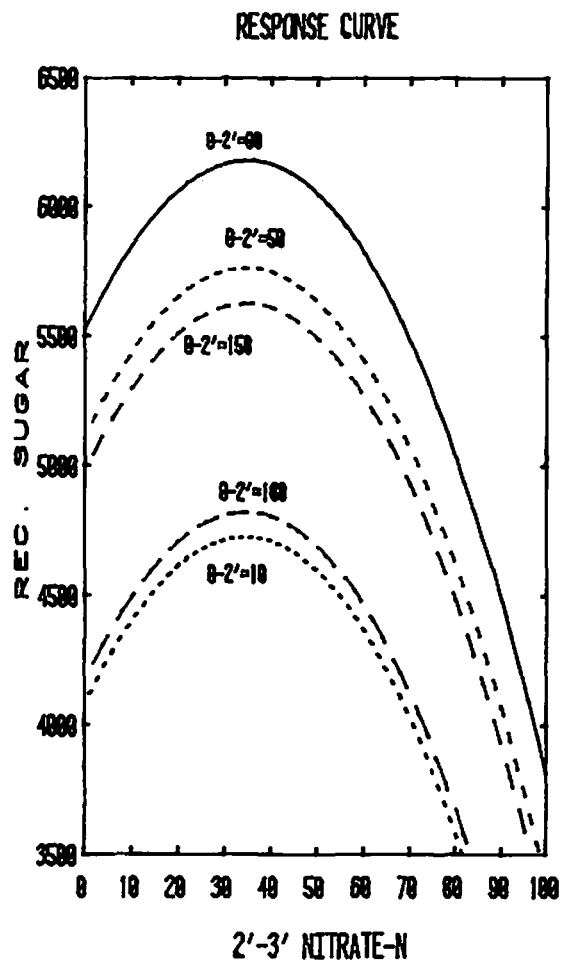
Graph 3. Distribution of nitrate-nitrogen (0-2') + fertilizer nitrogen for 131 replicated plots, 1976-1981.



Graph 4. Response curves for Equation 2: RS = 4155 + 37.2 (0-2')- .2069 $(0\text{-}2')^2$ and Equation 4:RS = 4255 + 20.3 (0-2' + Fert. N)- .0655 $(0\text{-}2' + \text{Fert. N})^2$



Graph 5. Response curve for Equation 3: RS = 3722 + 37.7 (0-3')-.19546 $(0\text{-}2')^2$ - 6.1 (.3 $(2'\text{-}3')^2$ when 2'-3' nitrate-N equals 34 lbs/A.



Graph 6. Response curve for Equation 3: RS = 3722 + 37.7 (0-3') -.19546 $(0\text{-}2')^2$- 6.1 (.3(2'-3') $)^2$ when 0-2' nitrate -N is 10,50,90, 150, and 180 lbs/A.

YIELD RESPONSE OF WHEAT TO STARTER FERTILIZER IN NORTHWESTERN MINNESOTA - 1981

W. E. Jokela and M. O'Leary

Application of low rates of fertilizer with the drill at planting time is a common practice for wheat production in northwest Minnesota. In an effort to evaluate the benefit of this practice on medium to high fertility soils several wheat growers in the area cooperated in this study. In Marshall County the cooperators were Art and Les Howard, Warren, and Medard and Don Yutrzenka, Argyle, and in Pennington County they were Clyde Christianson, Ken Mehrkens, and Mark and Charles Naplin, all in the Thief River Falls area.

Each grower left check strips without drill-applied fertilizer, alternated with strips with their normal rate of fertilizer. Nitrogen was applied to both treatments but no other broadcast fertilizer was used. Soil analysis from the check strips and the amount of starter fertilizer used are given in Table 1. Fertilizer was applied in a granular form on all sites except Yutrzenka (sites 3-5), where liquid (10-34-0) was used. Yield samples, consisting of four to eight samples per treatment depending on the site, were taken at maturity. Results are tabulated in Table 2.

Two of the nine comparisons showed a significant yield increase of approximately 10 bu/acre due to drill applied fertilizer. Both of these, as well as site 7 which showed a non-significant 7 bu/acre increase, were on soils testing medium-high in P and medium in K. Most of the non responding sites had high or very high levels of both P and K. No protein differences were observed and an average value is given.

Table 1. Soil analysis and starter fertilizer rates for 9 sites in northwestern Minnesota. 1981.

	Site Number	Soil Analysis, 0-6 in.				Starter Fertilizer Rate		
		Texture	pH	P(Bray 1) lb/A	K lb/A	N	P_2O_5	K_2O
						-------lb/A----------		
Marshall Co.								
Howard	1	C	8.1	29	600+	18	46	0
	2	C	8.1	16	580	18	46	0
Yutrzenka	3	CL	8.0	44	237	12	39	0
	4	CL	7.8	36	481	12	39	0
	5	CL	7.5	40	279	12	39	0
Pennington Co.								
Christianson	6	CL	7.6	23*	144	10	26	26
	7	SL	7.1	20*	98	10	26	26
Mehrkens	8	CL	6.6	36	201	15	30	30
Naplin	9	L	8.2	28*	122	11	22	22

*1:10 soil to solution ratio

Table 2. Wheat grain yields and protein percentage for 9 sites in northwestern Minnesota. 1981.

Marshall County	Site Number	Grain Yield bu/A Starter	No Starter	Signif.	Protein % Average
Howard	1	68.8	64.8	ns	11.3
	2	56.5	56.5	ns	12.5
Yutzrenka	3	61.6	60.5	ns	12.1
	4	45.5	44.3	ns	15.5
	5	52.6	55.8	ns	12.6
Pennington County					
Christianson	6	55.1	44.5	**	12.0
	7	52.8	45.6	ns	12.0
Mehrkens	8	60.1	63.2	ns	13.2
Naplin	9	62.2	51.3	**	11.9

COPPER AND MANGANESE FERTILIZATION OF WHEAT ON AN ORGANIC SOIL

Roseau County - 1981*

W. E. Jokela and M. O'Leary

Attempts to raise wheat on organic soils in the Roseau County area in recent years have been largely unsuccessful. In addition to limitations due to the short growing season there have been production problems that appear to be caused by nutrient deficiencies. Some fields were diagnosed as showing copper deficiency, but applications of copper on wheat in the following year did not correct the problem.

Method of application was suspected as a factor in effectiveness of copper fertilization. Also, in 1980 a response to manganese was observed in a Roseau County study. This trial was conducted to further examine these possible factors.

Experimental Procedures

This experiment was conducted on two sites on organic soils in Roseau County, consisting of 1½ to 2 feet of peat over clay mineral soil. At the Welin location copper had been applied to the field about five years earlier, whereas at the Habstritt site none had been applied. This difference is reflected in the copper soil analysis in Table 1.

Treatments consisted of rates of copper sulfate applied broadcast as dry crystals or in solution, incorportated with two passes of a double disk drill, with or without drill applied granular manganese. All treatments except the absolute check received 40-40-120 (N-P_2O_5-K_2O) broadcast. Fertilizer was applied and Era wheat planted on May 13. Forage samples were taken at heading on July 21. Experimental design was randomized complete block with four replications.

Results and Discussion

Grain yields and forage yields, uptake, and analyses for the two sites are shown in Table 2 through 5. At the Welin site yields were low and there were no differences in grain yield or forage yield or nutrient uptake. The only significant effect on forage elemental analysis was a depression of %Mg with NPK application. The poor production appears to be due to non-fertility factors.

At the Habstritt site dramatic copper deficiencies were observed. On July 21 when forage samples were collected most plants in the treatments without copper were dead. The treatment with dry copper showed large variation in growth between plants and many dead plants. These treatments with copper in solution looked somewhat better, but still quite poor. No dry matter yield could be obtained from the no copper treatments. Yields from other selected treatment (3 replications only) were highly variable, but do show a statistical difference at the 10% level. Little or no grain was produced by any treatments.

Table 1. Soil analysis, 0 to 6 inches. Organic soil. Roseau County. 1981. (U of M Soil Testing Lab).

Site	pH	P	K	S	Zn[1]	Cu[1]	Mn[1]
	---------lb/A---------			----------ppm----------			
Welin	7.4	41	226	40+	5.6	4.5	56.1
Habstritt	7.2	94	250	40+	12.0	1.6	73.0

[1]Zn, Cu, and Mn by DTPA extraction.

Table 2. Effect of copper and manganese treatments on grain yield and forage dry matter and nutrient uptake of wheat. Roseau County (Welin). 1981.

Treatment lb/A		Grain Yield	Forage (at heading) Dry Matter	Uptake lb/A				
Cu[1]	Mn[2]	Bu/A	lb/A	P	K	Zn	Cu	Mn
0 (no NPK)	0	24.2	1616	6.51	67.6	.04	.005	.15
0	0	23.8	1824	7.88	83.3	.05	.006	.18
12 sol	0	22.5	1953	7.67	86.0	.05	.007	.17
0	13	21.1	1799	7.32	82.5	.04	.006	.15
6 sol	13	23.0	1706	7.03	77.0	.05	.006	.17
12 sol	13	24.9	1961	7.98	89.6	.05	.007	.18
12 dry	13	25.4	2182	8.96	95.4	.05	.007	.22
Significance		ns	ns	ns	ns	ns	ns	ns
BLSD		-	-	-	-	-	-	-
C.V.		14.2	18.8	18.1	19.2	16.2	25.5	23.2

[1]Cu applied broadcast as $CuSO_4$ in solution (sol) or as $CuSO_4$ crystals (dry).
[2]Mn applied in granular form with drill.

Table 3. Effect of copper and manganese treatments on elemental analysis of wheat forage at heading. Roseau Co. (Welin). 1981.

Treatment lb/A		Elemental Analysis of Forage (at heading)										
		%				ppm						
Cu[1]	Mn[2]	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
0 (no NPK)	0	.41	4.22	.54	.43	27	75	113	90	28	3.3	5.4
0	0	.43	4.54	.48	.37	28	78	81	96	26	3.2	5.2
12 sol	0	.40	4.46	.46	.36	24	70	74	86	24	3.5	5.0
0	13	.41	4.61	.48	.38	26	74	116	84	24	3.2	5.5
6 sol	13	.41	4.53	.47	.37	22	71	98	95	27	3.5	4.7
12 sol	13	.41	4.63	.49	.38	28	76	76	93	25	3.5	6.4
12 dry	13	.41	4.40	.49	.36	28	72	78	96	24	3.2	7.0
Significance		ns	ns	ns	**	ns	ns	ns	ns	ns	ns	ns
BLSD		-	-	-	.03	-	-	-	-	-	-	-
C.V.		6.1	7.3	7.7	5.6	22.6	9.5	29.5	10.1	10.7	17.8	29.2

[1]Cu applied broadcast as $CuSO_4$ in solution (sol) or as $CuSO_4$ crystals (dry).
[2]Mn applied in granular form with the drill.

Table 4. Effect of copper and manganese treatments on forage dry matter and nutrient uptake of of wheat. Roseau Co. (Habstritt). 1981.

Treatment lb/A		Forage (at heading)					
			Uptake lb/A				
Cu[1]	Mn[2]	Dry Matter lb/A	P	K	Mn	Zn	Cu
12 sol	0	2416	10.35	92.0	1.54	.06	.004
6 sol	13	1682	7.82	65.4	.96	.05	.002
12 sol	13	1737	7.90	69.2	1.07	.05	.003
12 dry	13	1066	6.47	44.6	.53	.04	.002
Significance		+	ns	+	ns	ns	+
BLSD		861	-	31.0	-	-	.001
C.V.		27.6	31.0	25.3	50.5	26.8	26.8

[1]Cu applied broadcast as $CuSO_4$ in solution (sol) or as $CuSO_4$ crystals (dry).
[2]Mn applied in granular form with the drill.

Table 5. Effect of copper and manganese treatments on elemental analysis of wheat forage at heading. Roseau Co. (Habstritt). 1981.

Treatment lb/A		Elemental Analysis of Forage (at heading)										
		%				ppm						
Cu[1]	Mn[2]	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
0	0	.81	2.69	.87	.48	153	204	60	576	41	1.2	14.0
12 sol	0	.43	3.89	.49	.40	35	89	49	606	27	1.8	9.8
6 sol	13	.47	3.90	.50	.43	40	88	62	574	28	1.5	8.0
12 sol	13	.46	3.98	.51	.40	47	92	58	605	27	1.8	10.1
12 dry	13	.61	4.15	.57	.44	59	110	51	495	36	2.0	9.2
Statistics, excluding check (no Cu)[3]												
Significance		+	ns	ns	ns	*	+	ns	ns	*	ns	ns
BLSD (.05)		.14	-	-	-	14	18	-	-	8	-	-
C.V.		13.8	8.7	7.5	6.6	14.6	9.0	28.3	22.2	12.3	24.9	33.5

[1]Cu applied broadcast as $CuSO_4$ in solution (sol) or as $CuSO_4$ crystals (dry).
[2]Mn applied in granular form with the drill.
[3]No Cu treatment excluded from statistical analysis because plants were dead at time of sampling.

*This project was supported in part by funds from the Minnesota Wheat Council.

POTASSIUM ON WHEAT - PENNINGTON COUNTY, 1981*

William Jokela and Micheal O'Leary

This trial was established in 1980 to determine the effect of broadcast applications of potassium on wheat yield, potassium uptake, and soil test level on a soil testing medium in potassium.

Experimental Procedures

The experimental site is located on a Borup loam soil on the Evert Flesche farm in Pennington County. Six rates of potassium were broadcast and incorporated with secondary tillage in 1980 and again in the spring of 1981. Plot design was randomized complete block with four applications. In 1981 Solar variety of wheat was planted on April 25. No starter was used. Initial soil tests (Spring, 1980) for the 0 to 6 inch depth were pH - 7.8, P (Bray 1, 1:50) - 28 lb/A, and K - 158 lb/A.

Results and Discussion

The effect of potash rate on grain yield, on forage yield, % K, and K uptake, and on soil test K are shown in Table 1. Grain yield averaged about 6 bu/acre more on plots receiving K, but the difference was not statistically significant. Forage yield did not change, but % K, and consequently K uptake, increased with increasing K rate. Exchangeable K in the surface layer of soil after two years of fertilization increased with K rate, but the difference was significant only at the highest rate.

Table 1. Effect of potassium rate on grain yield, on forage yield, % K, and K uptake, and on exchangeable soil K. Pennington County (E. Flesche) 1981.

		Forage (soft dough)			Exchangeable Soil K
K_2O Rate (lb/A)	Grain Yield bu/A	Dry Matter lb/A	K %	K Uptake lb/A	Fall, 1981 lb/A, 0-6 in.
0	48.0	6501	1.10	72.0	186
40	54.6	6710	1.36	91.0	189
80	53.4	6917	1.46	101.5	189
120	54.0	7188	1.63	118.7	204
160	53.7	6833	1.54	105.2	203
320	54.8	6665	1.67	111.1	252
Significance	ns	ns	**	**	**
BLSD (.05)	-	-	0.16	24.5	29
C.V. (%)	8.3	10.2	7.8	15.5	9.4

*This project was supported in part by funds from the Minnesota Wheat Council.

Nitrogen Fertilization of Wheat and Barley

Under Irrigated and Dryland Conditions.

J. Wright, T. King, W. Jokela

Small grain plots were set out in Spring 1981 at the Westport research farm in Pope County. Four varieties of wheat were grown at four nitrogen rates under sprinkler irrigation. Era wheat and Morex barley were grown at four nitrogen rates without irrigation. Ammonium nitrate was applied at rates of 40, 80 and 120 pounds of nitrogen per acre on Estherville sandy loam. Yields were reduced by quackgrass competition. Rainfall for the growing season was 9.5 inches with 5.7 inches added through irrigation. The previous crop was soybeans.

The irrigated wheat experiment was designed to evaluate variety performance at four nitrogen fertility levels. A split plot design replicated four times with varieties as main plots and nitrogen rate as sub-plots was used. Nitrogen rates up to 120 lbs/A increased yields significantly for irrigated wheat. Test weight decreased with increased nitrogen rates. There was no significant yield difference between varieties under irrigation although test weight did show a difference.

On the dryland plots Era wheat responded to nitrogen at 40 lbs/A with no significant increase at higher rates. Test weight decreased with increased nitrogen rates. Yield for Morex barley was highest at 120 lbs N/A. Test weight and percent plump Kernels decreased with increased nitrogen rates. Percent protein increased with higher nitrogen applications.

Table 1. Comparison of four nitrogen rates and wheat variety performance under irrigation.

N-Rate	Yield bu/A	Test wt lbs/bu	Variety	Yield bu/A	Test wt lbs/bu
0#N/A	9.4	54.8	Era	25.7	54.4
40"	24.1	55.4	Len	23.5	53.6
80"	27.1	53.4	Olaf	21.8	52.0
120"	36.3	52.7	Mn70170	25.9	56.4
Significance	**	**		NS	**
BLSD (.05)	4.4	1.4		—	1.4
C.V.	28.2	3.6		28.2	3.6

Table 2. Era wheat and Morex barley at four nitrogen rates without irrigation.

	Era Wheat		Morex Barley			
Treatment	Yield	Test wt	Yield	Test wt	Protein	Plumpness
N-Rate	bu/A	lbs/bu	bu/A	lbs/bu	%	%
0#N/A	15.0	57.0	23.1	45.7	8.8	68
40"	28.2	57.3	37.1	46.1	9.1	68
80"	31.0	55.3	49.5	45.7	12.0	59
120"	30.9	55.0	53.2	44.4	13.5	48
Significance	**	*	**	+	**	**
BLSD (.05)	7.7	1.6	3.2	1.2	1.7	10
C.V.	14.5	1.4	4.1	1.5	7.9	8.1

WILD RICE FERTILIZATION RESEARCH - 1981

A PROGRESS REPORT
December 29, 1981

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Research was continued during 1981 on fertilization and nutrient requirement of wild rice. Soil, water and air temperatures, and quality of paddy water were monitored during the growing season at several locations to obtain information on the environment in which wild rice grows. A nitrogen experiment was conducted with the Netum variety on a mineral soil at Grand Rapids. A fertilization trial with the K2 variety was conducted on peat in Aitkin County. Tissue samples were collected for plant analysis to learn more about nutrient uptake by the plant.

A. WEATHER CONDITIONS AND PLANT DEVELOPMENT

Average temperatures recorded at four U.S. weather stations were slightly above normal in April and remained near normal during the main part of the growing season (Table 1).

Soil, water and air temperatures were measured at four locations by automatic sensing and recording thermographs (see Fig. 1, 2, 3, 4). Soil and water temperatures were not recorded at Gully because of an instrument malfunction.

Plants emerged on May 4 at Grand Rapids (Fig. 5). The jointing stage was reached by Netum on June 21, 48 days after plant emergence. Wild rice was harvested on August 12, 100 days after emergence. Accumulated Growing Degree Days (GDD) at each stage of plant development was calculated with a base temperature of 40°F. Accumulated GDD's for the 1981 season were 2,247, while total solar radiation for the season at Grand Rapids reached 36,745 langleys or calories per square centimeter.

B. CHEMICAL CHARACTERISTICS OF PADDY WATER

Water samples were collected at three different paddy locations during the 1981 growing season. At Grand Rapids, samples were collected from an experimental paddy used for nitrogen studies on mineral soil, and from the Prairie River which was the source of water. Water was also sampled within a production paddy in Aitkin County. Paddies at this site derived water from the Little Willow River via a diversion ditch. The third sampling site was in the Imle and Gunvalson paddies near Gully. This paddy derived water from the Clearwater River.

Water samples were collected and stored in 250 ml polyethylene bottles, with a preservative added (2 ml mercuric chloride solution, prepared by dissolving 40 mg $HgCl_2$/L, to 250 ml of sample). Chemical analyses were made by the Research Analytical Laboratory, University of Minnesota. Information on location, sampling dates, and chemical composition data of water is given in Table 2.

The <u>hardness</u> of water is a measurement of calcium and magnesium, expressed as $CaCO_3$, mg/liter. The water from the Clearwater River was very hard (348-389 mg/L). The water from the Prairie River and the Little Willow River was moderately hard, with values near 80 mg/L. At Gully and Grand Rapids, the levels of hardness, calcium and magnesium of paddy water were nearly the same as those found in the river water. In Aitkin County on peat, however, the paddy water showed 25 to 37% lower calcium and 28 to 58% lower magnesium content than the river water, and a 3-fold decrease in the hardness. Consequently, the water within the Kosbau paddy in Aitkin County was relatively soft, having values of 26 to 36 mg/liter.

At Grand Rapids, concentrations of total P, and K in paddy and river water were nearly the same. The paddy water, however, had slightly higher total N concentration than found in the river water.

At Gully, no difference was detected in the total P concentration of river and paddy water. The paddy water, however, had slightly higher concentration of total N, and K than river water. Nitrogen and potassium concentrations in samples of July 2 sampling appeared to be inconsistent.

Table 1. Average air temperature as measured at four U.S. weather stations.[1/]

Station Year	Month April	May	June	July	August	5 Month Average	GDD T_b=40
	----------average air temperature, °F----------						
Fosston, Polk Co.							
Normal[2/]	41.0	54.6	63.6	69.4	67.5	59.2	2955
1974	41.0	50.5	63.4	71.6	62.8	57.9	2744
1975	34.8	55.7	61.9	70.5	64.6	57.5	2852
1976	46.6	54.9	66.8	68.8	70.9	61.6	3315
1977	49.1	66.4	64.6	70.3	60.6	62.2	3446
1978	41.7	59.2	63.4	67.8	67.7	60.0	3060
1979	36.0	48.7	63.6	69.6	63.6	56.3	2627
1980	48.9	61.3M[3/]	68.5	71.0	64.6	62.9	3466
1981	44.4	55.3	60.8	68.1	65.7	58.8	2898
Grand Rapids, N.C. School							
Normal	39.9	52.7	62.0	67.4	65.1	57.4	2681
1974	41.6	49.4	62.7	70.7	62.8	57.4	2670
1975	34.7	57.0	62.2	71.5	65.2	58.1	2951
1976	47.1	54.4	66.1	68.2	67.4	60.6	3166
1977	48.2	63.8	64.0	69.2	60.2	61.1	3284
1978	41.3	57.9	62.8	66.5	66.0	58.9	2892
1979	37.1	49.5	61.5	68.1	62.6	55.8	2511
1980	46.1	59.9	64.0	69.0	66.4	61.1	3237
1981	43.9	54.8	62.0	68.0	67.0	59.1	2941
Aitkin							
1974	42.9	49.8	63.1	71.1	63.3	58.0	2770
1975	39.0M	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	50.6	62.0	68.1M	63.4	56.4	2585
1980	53.9	58.3	64.0	68.5	66.0	62.1	3394
1981	45.1M	53.8	62.1M	67.5	66.0	58.9	2902
Chaska, Carver Co.							
Normal[4/]	45.9	58.1	67.8	72.4	70.7	62.9	3528
1981	51.3	57.9	67.8	73.5	70.6	64.2	3715

1/ Source: Climatological Data, Minnesota, Vol. 80-87 (1974-81), U.S. Dept. of Commerce.
2/ Normals for the period 1931-1960.
3/ M = less than 10 days record missing.
4/ Normals for the period 1941-1970.

Table 2. Chemical composition of water collected from wild rice paddies during the 1981 growing season.

Sample No.	Sampling Date	Location	Conductivity milli-mhos/cm	Alkalinity as $CaCO_3$ mg/L	Hardness $CaCO_3$ mg/L	Total Kjeldahl N ppm	Nitrate & nitrite N ppm	Total P ppm	Soluble P ppm	Sulfate S ppm	Ca ppm	Mg ppm	K ppm	Na ppm
Location: Grand Rapids														
14-2	4/22	EP-W	0.19	60.0	83.0	0.7	0.08	0.01	0.01	1.2	22.2	6.4	2.5	3.1
14-1	4/22	PR	0.20	65.0	86.0	0.3	0.16	0.02	0.02	1.3	23.6	6.5	3.0	3.2
23-2	5/26	EP-W	-	52.0	64.3	0.6	<0.05	0.07	0.01	1.7	18.1	4.2	0.9	1.8
23-1	5/26	PR	-	55.5	74.7	0.5	<0.05	0.07	0.01	2.4	20.1	5.8	1.7	2.8
25-3	6/9	EP-W	0.16	64.0	75.2	1.3	<0.05	0.10	0.02	2.2	19.9	5.6	1.1	2.6
25-4	6/9	PR	0.13	70.5	79.2	0.4	<0.05	0.07	0.01	2.6	21.7	5.9	1.4	2.7
28-3	6/23	EP-W	0.16	69.5	80.7	0.4	<0.05	0.15	0.01	2.1	21.3	6.1	1.1	2.9
28-4	6/23	PR	0.20	68.5	82.0	1.3	<0.05	0.14	0.02	2.4	22.4	6.2	1.5	3.0
43-6	7/7	EP-W	0.18	-	-	2.9	-	0.09	-	-	21.6	5.9	2.0	4.1
43-5	7/7	PR	0.16	-	-	3.3	-	0.08	-	-	22.1	6.0	1.2	3.0
43-7	7/23	EP-W	0.22	-	-	2.0	-	0.13	-	-	23.3	6.6	1.9	3.2
43-8	7/23	PR	0.18	-	-	0.7	-	0.08	-	-	23.4	6.6	1.5	3.4
43-10	7/31	EP-W	0.16	-	-	2.0	-	0.07	-	-	21.6	5.9	1.0	2.7
43-9	7/31	PR	0.16	-	-	0.6	-	0.07	-	-	22.2	6.2	1.0	3.1
Abbreviations and descriptions of sampling sites at Grand Rapids: EP-W = Experimental Paddy #1 West; PR = Prairie River														
Location: Kosbau Bros., Aitkin Co.														
14-6	4/23	PP	0.11	25.0	26.0	2.1	<0.05	0.74	0.54	2.2	5.7	2.2	8.9	4.5
14-5	4/23	DD	0.22	80.0	91.0	0.7	0.05	0.02	0.02	1.6	22.9	7.8	1.4	4.3
23-4	5/26	PP	-	20.5	36.5	2.3	<0.05	1.08	0.71	3.1	8.4	3.5	7.4	4.9
23-3	5/26	DD	-	67.0	83.3	1.3	<0.05	0.07	0.01	1.7	22.8	6.0	0.7	2.9
25-1	6/9	PP	0.12	15.5	36.4	2.5	<0.05	1.47	1.24	3.4	8.2	3.5	6.2	4.8
25-2	6/9	DD	0.18	79.5	89.4	1.1	<0.05	0.16	0.04	2.7	22.7	7.5	0.7	4.2
28-2	6/23	PP	<0.10	9.0	28.8	1.9	<0.05	1.59	1.19	3.4	6.4	2.8	4.5	3.5
28-1	6/23	DD	0.16	63.0	84.1	1.0	<0.05	0.09	0.02	3.1	21.4	6.8	0.5	3.1
43-3	7/7	PP	0.10	-	-	9.2	-	1.86	-	-	8.9	4.3	4.5	4.2
43-4	7/7	DD	0.20	-	-	1.2	-	0.15	-	-	26.8	8.2	<0.5	3.9
Abbreviations and descriptions of sampling sites at Kosbau Bros.: PP = Production Paddy; DD = Diversion Ditch at bridge near the Little Willow River														
Location: Imle and Gunvalson, Gully														
14-4	4/22	PP	0.72	170.0	352.0	1.6	<0.05	0.07	0.04	48.8	88.1	31.9	9.2	8.4
14-3	4/22	CR	0.75	300.0	389.0	1.0	<0.05	0.06	0.04	36.3	96.7	35.7	6.7	9.3
28-8	5/14	PP	0.90	269.0	474.0	1.8	<0.05	0.14	0.05	64.0	121.0	41.5	11.5	11.9
28-7	5/14	CR	0.75	262.0	348.0	1.2	<0.05	0.15	0.05	26.6	86.0	32.0	4.6	9.0
43-1	7/2	PP	0.55	-	-	16.7	-	0.11	-	-	71.1	30.0	0.8	7.5
43-2	7/2	CR	0.50	-	-	3.4	-	0.13	-	-	66.3	25.8	2.4	6.2
Abbreviations and descriptions of sampling sites at Gully: PP = Production Paddy; CR = Clearwater River														

Fig. 1

MEAN AIR, WATER AND SOIL TEMPERATURES
GRAND RAPIDS - 1981

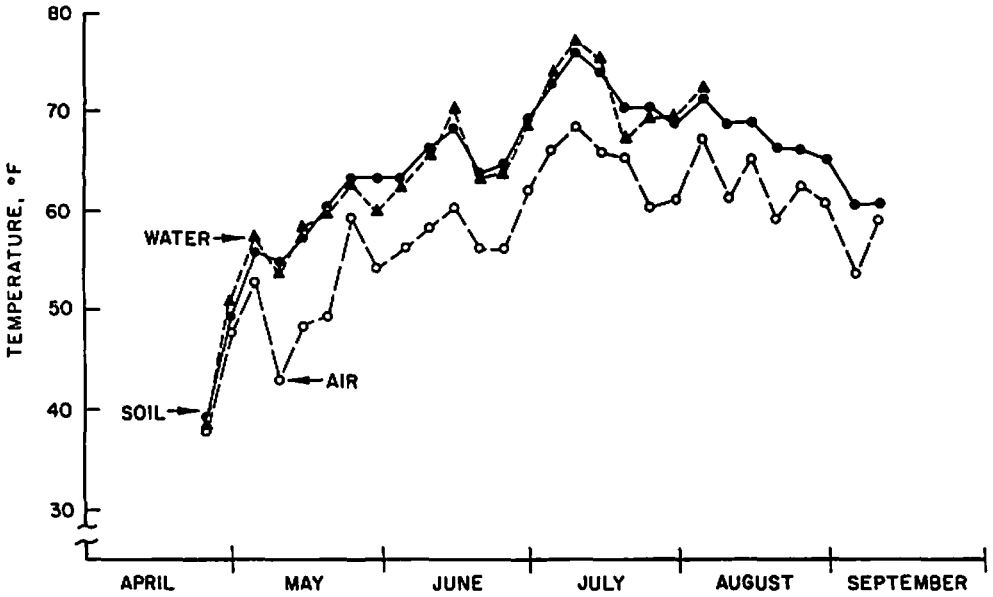

Fig. 2

MEAN AIR, WATER AND SOIL TEMPERATURES
KOSBAU BROS., AITKIN COUNTY - 1981

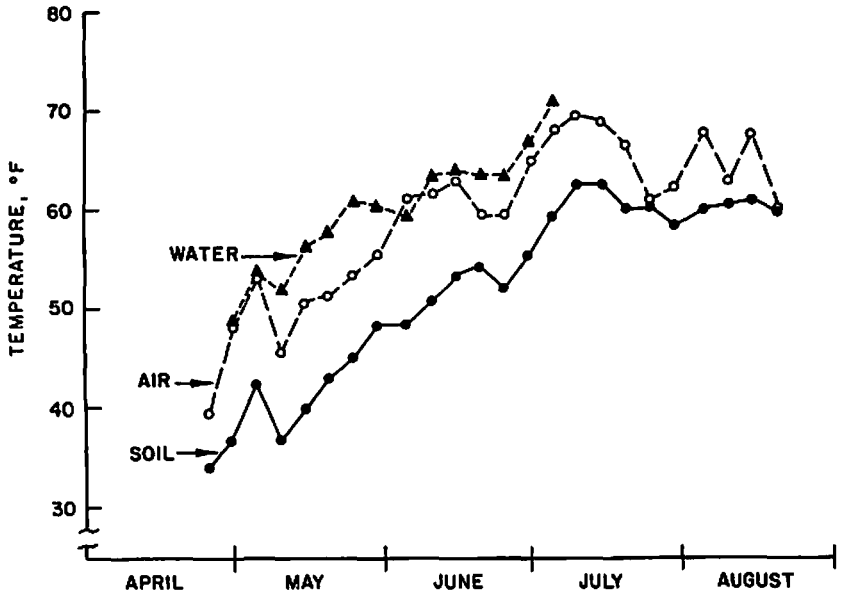

Fig. 3

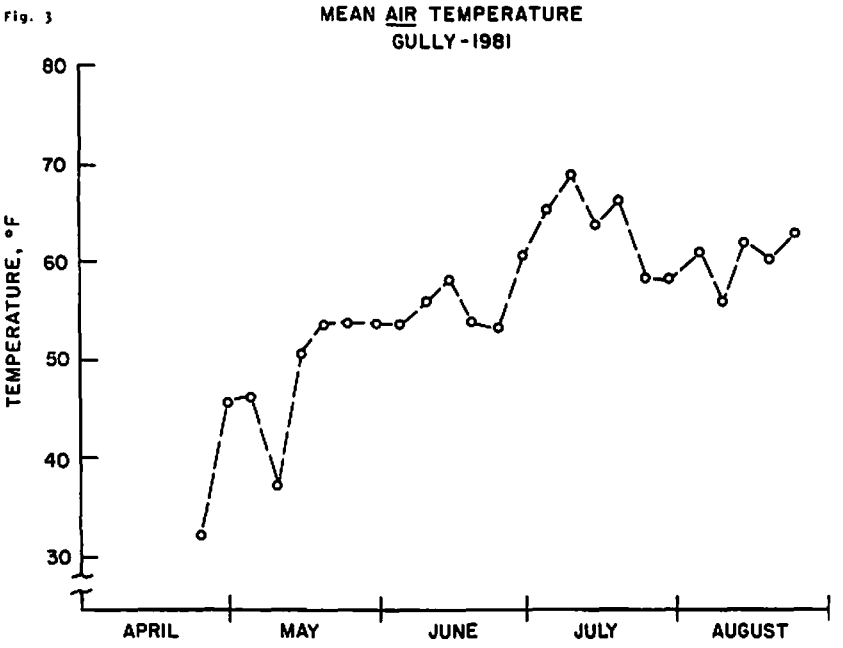
MEAN AIR TEMPERATURE
GULLY-1981
TEMPERATURE, °F
80
70
60
50
40
30
APRIL
MAY
JUNE
JULY
AUGUST

Fig. 4

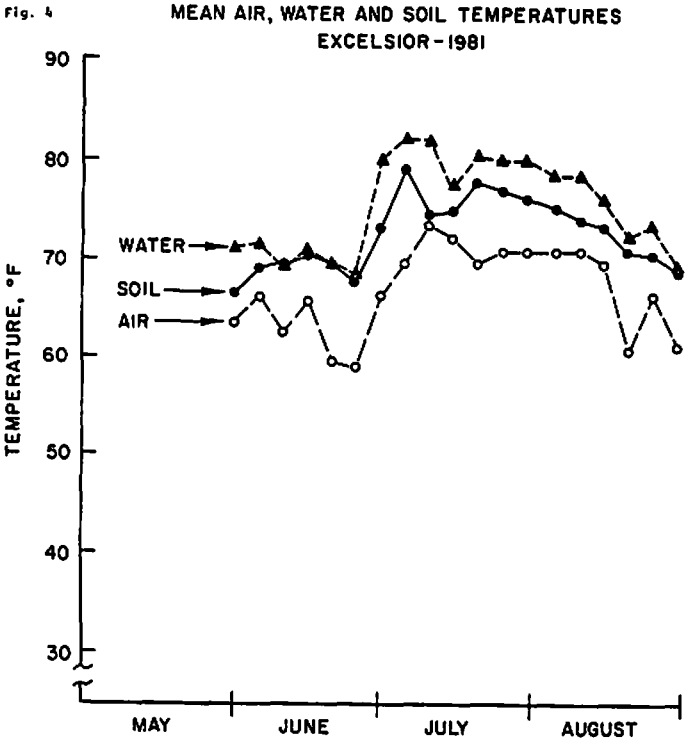
MEAN AIR, WATER AND SOIL TEMPERATURES
EXCELSIOR-1981
TEMPERATURE, °F
90
80
70
60
50
40
30
WATER
SOIL
AIR
MAY
JUNE
JULY
AUGUST

Fig. 5 WILD RICE DEVELOPMENT
NETUM VARIETY, 2ND YEAR STAND
GRAND RAPIDS, 1981

	STAGES OF DEVELOPMENT	DAYS	DATE	1/ GDD	2/ SOLAR
VEGETATIVE GROWTH PHASE	EMERGENCE	0	MAY	0	0
	FLOATING LEAF	14		151	6273
	AERIAL LEAF	32	JUNE	495	12442
	TILLERING	44		774	17021
	JOINTING	48		855	18306
	BOOT	52		932	19288
REPRODUCTIVE GROWTH PHASE	HEADING	61	JULY	1152	23097
	MID-FLOWERING	67		1349	26329
	LATE-FLOWERING	73		1533	27903
	MATURITY	100	AUGUST	2247	36745

1/ - ACCUMULATED GROWING DEGREE DAYS, $T_b = 40°F$

2/ - SOLAR RADIATION ACCUMULATED, LANGLEYS PER DAY (CAL.CM^{-2})

The paddy water of the Aitkin County location had considerably higher concentrations of total N, P, and K than found in the river water. This was consistent with the results of nutrient concentrations obtained at this location during previous growing seasons.

The sulfate concentration of water is reported in terms of parts per million of sulfate- sulfur, expressed as S. To convert results to the sulfate (SO_4) form, they must be multiplied by 3. For example, 1.2 ppm sulfate-S x 3 = 3.6 ppm sulfate (SO_4) in the water.

The water at Grand Rapids and in Aitkin County, generally, contained less than 10 ppm of sulfate. The sulfate concentration of the water at Gully, however, was relatively high (80 to 192 ppm SO_4).

C. NITROGEN STUDIES ON MINERAL SOIL

The nitrogen rate and time of application trial, initiated in fall of 1979, was continued with 2nd year stand of Netum in paddy No. 1 West at the North Central Experiment Station, Grand Rapids. Soil tests (Table 3) indicated very high levels of extractable phosphorus (59 pp2m) and exchangeable potassium (303 pp2m). It should be noted that the experimental area had not received any phosphate or potash fertilizer since the establishment of the paddy in 1974. It has been a common practice, however, to incorporate wild rice stubble into the soil.

Nitrogen treatments consisted of four rates (0, 20, 40, 80 lb N/acre) applied in single (fall) or split-applications (½ fall + ½ jointing, or ½ fall + ½ early flowering). Urea (46-0-0) was the source of nitrogen. Fall-application of urea was made on November 6, 1980 and the fertilizer was incorporated into the soil by rototilling. Additional N was topdressed by hand at jointing or early flowering. A randomized block design was used in this experiment. Each treatment was replicated four times. Individual plots occupied a 14 x 16 ft. area and were separated from adjoining plots by 5 ft. wide alleys. Plant density, at harvest, ranged from 1 to 3 plants per square foot. Water level was maintained at about 6 to 10 inches. Five plants were collected at random from each plot at late flowering for weight measurement and plant analysis. The jointing stage was reached on June 21 (Fig. 5). A 32 sq. ft. area from each plot was hand-harvested on August 12 for yield determination.

Individual plants at late flowering had accumulated 4 to 6 grams of dry matter and 63 to 86 milligrams of nitrogen (Table 4).

Netum grain yields (7% moisture) ranged from 280 to 538 pounds per acre (Table 5). The yield, however, was increased above the check only by two N treatments, namely, 40 lb/A (fall) and 80 lb/A (½ fall + ½ early flowering).

Table 3. Soil test values of experimental paddy No. 1 West, Grand Rapids.[1)]

pH	Extractable P pp2m	Exchangeable K pp2m	Nitrate-N lb/A
6.2[2)]	59	303	12

1) Samples collected from 0-6 inch depth on 11/6/80.

2) Average of four composite samples.

Table 4. Effect of nitrogen application on total uptake of N by Netum wild rice, 2nd year stand, Grand Rapids, 1981.

Treatment No.	N Rate lb/acre	Time of Application			N Uptake[1] mg/plant
		Fall	Jointing	Early Flowering	
		---------N lb/acre---------			
1	0	-	-	-	71
2	20	20	-	-	63
3	40	40	-	-	86
4	40	20	20	-	85
5	40	20	-	20	65
6	80	80	-	-	85
7	80	40	40	-	77
8	80	40	-	40	73
Significance					ns
C.V. (%)					39

1) Average of four replications.

Table 5. Effect of nitrogen application on the yield of Netum wild rice, 2nd year stand, Grand Rapids, 1981.

Treatment No.	N Rate lb/acre	Time of Application			Grain Yield[1] lb/acre
		Fall	Jointing	Early Flowering	
		---------N lb/acre---------			
1	0	-	-	-	311
2	20	20	-	-	280
3	40	40	-	-	538
4	40	20	20	-	335
5	40	20	-	20	401
6	80	80	-	-	476
7	80	40	40	-	380
8	80	40	-	40	502
Significance					+
BLSD (0.1)					171
C.V. (%)					29

1) At 7% moisture, average of four replications.

\+ Denotes significance at the 10% level.

D. FERTILIZATION STUDIES ON PEAT

A fertilizer experiment was conducted with the K2 variety of wild rice on organic soil in a Kosbau Bros. paddy in Aitkin County. Relatively high extractable phosphorus (25 pp2m), and medium exchangeable potassium (145 pp2m) levels were indicated by soil tests. The soil pH was 5.3. This was an incomplete factorial experiment with six NPK treatments, replicated six times, and arranged in randomized blocks. Individual plots occupied a 14 x 16 ft. area. Fertilizer materials (46-0-0, 0-46-0, 60-0-0) were applied by hand on October 8, 1980 and incorporated into the soil by disking.

Plants emerged on May 1 and reached the jointing stage on June 30. The paddy was drained on July 1.

The wild rice stand was extremely thin and spotty and the plants were short with only one or two tillers. The experimental area suffered from a heavy infestation by waterplantain which appeared to be related to a relatively shallow water level. On June 11, MCPA (¼ lb/acre a.i.) was applied with a 10-foot boom. A 0.1 inch localized thundershower, several hours after application, may have removed much of the applied herbicide. Herbicide application did not effectively control waterplantain in the experimental area.

Because of extremely poor stand and growth of wild rice, only one row of plots on the east side of the experiment (where the growth was best) was harvested on August 17 for yield determination. The grain yield (7% moisture) ranged from 96 to 164 pounds per acre. Average plant density, at harvest, was 2.5 plants per square foot. It should be noted that wild rice produced 392 to 555 lb/acre of grain in other areas within the same paddy with deeper water and little or no waterplantain.

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