SOIL SERIES 113

A REPORT ON FIELD RESEARCH IN SOIL SCIENCE

The 1983 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.

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

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 1982 experiments only and should be regarded on this basis. Since most data are from only 1982 studies, conclusions are not conclusive and are thus not for further publication without the written consent of the individual researchers involved.

Table of Contents

Lamberton Experiments

Morris Experiments

Staples Experiments

Waseca Experiments

Soil Classification

Soil Erosion

Soil Testing

Tillage

Alfalfa

Corn

Potatoes

Soybeans

Wild Rice

MINNESOTA SOIL MOISTURE - FALL 1982 AND SPRING 1983 OUTLOOK

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

Soil moisture measurements were obtained from 41 sites across the state in late autumn. The sampling was done on medium to fine textured soils to a 5-foot depth and the amount of plant-available water within the soil column was determined. These measurements were regressed against the spring 1982 soil moisture and the May-August precipitation (Figure 1) to estimate the September 1 soil moisture (map shown in figure 2). This data was then used with the September-October precipitation (figure 3) (using a relationship developed from data collected at 24 of the projects sites) to estimate the November 1 soil moisture (figure 4). These two relationships allow the use of data collected at a very limited number of soil moisture data collection sites to be used to estimate soil moisture at locations where only precipitation data is collected. Since there were 833 such stations in the state available for estimation, a very detailed analysis of soil moisture was possible. Details of each of the soil moisture measurement sites are listed in the table.

Results indicate that Minnesota soils entered this winter with the wettest conditions since the expanded soil moisture survey began 5 years ago. Other wet autumns over large parts of the state were 1968 and 1979.

Most of the soils in the state have a plant available-water holding capacity of 10 to 12 inches of soil moisture in the top 5 feet of soil (with the exception of sandy soils and many of the forested soils of the northeast). Thus, soils in the state are at or near their maximum water-holding capacity, except for the western tier of counties which includes most or all of the following counties: Pipestone, Murray, Lincoln, Lyon, Yellow Medicine, Lac Qui Parle, Chippewa, Big Stone, Swift, Traverse, Stevens, Grant, Douglas, Wilkin, Ottertail, Clay, Becker, Norman, Mahnomen, and Roseau. Even here the soil moisture levels are generally much above the average late fall condition.

These high autumn soil moisture levels have serious implications for this spring, since the Federal Crop Reporting Service data show that one-half to two-thirds of the plowing has been left for this coming spring. Thus, a very important field operation will have to be squeezed into the spring period which all too often is very limited due to weather and seeding constraints. Normal to above normal spring precipitation could make fields in many areas nearly impassable. This would be particularly serious in areas of poorly drained soils.

The mild winter experienced to date is a welcome respite following the severe winter of 1981-82. Some interesting climatological statistics are to be found in those springs following the combination of mild Decembers and Januarys. For example, it was found that in 13 of the 16 years, or 81 percent, in which both December and January were above normal, the succeeding spring arrived at the usual time or even a few days early. The "arrival of spring" statistic was measured in terms of when lakes were free of ice, which coincides very closely with the time when soils have thawed completely. Based upon this 81% statistic, it can be stated that in spite of the soil's currently high moisture content there will in all probability be time for the surface to dry sufficiently for necessary row crop tillage and planting operations, except perhaps where fall plowing was not possible. At this time small grain planting delays are more probable.

The 1982 soil water season at Lamberton compared to the 1964-1981 average is illustrated in figure 5. It shows that the content of soil water in 1982 was much above average, and only from late June to early August was there the usual drop in soil moisture, when the corn crop consumed more water than was supplied by precipitation. From early August until the end of the season the soil water reserves increased greatly. Only in the 1962 growing season were the soil moisture reserves as high and only in the fall of 1968 was the water content as high as fall 1982.

Figure 1.

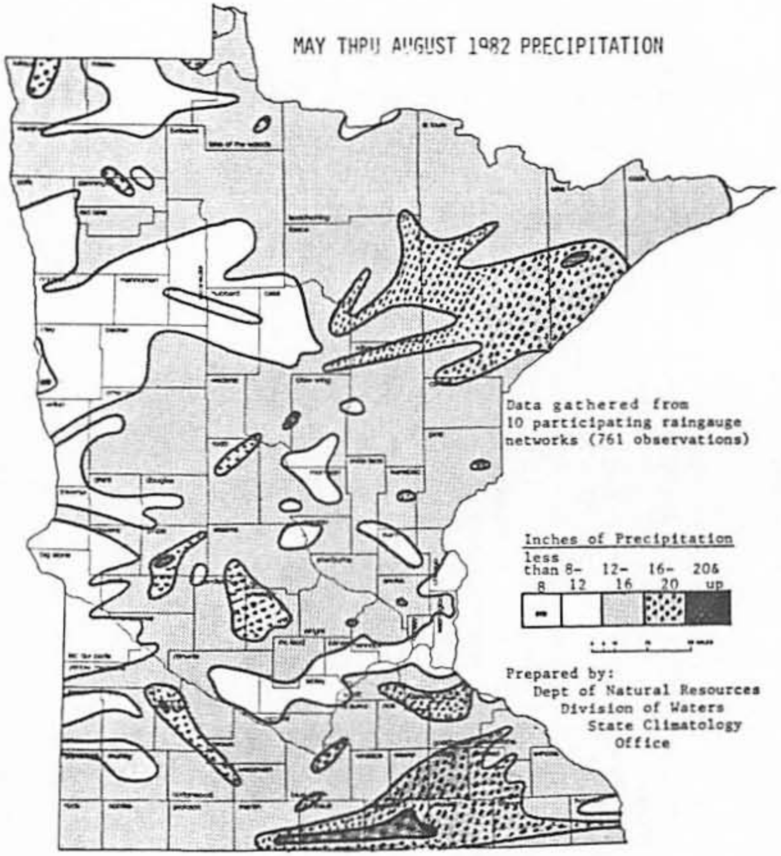


Figure 2.

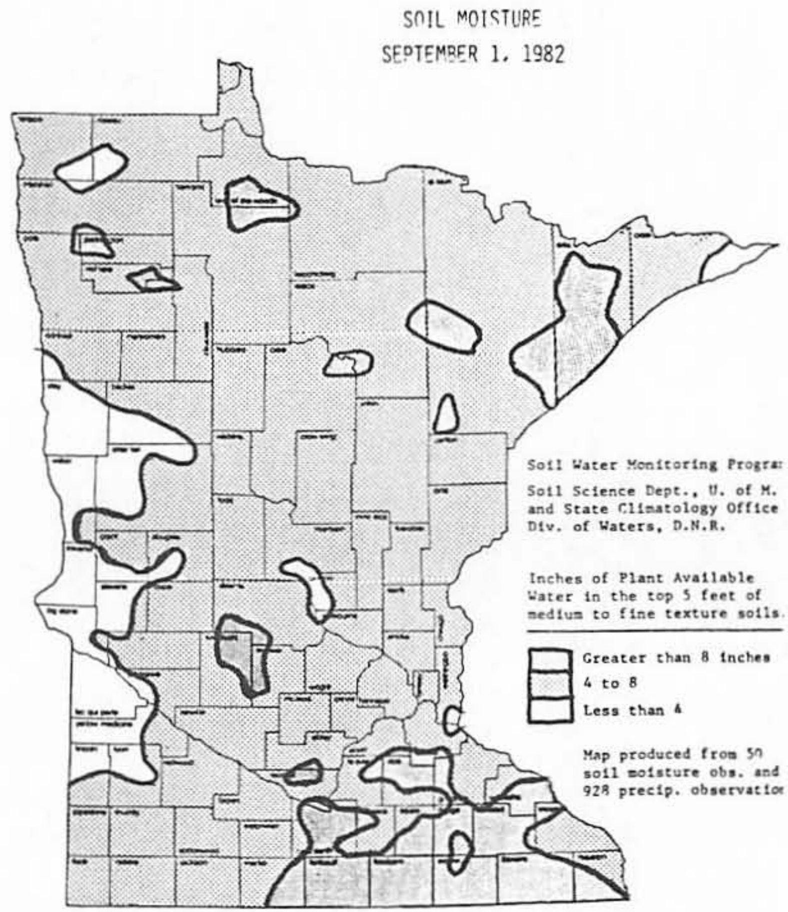
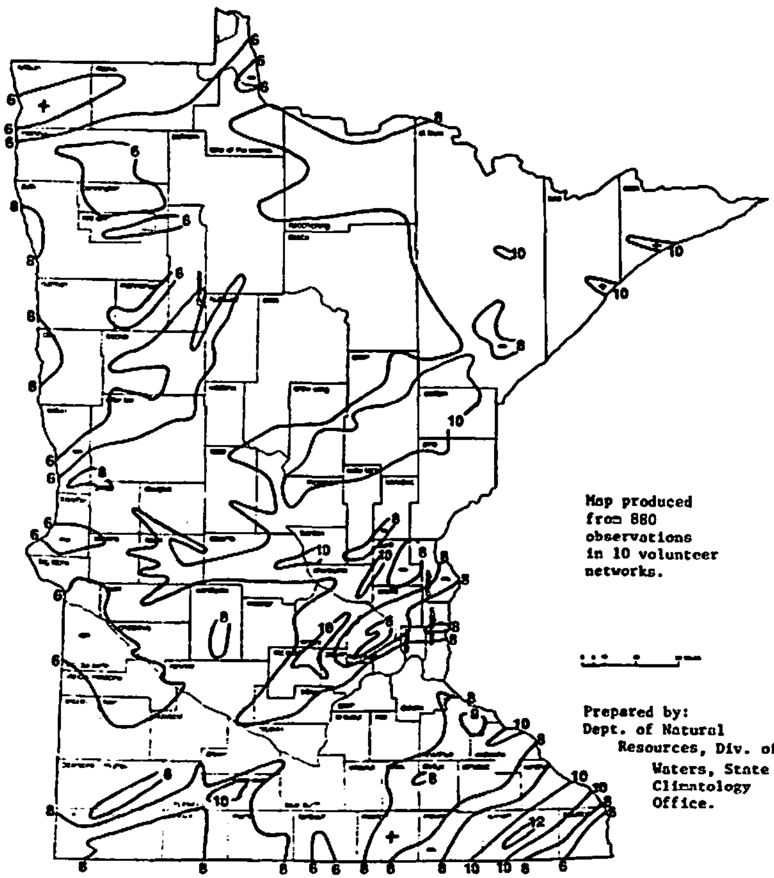


Figure 3.

SEPTEMBER-OCTOBER 1982 PRECIPITATION

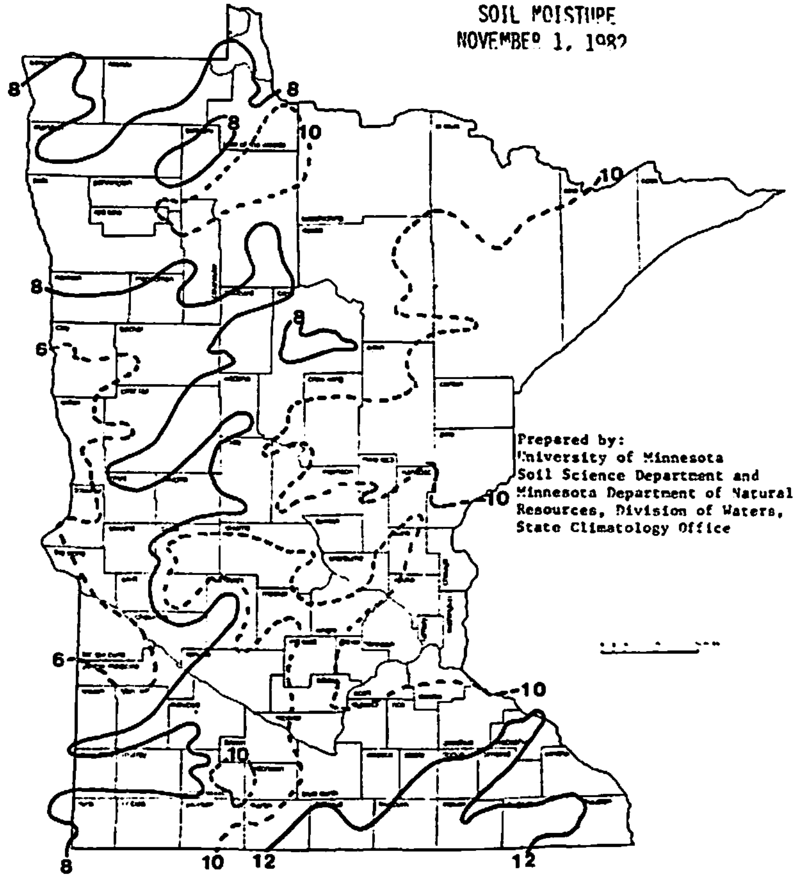


Map produced from 880 observations in 10 volunteer networks.

Prepared by: Dept. of Natural Resources, Div. of Waters, State Climatology Office.

Figure 4.

SOIL MOISTURE NOVEMBER 1, 1982



Prepared by: University of Minnesota Soil Science Department and Minnesota Department of Natural Resources, Division of Waters, State Climatology Office

Plant available soil moisture on November 1, 1982 expressed in inches for the top five feet of medium to fine textured soils. Information is based on actual soil moisture observations. These measurements are correlated to precipitation, resulting in a more detailed analysis of soil moisture.

Fall, 1982 Soil Moisture			September		November		
Cooperator	Address	Crop	Date	Available Water	Date	Available Water	Field Capacity
Viken	Roseau	Wheat	9/02	****	10/27	****	****
Riopelle	Argyle	Wheat	9/01	3.96	10/26	8.84	11.34
Driscoll	E. Grand Forks	Wheat	9/01	2.02	10/26	8.30	13.58
Christenson	Thief River Falls	Wheat	9/01	7.75	10/26	10.43	10.30
Buchholtz	McIntosh	Wheat	9/01	2.74	10/26	7.13	10.30
Brendemuhl	Moorhead	Wheat	9/01	0.91	10/26	7.62	13.34
Lieseth	Moorhead	Barley	8/31	5.13	10/25	11.20	13.58
Sethre	Carlisle	Corn	8/31	4.05	10/25	5.17	12.75
Evenson	Fergus Falls	Wheat	8/31	2.10	10/25	5.40	12.75
Homan	Beardsley	Corn	8/31	4.66	11/03	9.44	13.50
Bimberg	Ortonville	Corn	8/31	0.31	11/03	3.62	12.75
Nesvold	Madison	Corn	8/30	0.04	11/03	6.69	12.75
Pfau	Freeport	Corn	9/07	5.68	10/25	0.09	8.03
Powers	Hugo	Corn	9/07	1.86	10/28	6.60	8.03
Krause	Buffalo	Corn	9/07	2.16	11/02	6.46	13.34
Marklowitz	Litchfield	Corn	8/30	5.42	11/02	7.32	9.34
Rhoda	Raymond	Corn	8/30	7.93	11/02	10.02	12.23
Scheibel	Bird Island	Corn	9/08	8.21	11/02	10.92	13.50
Haubrich	New Ulm	Corn	9/09	3.41	11/05	5.04	14.50
Jeremiason	Minneota	Corn	9/08	2.51	11/03	5.06	12.23
Horton	Pipestone	Corn	9/08	5.69	11/04	9.81	13.99
Keller	Slayton	Soys	9/08	7.33	11/04	11.02	12.23
Turner	Bingham Lake	Corn	9/08	10.09	11/04	12.73	13.02
Ruschy	Sherburn	Corn	9/08	5.30	11/04	8.64	9.34
Van Sickle	Garden City	Corn	9/09	****	11/05	****	****
Seetin	Huntley	Corn	9/09	****	Not Sampled		****
Hassing	Wells	Soys	9/09	5.76	Not Sampled		14.50
Eniffke	Hayward	Soys	9/09	****	Not Sampled		****
Goodsell	Spring Valley	Corn	9/09	9.90	11/09	12.13	10.30
Hoscheit	Caledonia	Corn	8/23	11.39	11/08	14.74	15.61
Carter	Eyota	Corn	8/23	9.86	11/08	9.35	15.61
Nordling	Lakeville	Corn	8/23	5.40	11/08	9.87	10.30
Olson	Welch	Corn	8/23	5.43	11/08	12.66	15.61
(Airport)	Fairbault			Discontinued			
	S.C.S. SITES						
Hamann	Leverne	Corn	/	.	/	.	9.81
McNab	Brewster	Corn	9/02	.	11/04	.	9.81
Wollum	Milaca	Oats	9/13	6.34	——	——	9.64
Wollum	Milaca	Corn	——	——	11/01	8.37	9.64
Sandbo	Odin	Corn	9/03	6.02	11/02	13.22	13.02
Zickrich	Kellogg	Corn	9/13	10.52	11/03	12.27	15.61
Woods	Winthrop	Soys	8/25	4.41	11/01	8.66	11.78
Sutherland	Hayfield	Corn	Not Sampled		10/28	10.48	10.59
Hartung	Bertha	Alfalfa	8/30	1.99	11/03	7.46	8.33
	EXPERIMENT STATIONS						
North West	Crookston	Corn	——	——	——	——	——
West Central	Morris (DSL)	Corn	8/25	6.04	——	——	****
West Central	Morris (HCL)	Corn	8/25	6.38	——	——	****
South West	Lamberton	Corn	9/02	6.41	10/29	7.38	9.81
South Central	Waseca	Corn	——	——	——	——	——
Marcell Station Itasca Co. (U.S. Forest Service)		Forest (7.5 Feet)	9/23	7.76	11/17	11.40	****

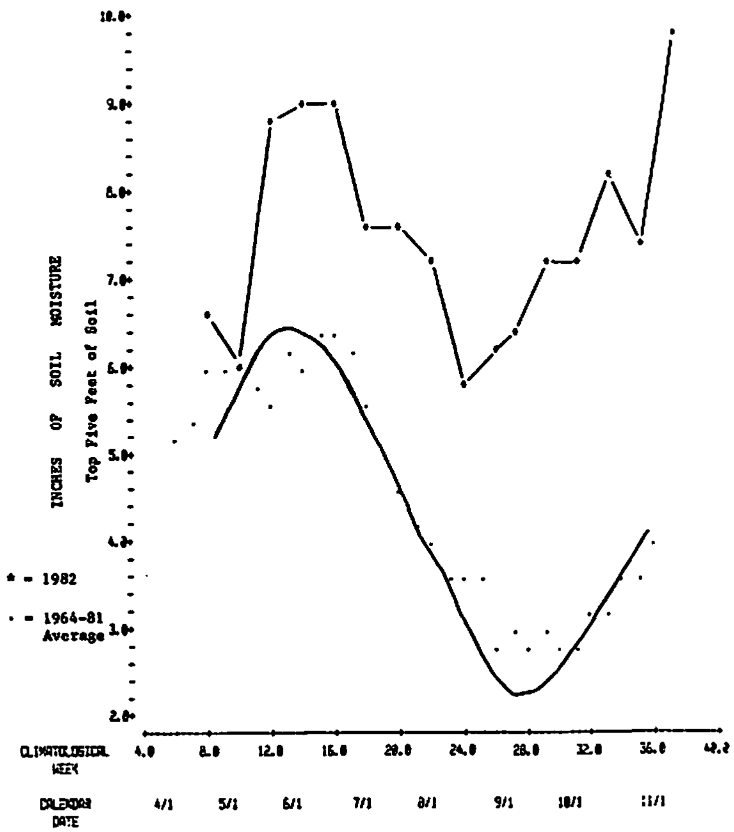
Figure 5.

SOIL MOISTURE

S.W. EXPERIMENT STATION

LAMBERTON, MN

1982 vs Normal



SOIL MOISTURE CONDITIONS, JUNE 1982

The spring soil moisture sampling of Minnesota showed the state with few exceptions to be wet. Plant available soil moisture amounted to 8 inches or more in the top 5 feet of soil for the state except in the very northwest corner and generally the western two tiers of counties from Fargo-Moorhead south. This western area had 4-8 inches of water in the top 5 feet, which is normal to a little less than normal for the spring period. Of real importance is the fact that in some parts of west-central and south-west Minnesota the soils contain more water this spring than has been the case for a number of years. For example, at the Lamberton Agricultural Experiment Station in southeastern Redwood County the tile drains are discharging water for the first time in two years.

At this time of year a plant available soil moisture content of 8 inches in medium to fine textured soils is above normal and 12 inches or more is exceptionally wet.

An analysis on June 1 of the May precipitation combined with the May 1 soil moisture shows the eastern two-thirds of the state with wet conditions which have caused planting delays. The wettest counties are Fillmore, Mower, Olmsted, Steele, Wabasha, and Winona.

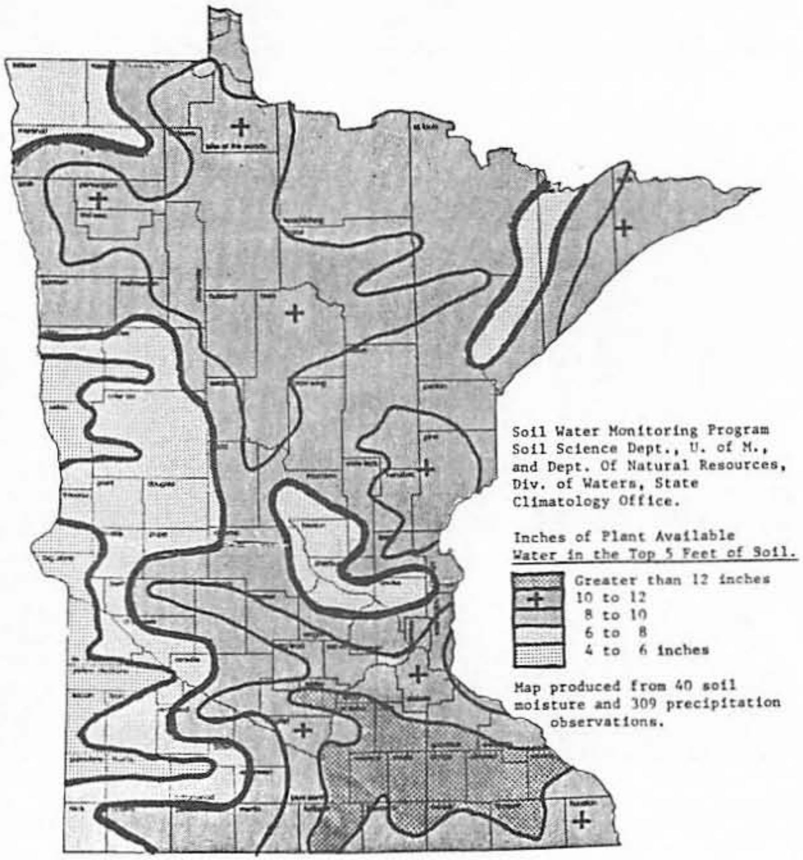
The combination of wet May 1 soil moisture conditions followed by a wet May occurs on the average about once every 8 years in Minnesota. Such conditions caused planting delays in Minnesota of corn and soybeans in 1960, 1965, and 1982 and of wheat in 1974.

The accompanying maps show the May 1 soil moisture and May 1982 precipitation.

MAY, 1982

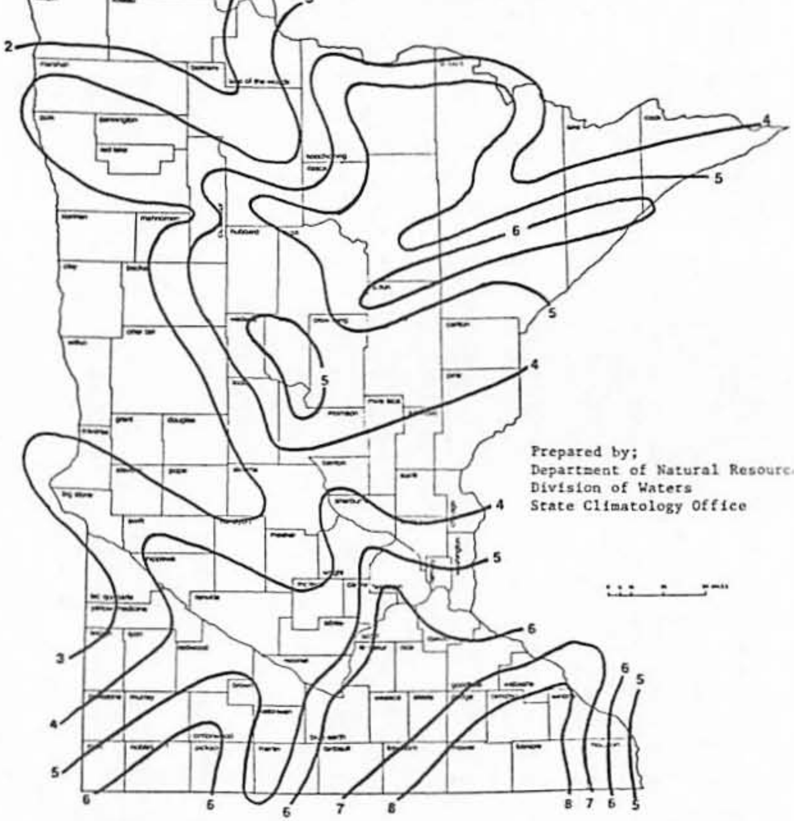
Date	Cooperator	Address	Crop	Avail. Water	Capacity
5/05	Viken	Roseau	Wheat	Not Available	
5/05	Riopelle	Argyle	Wheat	6.36	13.34
5/04	Driscoll	E. Grand Forks	Wheat	8.55	13.58
5/05	Christenson	Thief River Falls	Wheat	9.20	10.30
5/05	Buchholtz	McIntosh	Wheat	7.11	10.30
5/04	Brendamuhl	Moorhead	Wheat	7.07	13.34
5/04	Lieseth	Moorhead	Wheat	10.73	13.58
5/04	Sethre	Carlisle	Corn	11.29	12.75
5/04	Evenson	Fergus Falls	Wheat	2.24	12.75
4/30	Homan	Beardsley	Corn	7.94	13.50
4/30	Dimberg	Ortonville	Corn	3.91	12.75
4/30	Nesvold	Madison	Corn	9.30	12.75
4/30	Pfau	Freeport	Corn	8.97	8.03
5/07	Powers	Hugo	Corn	5.97	8.03
5/03	Krause	Buffalo	Corn	8.13	13.34
5/03	Marklowitz	Litchfield	Corn	4.73	9.34
5/03	Rhoda	Raymond	Corn	4.44	12.23
5/03	Scheibel	Bird Island	Corn	11.11	13.50
4/29	Haubrich	New Ulm	Corn	6.84	14.50
4/30	Jeremiason	Minneota	Corn	5.34	12.23
4/29	Horton	Pipestone	Corn	6.12	13.99
4/29	Keller	Slayton	Corn	9.87	12.23
4/29	Turner	Bingham Lake	Corn	11.49	13.82
4/28	Ruschy	Sherburn	Corn	9.33	9.34
4/29	Van Sickle	Garden City	Corn	Not Available	
4/28	Seetin	Huntley	Corn	Not Available	
4/28	Hassing	Wells	Corn	7.57	14.50
4/28	Gniffke	Hayward	Corn	Not Available	
4/28	Goodsell	Spring Valley	Corn	9.78	10.30
4/28	Hoscheit	Caledonia	Corn	14.67	15.61
4/27	Carter	Eyota	Corn	12.23	15.61
5/07	Nordling	Lakeville	Corn	7.42	10.30
4/27	Olson	Welch	Corn	12.29	15.61
4/27	(Airport)	Fairbault	Soybeans	9.27	12.75
		S.C.S. SITES			
5/06	Hamann	Luverne	Corn	.	9.81
4/30	McNab	Brewster	Alfalfa	.	9.81
5/04	Nichols	Milaca	Corn	8.03	9.64
5/04	Sandbo	Odin	Corn	11.18	13.82
5/06	Zickrick	Kellogg	Corn	12.13	15.61
5/04	Woods	Winthrop	Wheat	10.34	11.78
5/09	Sutherland	Hayfield	Corn	8.06	10.59
5/05	Hartung	Bertha	Alfalfa	5.09	8.33
		EXPERIMENT STATIONS			
-	North West	Crookston	Corn	No Data	
-	West Central	Morris (DSL)	Corn	No Data	
-	West Central	Morris (HCL)	Corn	No Data	
5/04	South West	Lamberton	Corn	5.99	9.81
-	South Central	Waseca	Corn	No Data	-
5/12	Marcell Station Itasca Co. (U.S. Forest Service)		Forest (7.5 Feet)	13.68	-

SOIL MOISTURE
MAY 1, 1982

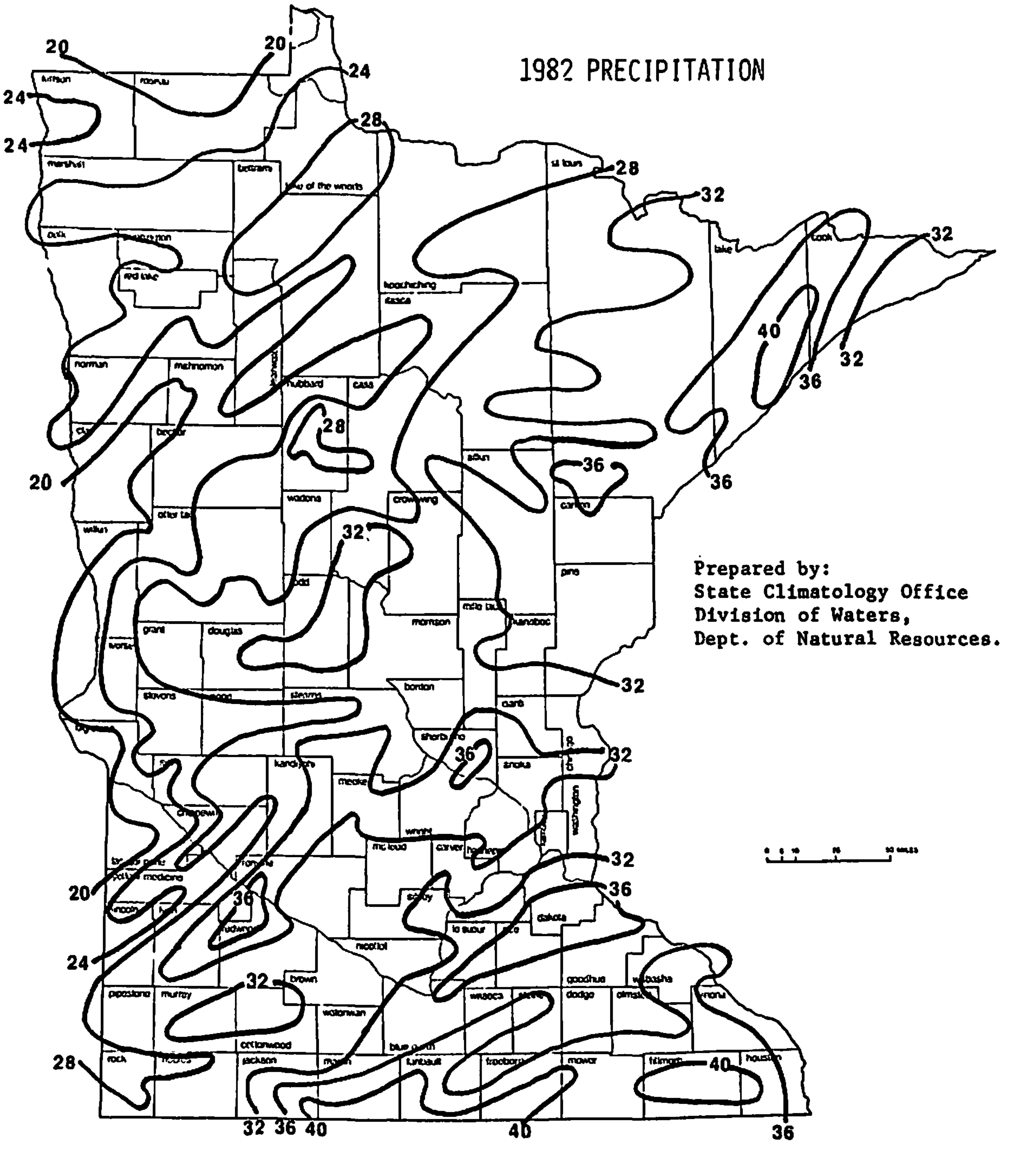


PRELIMINARY

1982 MAY PRECIPITATION



May 1982 precipitation was normal or above for the entire state except for the very northwest where less than 2 inches fell. The very wet areas with more than 7 inches were the counties in the southeast from Freeeborn east thru Fillmore counties and northeast from there thru Wabasha and Winona counties. The wet areas w ere generally south of a line from the southwest corner of the State thru the Twin Cities and much of the northcentral and northeast districts of the State



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

Annual precipitation for 1982 for Minnesota was about 2 to 4 inches above normal across the state. The greatest amounts are generally in the southern row of counties from Jackson County east and in Lake County with more than 36 inches and a few areas with amounts greater than 40 inches. The areas with the least amounts were in general the western row of counties from Lac Qui Parle north to the Canadian border and a 40 mile wide band extending northeast from Moorhead to the southern edge of the Red Lake and Bemidji area. Most of this area received 24 inches or less. The fall rains as a whole were much above normal.

The map was prepared from 462 observations from 10 networks throughout the state. The greatest recorded amount was in southwest St. Louis County with 42.24 inches and the least was 18.63 inches in northeast Kittson County. The mean precipitation from all observations was 29.98 inches which is about 3 inches greater than the average for the State.

SOME NOTES ON AGRICULTURAL REMOTE SENSING AND THE IMPLEMENTATION OF NEW DATA HANDLING TECHNOLOGIES IN FIELD RESEARCH

M. Seeley and D. Ruschy

I. Spectral Characteristics of Soils

This project is supported by the USDA Statistical Reporting Service (SRS) and NASA/AgRISTARS - Early Warning and Crop Condition Assessment branch. The purpose of the project is to define characteristic spectra of Minnesota crops and soils using the thematic mapper bands of the new Barnes Model 1200, Modular Multiband Radiometer (MMR). This instrument is similar to that being used aboard the new LANDSAT - 4, a satellite designed for making agricultural and geological surveys. During the 1982 crop season, a truck-mounted MMR was used to measure the spectra of crops and soils at the Rosemount Agricultural Experiment Station.

Shown in Figures 1 through 5 are sample thematic mapper spectra taken from a USDA-ARS tillage experiment at Rosemount, were the soil is a Waukegan silt loam. The following types of surface conditions are depicted: spring tilled (high level of roughness), fall tilled (weathered and moderate level of roughness), smooth (no tillage, low level of roughness), and corn residue (100 percent coverage). In addition, some spectra illustrate differences between wet and dry conditions. The thematic mapper bands are shown on the abscissa. Band widths (channels) are defined in microns. The ordinate represents a bidirectional reflectance factor (BRF) defined as the ratio of the radiant flux reflected by the sample surface to that which would be reflected into the same reflected beam geometry by an ideal (lossless) perfectly diffuse (Lambertian) standard surface irradiated in exactly the same way as the sample. The term bidirectional reflectance factor (BRF) refers to both the viewing angle of the instrument (usually 0° from normal) and to the solar zenith and azimuth angles, see Bauer et al[1].

Description of Spectra:

Figure 1. This figure compares the BRF values of three distinctly different surfaces, all under dry conditions. Differences in reflectance are due primarily to surface roughness features. The overall pattern showing increasing reflectance with increasing wavelength agrees with other data reported by Stoner[2] for Mollisols. Differences in the amplitude of reflectance are most significant between the smooth and spring tilled surfaces. Channel 4 through 7 represent the spectral range where most of the energy from the sun is received at the soil surfaces. In these wavelengths, the spring tilled surface is absorbing approximately 40 to 50 percent more energy than the smooth surface. Differences of this magnitude should allow for separability of these surfaces in thematic mapper data, however soil moisture content, organic matter, and texture differences frequently confound interpretation of large scale satellite - based multispectral images.

The fall tilled surface (weathered) shows reflectance properties which are intermediate between the smooth surface and that of the spring tilled soil. As expected, the weathering process eventually makes tilled surfaces spectrally similar to smooth bare soil conditions by altering structure.

Figure 2. This figure illustrates the effect of surface moisture conditions on the BRF signature (pattern) of spring tilled Waukegan silt loam. Data collected on August 11 followed 16 days of warm weather and no measurable rainfall. The surface was extremely dry to a depth of 5 cm. Data acquired on August 25 represent very wet conditions since over 38 mm of rain fell the previous day. Sun angles were similar for both dates, with the data being taken at approximately 1700 hours GMT. Note that the wet conditions suppressed BRF values by 50 percent or more. Differences were proportionally greatest in the visible bands (blue, green, red), channels 1, 2, and 3 than in the near-infrared and middle-infrared bands, channels 4 through 7. This correlates to a shift in Munsell notation from 10YR 2 1 under wet conditions to 10YR 3 1 under dry conditions. Thus, thematic mapper appears to show a greater sensitivity to change in the value (brightness) dimension of the Munsell system. This will be investigated in future research.

The shifts in spectral amplitude shown in these data can provide important planting time information for agricultural surveys.

Figure 3. This figure compares the spectra of corn residue (100 percent cover) under different moisture conditions. Note that the BRF signature of residue is very similar, in terms of both pattern and amplitude, to that of the smooth bare soil surface under dry conditions (Figure 1). This indicates that such surfaces may be difficult to separate in remote sensing surveys.

The moisture conditions had little effect on the BRF signatures of corn residue, as noted by the nearly constant values in each channel. The residue dried more quickly than the soil and therefore the moisture differences between dates were not as significant as they were for the soil surface conditions. Thus, the spectra shown here do not really represent the same range of moisture conditions as those shown in Figure 2.

Figure 4. This figure compares the spectra of corn residue (100 percent cover) to spring tilled soil under very dry conditions. Differences in the visible and near-infrared bands range from 32 to 39 percent, with the corn residue showing consistently higher BRF values. The differences in the water absorption bands likely indicate similar moisture content between the corn residue and the soil surface. However, actual measurements of moisture were not made.

Figure 5. This figure compares the spectra of spring tilled soil to corn residue under very wet conditions. The differences here are most extreme. As mentioned previously, the corn residue consumes very little energy in evaporation (channels 4 through 7) and tends to behave spectrally as a dry surface. The bare soil consumes much more energy in evaporation as evidenced by the very suppressed BRF values in channels 4 through 7. Unlike Figure 4, this comparison suggests that thematic mapper separation of tilled soils from crop residues is most definitive under wet conditions. This is an important consideration in making satellite-based agricultural surveys. The tilled bare soil BRF values are only 20 to 25 percent as high as those of the corn residue in channels 1 through 4, indicating a spectral difference due to both color and structure of the respective surfaces. In the water absorption bands (channels 6 and 7) the soil BRF values are only 35 to 40 percent as high as those of the residue.

II. Notes on the Use of Data Recorders and Micro-Computers for Field Research.

Bidirectional reflectance data are collected with a Modular Multispectral Radiometer (MMR). This MMR has 8 independent optically-chopped radiometers, each with a field of view of 15°. It is mounted on a boom designed to raise the instrument and a 35 mm camera 7.63 m above the ground. The MMR has 3 visible channels: (Blue) .45 to .52 microns, (Green) .52 to .60 microns, and (Red) .63 to .69 microns; 4 infrared channels: .76 to .90, 1.15 to 1.30, 1.55 to 1.75, and 2.08 to 2.35 microns; and a thermal channel - 10.4 to 12.5 microns.

The MMR is remotely controlled by a programmable Omnidata Polycorder with a storage capacity of 30,000 digits or 15,000 alphanumeric characters (about 250 lines of data). The polycorder is set up to ask for a code number for the scene being observed and then automatically samples all 8 channels on the MMR and stores the data.

Data collection consists of (1) a "dark" reading to offset all data readings to zero; (2) calibration readings taken every 20 minutes over a calibration panel coated with barium sulfate that is nearly 100% reflective in all but the thermal channels; and (3) the various scene readings in all 8 channels.

The polycorder is connected to the University CYBER computer to dump the data for storage and editing. The polycorder can be used as a 'dumb terminal' or can be connected to a second RS-232 connector on the modem after the data storage file is ready.

The data are transformed to bidirectional reflectance by offsetting all calibration and scene readings with the dark reading, adjusting each calibration reading for the effectiveness of the calibration panel and then dividing the scene reading by an interpolated calibration reading based on time.

The bidirectional reflectance data are then available to be displayed as bargraphs using color graphics programs on the IBM/PC. The bargraph program can display up to three different scene readings in color at one time on the Amdek II color monitor. Fixed colors are translated to various symbols by a separate computer program and sent to the Epson printer for hard copy. This represents a first effort to fully automate data acquisition, processing, editing, display, and output utilizing portable data loggers and micro-computers. Further development of such techniques will enhance remote sensing research and other field research projects as well.

References

1. Bauer, M. E., L. L. Biehl, C. S. T. Daughtry, B. F. Robinson, and E. R. Stover. 1979. Agricultural Scene Understanding and Supporting Field Research. Vol. I. LARS Contract Report 112879. NASA Contract NAS9-15466. Purdue University, West Lafayette, IN.

2. Stoner, E. R. and M. F. Baumgardner. 1980. Physiochemical, site, and bidirectional reflectance factor characteristics of uniformly-moist surface soils. Tech. Rep. 111679, LARS, Purdue University, West Lafayette, IN.

FIGURE 1

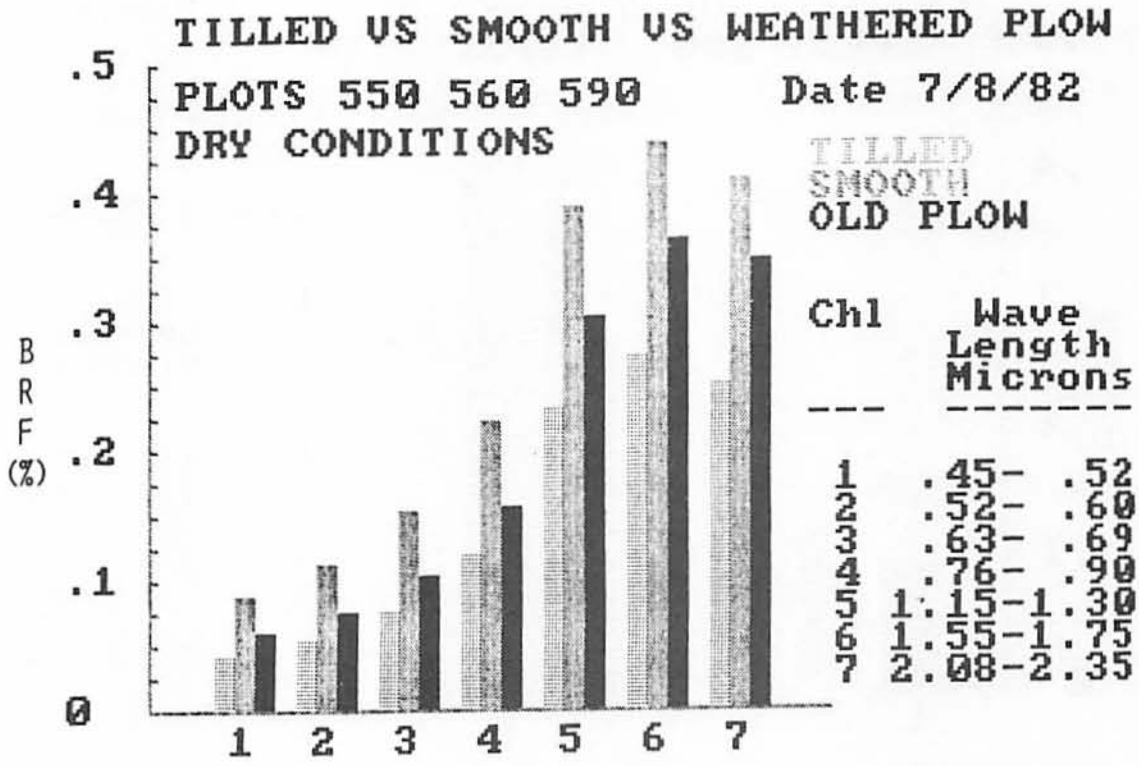


FIGURE 2

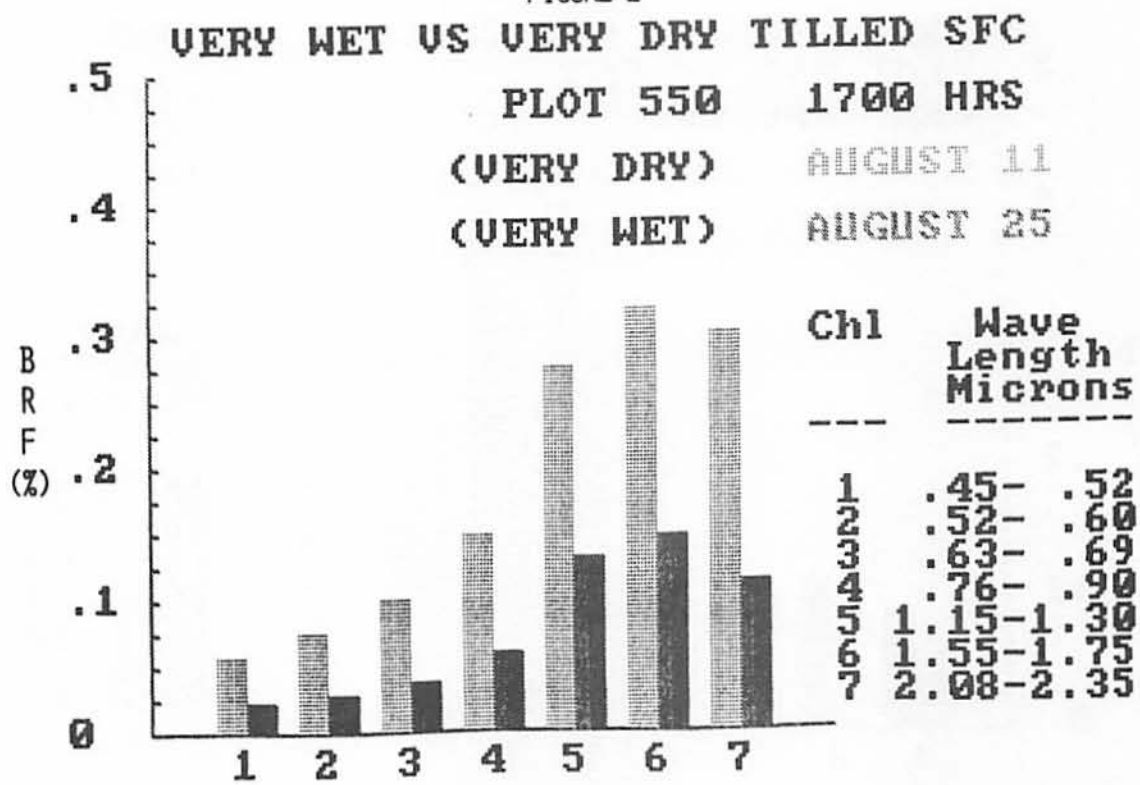


FIGURE 3

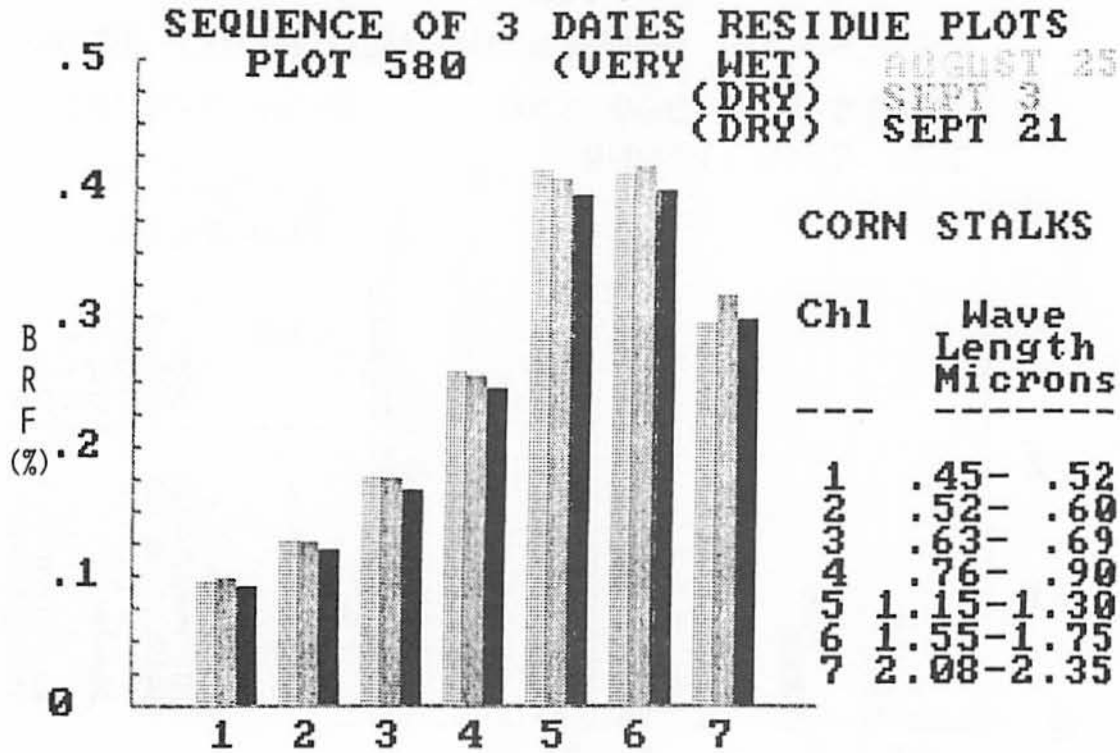


FIGURE 4

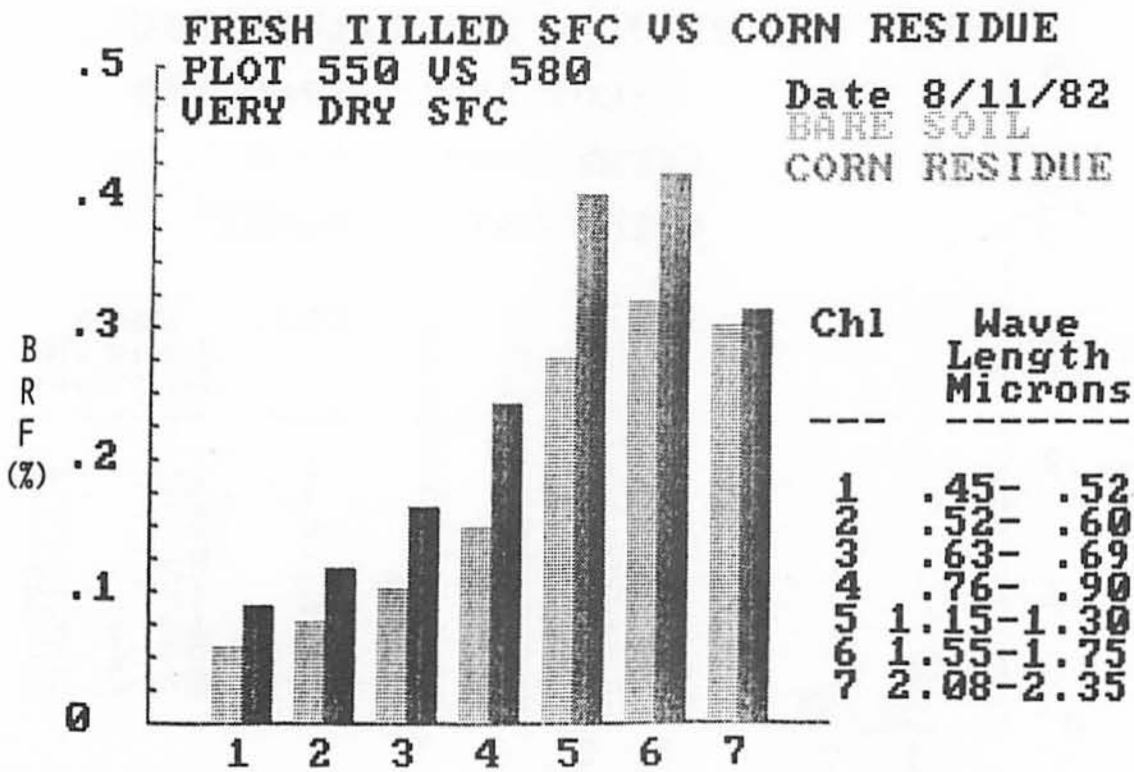
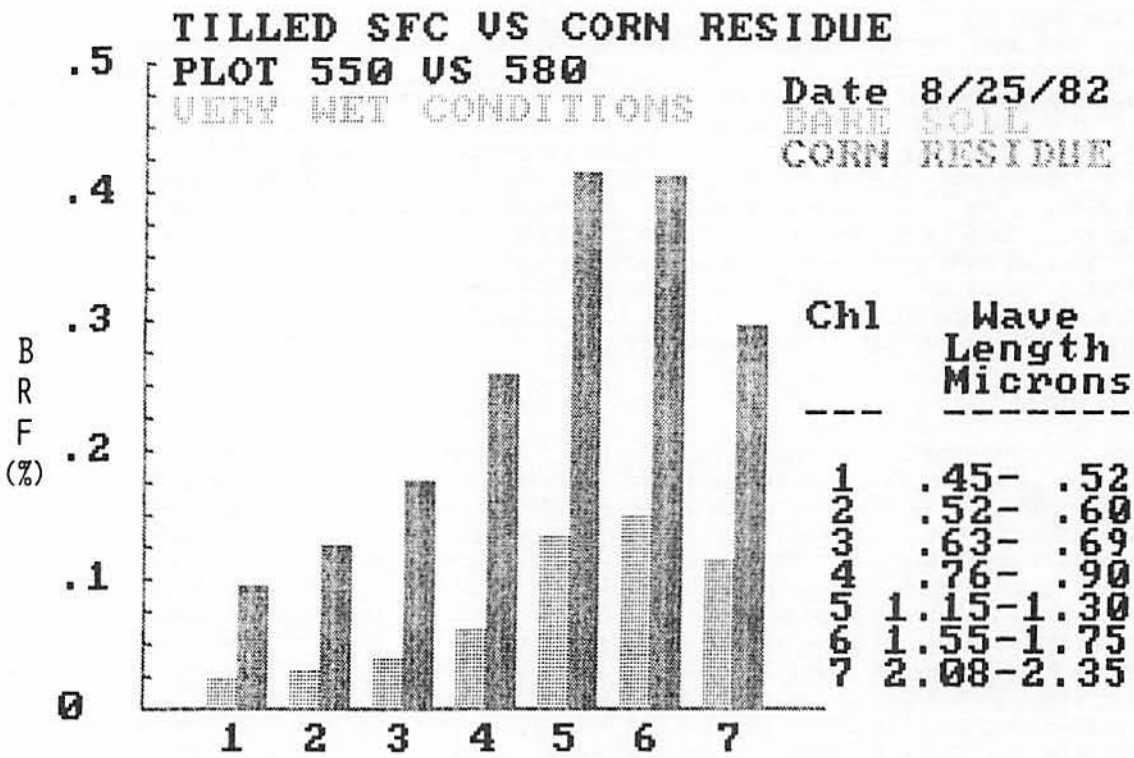


FIGURE 5


TILLED SFC VS CORN RESIDUE
PLOT 550 VS 580
VERY WET CONDITIONS
Date 8/25/82
BARE SOIL
CORN RESIDUE
.5
.4
.3
.2
.1
0
B
R
F
(%)
1 2 3 4 5 6 7
Chl
Wave Length Microns

----
1 .45- .52
2 .52- .60
3 .63- .69
4 .76- .90
5 1.15-1.30
6 1.55-1.75
7 2.08-2.35

INFLUENCE OF NITROGEN RATE, TIMING OF NITROGEN APPLICATION AND USE OF NITRIFICATION INHIBITORS FOR IRRIGATED CORN PRODUCTION - BECKER, MN. 1982.

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 managment 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 a late sidedressing treatment. These management alternatives aften add to the cost of production. Commercial availability of chemical additives known as nitrification inhibitors also offer some potential in minimizing nitrogen losses and may add flexibility into the overall nitrogen managment program. An experiment was established in 1980 to evaluate the significance of nitrogen rates, timing of nitrogen application and the use of nitrification inhibitors.

EXPERIMENTAL PROCEDURES

The 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 inhibitor treatments (none, N-Serve-Dow Chemical Co. and Dwell-Terrazole-Olin Corporation) and five nitrogen application programs (all N preplant, all N 8-leaf, all N 12-leaf, 1/3 N preplant, 2/3 N 12-leaf, and 2/3 N preplant, 1/3 N 12-leaf) were utilized. The experiemtnal 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 (N-Serve or Dwell) at the 8-leaf stage. When a nitrification inhibitor was applied with the two times of N application treatment (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 # ai/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 (May 3), at the 8-leaf stage of corn growth (June 9), at the 12-leaf growth stage (June 24) and at tasseling (July 19).

Prior to planting broadcast applications of potassium-magnesium sulfate (300 #/A 0-0-22), potassium (225 #/A 0-0-60) and phosphorus (85 #/A 0-46-0) were made and incorporated by plowing. Corn (Pioneer 3901 - 100 day R.M.) was planted on May 4th in 30" rows at a population of 30,700 seeds/A. Starter fertilizer was applied at the rate of 165 #/A of 8-10-30 banded at planting. A tank mix of Lasso (2 # ai/A) and Atrazine (1¼ # ai/A) was applied on May 5 for weed control. The insecticide Sevin (1 # ai/A) was sprayed on the corn on June 28 to minimize damage from corn bore.

Leaf samples from opposite and below the ear at mid-silking were obtained on July 21, and were dried, ground and analyzed for Kjeldahl nitrogen. Dry matter production was determined on September 20 by hand harvesting 50 ft^2 of each plot. Ears were separated from stalks, field weights obtained and samples removed for moisture and nitrogen determination. Corn yield was determined on October 15 and 19 by hand harvesting 100 ft^2 of plot area. Final grain yield estimates were calculated by considering the total 150 ft^2 harvested for total dry matter and grain. We took the grain yields which were adjusted to 15.5% moisture.

The irrigation program was started on June 9 and continued through August 26 with a total of 11.15 inches of water being applied throughout irrigation. An additional 21.05 inches of water was obtained during the growing season through rainfall.

GENERAL RESULTS

Nitrogen losses experienced at the Becker location in 1982 were exceptionally low compared to the previous year. Although the spring was relatively wet there was no single daily precipitation event in excess of .75 inches during the first two months of the experiment. Significant grain yield increases were obtained up through the highest rate of nitrogen application, although even in 1982 when the N losses were low proper management could have reduced the optimum N rate from the actual highest

N rate applied. In general, timing of N application influenced yields very little. The one major exception to this was the latest N application made at tasseling. The late application reduced both yield and many of the the nitrogen utilization characteristics, suggesting that the single application of N at tasseling was not sufficient for top yields. Although the crop was capable of utilizing a portion of the nitrogen, it was not able to take up and utilize the same amounts as was possible with higher rates in earlier applications. A significant N rate x inhibitor x time interaction tended to confuse the issue in the evaluation of the inhibitor treatment. With early applicaton of N, the inhibitor treatments appeared to contribute very little toward yield. At the low N rates when it was applied later in the season (12-leaf) Dwell appeared to have a positive influence on yield, while N-Serve had a negative effect. When the nitrogen rate was increased the negative aspect associated with N-Serve was eliminated. No reason is known at this time for why this might have happened, but it may be highly related to the interactions that the inhibitors have in the N nutrition of the crop under conditions where N losses are not substantial.

Table 1. Influence of nitrogen rate, timing of nitrogen application, and nitrification inhibitors on leaf N content, grain yield and dry matter production on irrigated corn. Becker, MN - 1982

Treatments			Leaf	Grain	Dry Matter Production		
N-Rate	Appl. Time	Inh.	N	Yield	Grain	Stover	Total
#/A			%	Bu/A	- - - - - -	T/A	- - - - -
Check	-	-	1.61	111.9	2.65	2.81	5.46
75	ppl	-	2.43	173.4	4.10	3.69	7.79
75	sp(4)	-	2.50	164.3	3.89	3.40	7.29
75	sp(2)1/3,2/3	-	2.20	168.3	3.98	3.49	7.47
75	sp(2)2/3,1/3	-	2.29	170.9	4.04	3.53	7.57
75	8-leaf	-	2.47	164.3	3.89	3.82	7.71
75	12-leaf	-	2.42	174.3	4.12	3.36	7.48
75	tassel	-	1.68	162.7	3.85	3.02	6.87
75	ppl	Dwell	2.35	174.9	4.14	3.59	7.73
75	sp(2)1/3,2/3	Dwell	2.54	171.3	4.05	3.44	7.49
75	sp(2)2/3,1/3	Dwell	2.49	163.1	3.86	3.41	7.27
75	8-leaf	Dwell	2.58	176.0	4.16	3.54	7.70
75	12-leaf	Dwell	2.58	182.0	4.31	3.48	7.79
75	ppl	N-S	2.25	173.7	4.11	3.62	7.73
75	sp(2)1/3,2/3	N-S	2.48	173.2	4.10	3.42	7.52
75	sp(2)2/3,1/3	N-S	2.27	158.6	3.75	3.51	7.26
75	8-leaf	N-S	2.70	166.6	3.94	3.67	7.61
75	12-leaf	N-S	2.59	163.0	3.86	3.09	6.95
150	ppl	-	2.76	196.6	4.64	4.12	8.76
150	sp(4)	-	2.72	202.3	4.79	3.93	8.71
150	sp(2)1/3,2/3	-	2.79	193.5	4.47	3.75	8.22
150	sp(2)2/3,1/3	-	2.76	194.3	4.60	4.25	8.85
150	8-leaf	-	2.92	193.1	4.57	3.95	8.52
150	12-leaf	-	2.80	191.6	4.53	3.60	8.13
150	tassel	-	1.62	173.0	4.09	3.17	7.27
150	ppl	Dwell	2.87	197.4	4.66	4.40	9.05
150	sp(2)1/3,2/3	Dwell	2.63	194.7	4.61	3.72	8.33
150	sp(2)2/3,1/3	Dwell	2.94	190.6	4.51	4.15	8.66
150	8-leaf	Dwell	2.74	192.6	4.55	3.98	8.54
150	12-leaf	Dwell	2.84	197.5	4.67	3.76	8.44
150	ppl	N-S	2.97	195.9	4.64	4.21	8.85
150	sp(2)1/3,2/3	N-S	2.72	196.1	4.64	4.32	8.96
150	sp(2)3/2,1/3	N-S	2.84	195.4	4.62	3.93	8.55
150	8-leaf	N-S	2.93	191.1	4.52	4.12	8.64
150	12-leaf	N-S	2.74	192.7	4.56	3.27	7.83

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 1982.

Treatment			N Content		N Removal		
N-Rate	Appl. Time	Inh.	Grain	Stover	Grain	Stover	Total
#/A			- - - % - - - -		- - - - -lbs/A - - - - - -		
Check	-	-	1.02	0.45	53.9	24.9	78.8
75	ppl	-	1.24	0.58	101.8	42.9	144.8
75	sp(4)	-	1.19	0.58	93.5	40.2	133.7
75	sp(2)1/3,2/3		1.21	0.48	96.8	33.8	130.6
75	sp(2)2/3,1/3	-	1.15	0.52	93.2	36.6	129.8
75	8-leaf	-	1.16	0.56	90.2	42.5	132.7
75	12-leaf	-	1.16	0.61	95.9	40.8	136.6
75	Tassel	-	1.40	0.64	108.0	38.8	146.8
75	ppl	Dwell	1.22	0.47	101.7	33.9	135.6
75	sp(2)1/3,2/3	Dwell	1.17	0.48	95.0	33.1	128.2
75	sp(2)2/3,1/3	Dwell	1.23	0.57	95.0	39.4	134.4
75	8-leaf	Dwell	1.24	0.54	103.7	37.9	141.6
75	12-leaf	Dwell	1.19	0.59	102.9	40.6	143.6
75	ppl	N-S	1.25	0.54	103.4	39.3	142.7
75	sp(2)1/3,2/3	N-S	1.28	0.52	104.8	35.6	140.4
75	sp(2)2/3,1/3	N-S	1.11	0.51	83.5	35.6	119.1
75	8-leaf	N-S	1.21	0.51	96.0	37.5	133.6
75	12-leaf	N-S	1.18	0.62	90.8	36.8	127.6
150	ppl	-	1.30	0.63	121.1	52.4	173.5
150	sp(4)	-	1.42	0.72	136.2	56.5	192.7
150	sp(2)1/3,2/3	-	1.39	0.71	124.3	54.1	178.4
150	sp(2)2/3,1/3	-	1.39	0.69	128.0	58.0	186.1
150	8-leaf	-	1.44	0.70	131.7	55.0	186.8
150	12-leaf	-	1.32	0.77	119.7	55.6	175.3
150	Tassel	-	1.39	0.66	113.8	41.6	155.5
150	ppl	Dwell	1.45	0.69	135.5	62.1	197.6
150	sp(2)1/3,2/3	Dwell	1.35	0.63	124.4	47.4	171.8
150	sp(2)2/3,1/3	Dwell	1.41	0.73	126.8	61.1	187.8
150	8-leaf	Dwell	1.48	0.68	134.8	54.5	189.3
150	12-leaf	Dwell	1.35	0.75	126.3	56.5	182.7
150	ppl	N-S	1.44	0.82	133.1	69.2	202.2
150	sp(2)1/3,2/3	N-S	1.35	0.63	125.5	54.7	180.2
150	sp(2)2/3,1/3	N-S	1.28	0.64	118.8	50.4	169.2
150	8-leaf	N-S	1.43	0.67	129.1	55.0	184.2
150	12-leaf	N-S	1.36	0.72	124.3	46.6	171.0

Table 2 continued on next page

Table 1 continued

Treatments N-Rate	Appl. Time	Inh.	Leaf N	Grain Yield	Dry Matter Production Grain	Stover	Total
#/A			%	Bu/A	- - - - - - T/A - - - - -		
225	ppl	-	2.86	199.1	4.71	4.31	9.02
225	sp(4)	-	3.01	199.8	4.73	4.22	8.95
225	sp(2)1/3,2/3	-	2.90	203.9	4.82	4.28	9.10
225	sp(2)2/3,1/3	-	2.90	204.9	4.85	4.39	9.24
225	8-leaf	-	3.02	205.7	4.87	4.13	9.00
225	12-leaf	-	2.92	187.5	4.44	3.64	8.07
225	Tassel	-	1.68	176.5	4.17	3.17	7.35
225	ppl	Dwell	3.09	204.0	4.79	4.62	9.41
225	sp(2)1/3,2/3	Dwell	2.83	190.5	4.51	3.75	8.26
225	sp(2)2/3,1/3	Dwell	2.91	211.9	5.01	4.49	9.51
225	8-leaf	Dwell	3.01	196.7	4.65	4.06	8.71
225	12-leaf	Dwell	3.04	192.8	4.56	4.11	8.67
225	ppl	N-S	2.92	187.8	4.44	3.68	8.12
225	sp(2)1/3,2/3	N-S	2.85	201.5	4.78	4.08	8.86
225	sp(2)2/3,1/3	N-S	3.05	199.4	4.72	3.51	8.22
225	8-leaf	N-S	3.07	202.9	4.80	4.32	9.11
225	12-leaf	N-S	2.83	201.1	4.76	3.94	8.70
150	8-leaf	Dwell ½#	2.91	196.1	4.64	4.14	8.78
150	8-leaf	N-S ½#	3.08	194.5	4.60	3.82	8.42
Significance			**	xx	**	**	**
BLSD (.05)			0.23	11.8	0.28	0.55	0.67

Table 2 continued

Treatment N-Rate	Appl. Time	Inh.	N Content Grain	Stover	N Removal Grain	Stover	Total
#/A			- - - % - - - -		- - - - -lbs/A - - - - - -		
225	ppl	-	1.52	0.82	143.8	70.3	214.1
225	sp(4)	-	1.42	0.80	134.5	68.1	202.6
225	sp(2)1/3,2/3	-	1.48	0.77	142.9	66.6	209.5
225	sp(2)2/3,1/3	-	1.52	0.75	147.1	65.8	212.9
225	8-leaf	-	1.45	0.76	141.2	63.2	204.4
225	12-leaf	-	1.35	0.76	120.0	55.4	175.4
225	Tassel	-	1.45	0.77	121.3	49.2	170.4
225	ppl	Dwell	1.49	0.84	143.0	77.8	220.8
225	sp(2)1/3,2/3	Dwell	1.35	0.78	122.1	58.6	180.7
225	sp(2)2/3,1/3	Dwell	1.46	0.83	146.4	74.9	221.3
225	8-leaf	Dwell	1.48	0.83	137.5	67.6	205.1
225	12-leaf	Dwell	1.36	0.76	124.4	62.9	187.2
225	ppl	N-S	1.45	0.86	128.7	63.1	191.7
225	sp(2)1/3,2/3	N-S	1.45	0.81	138.9	66.5	205.4
225	sp(2)2/3,1/3	N-S	1.44	0.84	136.5	58.7	195.2
225	8-leaf	N-S	1.43	0.73	137.6	63.7	201.2
225	12-leaf	N-S	1.36	0.73	129.2	58.3	187.5
150	8-leaf	Dwell ½#	1.37	0.76	126.9	62.8	189.7
150	8-leaf	N-S ½#	1.34	0.67	122.9	51.2	174.1
Significance			**	**	**	**	**
BLSD (.05)			0.10	0.11	12.6	10.6	18.9

Table 1 and 2 continued

Treatments	Leaf N	Grain Yield	Dry Matter Production Grain	Stover	Total	N Content Grain	Stover	N Removal Grain	Stover	Total
	%	Bu/A	- - - - - T/A - - - -			- - - % - - - -		- - - -lbs/A- - - - -		
Factorial Arrangement (Nitrogen Rate X Time of application)										
N-Rate #/A										
75	2.28	168.3	3.98	3.47	7.45	1.22	0.57	97.0	39.4	136.4
150	2.62	192.1	4.53	3.82	8.35	1.38	0.70	125.0	53.3	178.3
225	2.75	196.8	4.66	4.02	8.67	1.46	0.78	135.8	62.7	198.5
Significance	**	**	**	**	**		**		**	
BLSD (.05)	0.09	4.6	0.11	0.17	0.24		0.04		3.6	
Time										
preplant	2.68	189.7	4.48	4.04	8.52	1.35	0.68	122.3	55.2	177.5
Sp(4)§	2.75	188.8	4.47	3.85	8.31	1.34	0.70	121.4	55.0	176.3
Sp(2)1/3,2/3	2.63	188.6	4.42	3.84	8.27	1.36	0.66	121.3	51.5	172.8
Sp(2)2/3,1/3	2.65	190.5	4.50	4.06	8.55	1.35	0.65	122.8	53.5	176.2
8-leaf	2.80	187.7	4.44	3.96	8.41	1.35	0.67	121.0	53.6	174.6
12-leaf	2.71	184.5	4.36	3.53	7.90	1.27	0.71	111.8	50.6	162.4
Tassel	1.66	170.7	4.04	3.12	7.16	1.41	0.69	114.4	43.2	157.6
Significance	**	**	**	**	**		NS		**	
BLSD (.05)	0.14	7.8	0.19	0.26	0.39		--		0.65	
N-Rate X Time	NS	NS	NS	NS	NS	**	NS	**	NS	**
Factorial Arrangement (Nitrogen rate X Inhibitor X Time)										
N-Rate #/A										
75	2.44	170.2	4.03	3.51	7.54	1.20	0.54	97.0	37.8	134.7
150	2.81	194.4	4.58	3.97	8.56	1.38	0.70	126.9	55.5	182.4
225	2.95	199.3	4.71	4.09	8.80	1.44	0.79	135.9	64.9	200.8
Significance	**			**			**		**	
BLSD (.05)	0.06			0.15			0.03		2.66	
Nitrification Inhibitor										
None	2.69	188.1	4.44	3.89	8.33	1.34	0.67	119.8	52.9	172.3
Dwell	2.76	189.1	4.47	3.90	8.37	1.35	0.68	121.3	53.9	175.2
N-Serve	2.74	186.6	4.41	3.78	8.19	1.33	0.68	118.7	51.4	170.1
Significance	NS						NS		NS	
BLSD (.05)	--						--		--	
Time										
preplant	2.72	189.2	4.47	4.02	8.49	1.37	0.70	123.6	56.8	180.4
sp(2)1/3,2/3	2.66	188.1	4.44	3.81	8.25	1.34	0.65	119.4	50.0	169.5
sp(2)2/3,1/3	2.72	187.7	4.44	3.91	8.35	1.33	0.68	119.5	53.4	172.9
8-leaf	2.82	187.7	4.44	3.95	8.39	1.37	0.66	122.4	53.0	175.4
12-leaf	2.75	187.0	4.42	3.58	8.01	1.29	0.70	114.8	50.4	165.2
Significnace	**						*		**	
BLSD (.05)	0.08						0.04		3.12	
N-Rate X Inh.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N-Rate X Time	NS	**	**	NS	NS	*	NS	**	NS	*
Inh. X Time	NS	NS	NS	*	**	*	NS	*	NS	*
Rate X Ihn. X Time	NS	*	*	NS	*	NS	NS	NS	NS	NS

§ = 1/6, 1/6, 1/2, 1/6

INFLUENCE OF NITROGEN FORM, NITROGEN RATE, TIMING OF NITROGEN APPLICATION AND NITRIFICATION INHIBITORS FOR IRRIGATED CORN - BECKER, MN. 1982

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 fertilzation such as rates, form, method, time, equipment, and additives. Nitrogen fertilzer 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 applications, which may be facilitated through the irrigation water. With such management systems a variety of fertilzer nitrogen forms may be utilized. These management alternatives often add to the cost of production and require a reasonable amount of timeliness to avoid yield reductions. A new trial was established in 1980 to evaluate the significance of nitrogen rates, nitrogen form, timing of nitrogen application and the use of nitrification inhibitors for irrigated corn production.

Experimental Procedure

An experiment consisting of 25 treatments, with four replications was arranged in a randomized complete block design and established at the Sand Plain Research Farm near Becker, 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. Five additional treatments including a control, and four urea treatments (150 #N/A applied with four nitrification inhibitor treatments) were also included. Nitrogen fertilizer was applied at rates of 75 and 150 #/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 were not included with the later sidedress treatments of 28% N solution or anhydrous ammonia.

Prior to planting, broadcast application of potassium-magnesium sulfate (425 #/A 0-0-22), potassium (225 #/A 0-0-60) and phosphorus (85 #/A 0-46-0) were made and incorporated by plowing. Nitrogen applications were made prior to planting (May 5 and 6) at the 8-leaf stage (June 10) and at the 12-leaf stage (June 25). Corn (Pioneer 3901 - 100 day relative maturity) was planted on May 6 in 30" row at a population of 30,700 seeds/A. Starter fertilizer was applied at the rate of 165 #/A 8-10-30 banded at planting. A tank mix of Atrazine (1½ # ai/A) and Lasso (2 # ai/A) was applied on May 6 for weed control. On June 28 the insecticide Sevin (1 # ai/A) was sprayed to minimize corn bore damage.

Leaf samples from opposite and below the ear at mid-silking were obtained on July 21, and were dried and analyzed for Kjeldahl nitrogen. Total dry matter production was determined on September 17 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. Additional corn grain yield estimates were obtained on October 4 by hand harvesting 100 ft^2 of plot area. Overall corn grain yield estimates were obtained by considering the total 150 ft^2 harvested. Grain yields were adjusted to 15.5% moisture.

The irrigation program was started on July 3 and continued through August 26 with a total of 10.25 inches being applied through irrigation. An additional 17.48 inches of water were obtained during the growing season through rain fall.

GENERAL RESULTS

The growing season and the yields obtained at the Becker location were excellent in 1982. A summary of the yields, and partitioning of dry matter are included in Table 1, while N utilization and N removal characteristics are presented in Table 2. Grain yields ranged from 103 bu/A on the control treatment (zero N) to 196 bu/A with some of the better N treatments with nitrogen response being reflected up through the highest rate of N fertilzation.

The fertilizer nitrogen loses experienced at the Sand Plains Research Farm were relatively small in 1982. This can be observed by comparing the preplant N applications with the sidedressed treatment. If losses of N occurred with early applications the yields from the sidedressed treatments should be considerably higher than preplant applications. Not only were the sidedressed applications not higher, but in certain cases they were significantly lower. Careful examination of the climatic information suggests that N losses should have been relatively low. Although the frequency of precipitation was relatively high early in the season, the total quantity received at any one time was relatively low. During the first two months of the experiment there was no one day precipitation event over 1.9 cm recorded. Further examination of the climatic records indicates that after each sidedressing there was a period of a least seven days in which no precipitation was received. The decreased or depressed yields and reduced N utilization from sidedressing may have been due to an adverse effect related to an interaction of the plant rooting system, fertilizer treatment and subsequent climatic conditions encountered.

Although N losses were not severe, modest yield increases due to nitrification inhibitor applications were obtained with preplant N application. At the 75 # N/A rate of application both N-Serve and Dwell, when applied with anhydrous ammonia, significantly increased stover yield and for N-serve also significantly increased grain yield.

Table 1. Influence of nitrogen form, nitrogen rates, nitrification inhibitors, timing of nitrogen application on yield grain, and dry matter production on irrigated corn. Becker, MN 1982.

Treatments				Grain	Dry Matter Production			
N-Rate	N-Form	Inh.	Time	Yields	Grain	Cob	Stover	Total
#/A				Bu/A	- - - - - -	- -	T/A - - - -	- - - -
Check	--	--	--	102.8	2.43	0.29	2.22	4.95
75	AA	--	ppl	183.0	4.33	0.56	3.00	7.89
75	AA	--	8-leaf	166.8	3.92	0.52	2.85	7.29
75	AA	--	12-leaf	174.1	4.12	0.48	2.72	7.32
75	28%	--	ppl	180.3	4.26	0.54	2.99	7.80
75	28%	--	8-leaf	174.8	4.14	0.51	2.89	7.54
75	28%	--	12-leaf	155.0	3.67	0.42	2.87	6.96
75	AA	Dwell	ppl	190.2	4.50	0.57	3.57	8.64
75	28%	Dwell	ppl	179.0	4.24	0.56	3.16	7.95
75	AA	N-S	ppl	195.5	4.62	0.64	3.83	9.09
75	28%	N-S	ppl	173.3	4.10	0.46	3.34	7.91
150	AA	--	ppl	192.4	4.55	0.68	3.29	8.52
150	AA	--	8-leaf	185.7	4.39	0.63	2.94	7.96
150	AA	--	12-leaf	184.4	4.36	0.58	2.67	7.62
150	Urea	--	ppl	189.0	4.47	0.62	3.40	8.50
150	28%	--	ppl	191.2	4.52	0.65	3.25	8.43
150	28%	--	8-leaf	186.6	4.42	0.58	3.00	8.00
150	28%	--	12-leaf	185.7	4.39	0.60	2.94	7.93
150	AA	Dwell	ppl	198.3	4.69	0.64	3.36	8.69
150	Urea	Dwell	ppl	196.5	4.65	0.66	3.44	8.75
150	28%	Dwell	ppl	190.4	4.50	0.66	3.34	8.50
150	AA	N-S	ppl	193.3	4.57	0.65	3.40	8.51
150	Urea	N-S	ppl	190.0	4.49	0.66	3.64	8.79
150	28%	N-S	ppl	185.8	4.40	0.60	3.43	8.43
150	Urea	DAC-48988	ppl	190.9	4.52	0.69	3.67	8.87
Significance				**	**	**	**	**
BLSD (.05)				9.5	0.23	0.07	0.41	0.54

Factorial Arrangement (Excludes check, and area treatments)

	Grain Yields	Grain	Cob	Stover	Total
N-Rate					
75	183.5	4.34	0.56	3.31	8.21
150	191.9	4.54	0.65	3.33	8.51
Significance		**	**	NS	
N-Form					
AA	192.1	4.54	0.62	3.39	8.56
28%	183.3	4.34	0.58	3.25	8.17
Significance				NS	
Inhibitor					
None	186.7	4.42	0.61	3.13	8.16
Dwell	189.5	4.48	0.61	3.36	8.44
N-Serve	187.0	4.42	0.58	3.48	8.48
Significance	NS				
N-Rate X N-Form	*	NS	NS	*	*
N-Rate X Inhibitor	NS	NS	NS	*	*
N-Form X Inhibitor	*	*	*	NS	NS
Rate X Form X Inhibitor	NS	NS	NS	NS	NS

Table 1 continued on page after next

Table 2. Influence of nitrogen form, nitrogen rates, nitrification inhibitors, timing of nitrogen application, leaf N content, grain N content and nitrogen removal by irrigated corn. Becker, MN 1982.

Treatments				N-Content			N-Removal		
N-Rate	N-Form	Inh.	Time	Leaf	Silage Grain	Stover	Grain	Stover§	Total
#/A				- - - - % - - - - - -			- - - - -lbs/A- - - - -		
Check	--	-	--	1.58	1.11	0.47	54.1	23.6	77.1
75	AA	-	ppl	3.01	1.22	0.63	105.6	44.6	150.2
75	AA	-	8-leaf	2.83	1.22	0.60	95.9	40.2	136.1
75	AA	-	12-leaf	2.99	1.20	0.63	98.7	40.7	139.4
75	28%	-	ppl	2.88	1.21	0.66	103.3	46.2	149.6
75	28%	-	8-leaf	2.97	1.17	0.60	96.9	40.4	137.3
75	28%	-	12-leaf	2.74	1.11	0.57	81.6	38.0	119.6
75	AA	Dwell	ppl	3.05	1.30	0.76	117.3	63.1	180.4
75	28%	Dwell	ppl	2.77	1.22	0.62	103.4	46.1	149.5
75	AA	N-S	ppl	3.02	1.37	0.84	126.5	74.7	201.2
75	28%	N-S	ppl	2.76	1.15	0.50	94.2	37.9	132.1
150	AA	-	ppl	3.31	1.37	0.84	125.0	66.6	191.5
150	AA	-	8-leaf	2.96	1.29	0.62	113.2	44.5	157.8
150	AA	-	12-leaf	2.84	1.25	0.84	109.2	54.5	163.6
150	Urea	-	ppl	3.10	1.35	0.72	121.0	57.4	178.3
150	28%	-	ppl	3.14	1.39	0.86	125.8	66.8	192.6
150	28%	-	8-leaf	2.94	1.36	0.64	119.7	46.3	166.0
150	28%	-	12-leaf	2.91	1.32	0.78	115.7	55.6	171.3
150	AA	Dwell	ppl	3.11	1.46	0.78	136.5	63.2	199.7
150	Urea	Dwell	ppl	3.02	1.34	0.68	124.2	56.0	180.1
150	28%	Dwell	ppl	3.18	1.47	0.76	132.7	60.7	193.4
150	AA	N-S	ppl	3.32	1.41	1.00	128.8	79.5	208.3
150	Urea	N-S	ppl	3.20	1.34	0.67	120.9	58.6	179.5
150	28%	N-S	ppl	3.04	1.28	0.79	112.9	63.7	176.6
150	Urea	OAC-48988	ppl	3.12	1.38	0.77	124.4	67.2	191.6
Significance				**	**	**	**	**	**
BLSD (.05)				0.20	0.10	0.16	11.2	14.0	20.7

Factorial Arrangement (Excludes check, and urea treatments)

	Leaf	Silage Grain	Stover	Grain	Stover§	Total
N-Rate #/A						
75	2.91	1.24	0.67	108.4	52.1	160.5
150	3.18	1.40	0.84	126.9	66.7	193.7
Significance	**	**	**		**	
N-Form						
AA	3.13	1.35	0.81	123.3	65.3	188.6
28%	2.96	1.29	0.70	112.0	53.6	165.6
Significance	**					
Inhibitor						
None	3.08	1.30	0.74	114.9	56.0	170.9
Dwell	3.03	1.36	0.73	122.4	58.3	180.7
N-Serve	3.03	1.30	0.78	115.6	63.9	179.6
Significance	NS		NS		NS	NS
N-Rate X N-Form	NS	NS	NS	*	NS	*
N-Rate X Ihnibitor	NS	NS	NS	NS	NS	NS
N-Form X Inhibitor	NS	**	**	**	**	*
Rate X Form X Inhibitor	NS	NS	NS	NS	NS	NS

Table 2 continued on next page

Table 1 continued

Treatments				Grain	Dry Matter Production			
N-Rate	N-Form	Inh.	Time	Yields	Grain	Cob	Stover	Total
#/A				Bu/A	- - - - - -		T/A - - - - - - -	
Factorial Arrangement (Excludes check, urea, and inhibitor treatments)								
	N-Rate #/A							
	75			172.3	4.07	0.51	2.88	7.47
	150			187.7	4.44	0.62	3.01	8.08
	Significance				**	**	*	**
	N-Form							
	AA			181.1	4.28	0.58	2.91	7.78
	28%			178.9	4.23	0.55	2.99	7.78
	Significance			NS	NS	NS	NS	NS
	Time							
	ppl			186.7	4.42	0.61	3.13	8.16
	8-leaf			178.5	4.22	0.56	2.92	7.70
	12-leaf			174.8	4.14	0.52	2.80	7.46
	Significance				**	**	**	**
	N-Rate X N-Form			NS	NS	NS	NS	NS
	N-Rate X Time			NS	NS	NS	NS	NS
	N-Form X Time			NS	NS	NS	NS	NS
	Rate X Form x Time			*	NS	NS	NS	NS

Table 2 continued

Treatments				N-Content			N-Removal		
					Silage				
N-Rate	N-Form	Inh.	Time	Leaf	Grain	Stover	Grain	Stover§	Total
#/A				- - - -	% - - - - - -		- - - - -	-lbs/A- - - - -	
Factorial Arrangement (Excludes check, urea, and inhibitor treatments)									
	N-Rate #/A								
	75			2.90	1.18	0.61	97.0	41.7	138.7
	150			3.02	1.32	0.76	118.1	55.7	173.8
	Significance				**		**		**
	N-Form								
	AA			2.99	1.26	0.69	107.9	48.5	156.4
	28%			2.93	1.26	0.68	107.1	48.9	156.1
	Significance			NS	NS	NS	NS	NS	NS
	Time								
	ppl			3.08	1.30	0.74	114.9	56.0	171.0
	8-leaf			2.93	1.26	0.62	106.4	42.9	149.3
	12-leaf			2.87	1.22	0.70	101.3	47.2	148.5
	Significance				*		**		**
	N-Rate X N-Form			NS	NS	*	NS	NS	NS
	N-Rate X Time			*	NS	*	NS	*	NS
	N-Form X Time			NS	NS	NS	NS	NS	NS
	Rate X Form X Time			NS	NS	NS	NS	NS	NS

§ = Stover includes cob + stover N-Removal
AA = Anhydrous Ammonia
28% = 28% nitrogen solution

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

G.L. Malzer, J. Orf, F. Bergsrud, J. Geadelmann and T. Graff

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

EXPERIMENTAL PRODCEDURES

Corn - Experimental Treatment - An experiment consisting of four replications of nine treatements, was arranged in a randomized complete block design. A factorial arrangement consisting of two fertilizer application rates, two varieties 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 utilized were Pioneer 3901 and Pioneer 3978. The control treatment received 220 lbs N/A and was planted with Pioneer 3901 at the plant population of 28,000 plants/A.

Soybean - Experimental Treatments - This experiment was adjacent to the corn trial, and was the experimental area used in the 1981 corn experiment. The soybean experiment consisted of nine treatments, with four replications, and was arranged in a randomized complete block design. A factorial arrangement consisting of two fertilizer application rates, two plant population and two varieties were combined with a control plot receiving no fertilzer treatment. The fertilizer variables included treatments of 0 + 60 + 220 and an application 50% higher of 0 + 90 + 330. Plant population included rates of 5 and 10 seed/ft of row in 14 inch rows. The two varieties utilized were Hodgson-78 and Simpson. The control treatment was planted to Hodgson-78 at a population of 5 seeds/ft of row.

MANAGEMENT AND CULTURAL PRACTICES

Prior to planting potassium magnesium sulfate (300 #/A 0-0-22) was broadcast over both experiemental areas. Boron (2 #/A as Borate 68) was applied with the phosphorus and potassium treatments to the soybean plots, with the check plots therefore receiving a boron application. Boron was applied as a split application with the nitrogen fertilzer with 1 #/A applied at planting and an additional 1 #/A at the 12 leaf growth stage. Nitrogen was applied to the corn as broadcast applications of urea throughout the season with 1/6 of the nitrogen applied preplant (April 27), 1/6 at the 8-leaf (June 9), 3/6 at the 12-leaf (June 24) and the last 1/6 at tasseling. Due to the difference in the maturity rates, the tasseling treatments were applied on July 6 for Pioneer 3978 and on July 14 for Pioneer 3901. A nitrification inhibitor (N-Serve-Dow Chemical was applied at 0.5 # ai/A with the preplant nitrogen application. Starter fertilzer was applied at the rate of 165 # 8-10-30 banded before planting to mark the rows. Corn (Pioneer 3978 - 85 day relative maturity and Pioneer 3901 - 100 day relative maturity) was hand planted into the experimental area on May 3. Weed control was accomplished utilizing Lasso (2 # ai/A) and mechanically as needed. The insecticide Sevin (1 # ai/A) was used on June 18 to minimize damage from corn bore.

Leaf samples from opposite and below the ear at mid-silking were taken on July 14 for Pioneer 3978 and on July 19 for Pioneer 3901. Samples were dried, ground and analyzed for elemental concentrations. Total dry matter production was determined on September 17 by hand harvesting 50 ft^2. Ears were separated from the stalks, field weight obtained, and samples removed for moisture determination and elemental concentration. Corn grain yields were taken on October 4 by hand harvesting 100 ft^2. Final grain yield estimates were obtained by considering the total 150 ft^2 area harvested. Grain yields were adjusted to 15.5% moisture. The irrigation program was started on June 9th and continued through August 26 with a total of 10.25 inches of water being applied through irrigation. An additional 18.8 inches of water was obtained during the growing season through rainfall. The soybeans (Hodgson-78 and Simpson-medium to late maturing) were planted on May 19 utilizing a cone seeder. Leaf samples from the first mature soybean trifoliate were taken on July 29, dried ground and analyzed for elemental concentration. Soybean grain yields were adjusted to 13% moisture. The irrigation program for the soybeans was started on July 2 and continued through August 26 with a total of 9.75 inches of water being applied through irrigation. An additional 17.28 inches of water was obtained during the growing season through rainfall. Weed control was accomplished with Treflan (1/2 # ai/A) and Amiben (1/2 # ai/A) and mechanically as needed.

GENERAL RESULTS

The results obtained from the corn and soybean research experiments conducted in 1982 are contained in tables 1-6. The yields for both corn and soybeans were excellent in 1982 with record yields being established for both crops. Corn grain yields were not increased by "extra high" fertilzation rates. Grain yields were not highly influenced by variety although there was a significant (.05) variety x population interaction. Pioneer 3901 yields were increased when the population was increased from 28,000 ppa to 42,000 ppa, while Pioneer 3978 yields were not increased. Plant population and variety appeared to be the two major factors influencing growth and nutrient uptake parameters. Although yields between the two varieties were similar, Pioneer 3978 tended to drier, produced less stover and in general leaf nutrient concentrations were higher (especially N, K and kCA). Total nutrient removal by the two varieties was either equal or significantly lower for Pioneer 3978 than it was for Pioneer 3901. This was especially noted for N, P, and K removal. In general, increased plant populations increased stover production, increased grain yield but only for Pioneer 3901, increased moisture content, decreased nutrient concentrations for N and P, but increased total nutrient removal of N and K.

Soybean yields were significantly influenced by variety with Hodgson-78 being superior to Simpson. Plant population and fertility variables did not influence grain yield. Leaf nutrient concentrations were influenced by both variety and plant population. Simpson tended to have equal or lower elemental concentrations in the leaves while increased plant population tended to result in equal or lower nutrient concentrations.

Table 1. Influence of fertilizer treatment, variety and plant population on corn forage production, grain yield and grain nitrogen. Becker, MN 1982.

Treatments					Corn Forage Production								Harvest Grain	
N	P_2O_5	K_2O	Plant pop.	Variety	D.M. Grain	D.M. Stover	Barren Stalks	Shelling	Grain N Content	Grain	Stover	Total	D.M. Grain	Yield
----#/A----					--------%				--------	---------T/A		-------	%	Bu/A
220	0	0	28	P3901	60.7	23.9	3.9	85.6	1.50	4.75	4.18	8.93	67.3	200.8
220	60	220	28	P3901	60.4	23.7	5.5	87.1	1.50	4.56	4.04	8.59	67.4	192.6
220	60	220	28	P3978	65.0	29.8	2.4	89.3	1.36	4.66	3.23	7.89	74.6	194.9
220	60	220	42	P3901	59.5	23.5	2.9	88.1	1.39	4.94	4.62	9.56	67.0	208.8
220	60	220	42	P3978	63.6	27.6	7.2	88.6	1.32	4.53	3.67	8.20	73.4	191.5
330	90	330	28	P3901	60.2	23.4	2.2	88.1	1.45	4.63	4.28	8.91	68.0	195.8
330	90	330	28	P3978	64.5	29.0	3.2	88.5	1.34	4.62	3.13	7.75	74.0	195.2
330	90	330	42	P3901	59.3	22.9	6.2	87.9	1.37	4.73	4.55	9.29	67.0	200.1
330	90	330	42	P3978	63.3	28.5	7.5	88.8	1.28	4.74	3.98	8.72	73.0	200.4
Significance					**	**	NS	**	**	*	**	**	**	*
BLSD (.05)					1.1	1.1	--	1.0	0.12	0.24	0.31	0.42	0.8	10.0
Factorial Statistics														
Variety														
Pioneer 3901					59.8	23.4	4.2	87.8	1.43	4.72	4.37	9.09	67.3	199.3
Pioneer 3978					64.1	28.7	5.1	88.8	1.32	4.64	3.45	8.14	73.8	195.5
Significance					**	**	NS	**	**	NS	**	**	**	NS
Population (plants per acre)														
28,000					62.5	26.4	3.3	88.2	1.41	4.62	3.67	8.28	71.0	194.6
42,000					61.4	25.6	6.0	88.4	1.34	4.74	4.20	8.94	70.1	200.2
Significance					**	*	+	NS	**	*	**	**	**	*
Fertility														
220 + 60 + 220					62.1	26.2	4.5	88.3	1.39	4.67	3.89	8.56	70.6	196.9
330 + 90 + 330					61.8	25.9	4.8	88.3	1.36	4.68	3.98	8.67	70.5	197.9
Significance					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Variety X Population														
Pioneer 3901			28		60.3	23.5	3.8	87.6	1.47	4.59	4.16	8.75	67.7	194.2
Pioneer 3978			28		64.7	29.4	2.8	88.9	1.35	4.64	3.18	7.82	74.3	195.1
Pioneer 3901			42		59.4	23.2	4.6	88.0	1.38	4.84	4.59	9.42	67.0	204.4
Pioneer 3978			42		63.4	28.1	7.4	88.7	1.30	4.64	3.82	8.46	73.2	196.0
Significance					NS	NS	NS	NS	NS	*	NS	NS	NS	*
Variety X Fertility														
Pioneer 3901			220+60+220		59.9	23.6	4.2	87.6	1.44	4.75	4.33	9.08	67.2	200.7
Pioneer 3978			220+60+220		64.3	28.7	4.8	89.0	1.34	4.60	3.45	8.04	74.0	193.2
Pioneer 3901			330+90+330		59.8	23.2	4.2	88.0	1.41	4.68	4.42	9.10	67.5	197.9
Pioneer 3978			330+90+330		63.9	28.7	5.4	88.6	1.31	4.68	3.55	8.23	73.5	197.8
Significance					NS	NS	NS	NS	NS	NS	NS	NS	*	NS
Population X Fertility														
28			220+60+220		62.7	26.8	3.9	88.2	1.43	4.61	3.63	8.24	71.0	193.7
42			220+60+220		61.5	25.6	5.1	88.4	1.35	4.74	4.15	8.88	70.2	200.2
28			330+90+330		62.4	26.2	2.7	88.3	1.40	4.62	3.70	8.33	71.0	195.5
42			330+90+330		61.3	25.7	6.9	88.3	1.32	4.74	4.26	9.00	70.0	200.2
Significance					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Variety X Pop. X Fertility														
Significance					NS	NS	NS	+	NS	*	*	*	NS	*

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 - 1982.

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	P3901	3.15	0.32	2.33	0.53	0.41	52	118	57	73	26	18	15
220	60	220	28	P3901	3.12	0.33	2.80	0.45	0.31	51	116	57	66	26	16	14
220	60	220	28	P3978	3.37	0.32	3.55	0.54	0.28	63	134	48	62	28	17	12
220	60	220	42	P3901	2.97	0.31	2.65	0.46	0.31	51	112	58	67	25	15	15
220	60	220	42	P3978	3.02	0.28	3.55	0.48	0.26	56	124	53	58	26	16	15
330	90	330	28	P3901	2.96	0.34	2.92	0.40	0.27	56	118	58	70	26	15	16
330	90	330	28	P3978	3.15	0.30	3.58	0.54	0.27	58	129	49	65	28	17	14
330	90	330	42	P3901	2.65	0.31	2.98	0.43	0.29	56	114	61	70	26	14	17
330	90	330	42	P3978	3.11	0.30	3.56	0.53	0.27	55	130	49	67	27	17	17
Significance					**	**	**	**	**	NS	**	**	NS	NS	**	NS
BLSD (.05)					0.28	0.01	0.17	0.04	0.02	--	7	5	--	--	1	--
Factorial Statistics																
Variety																
Pioneer 3901					2.92	0.32	2.83	0.44	0.29	53	115	58	68	26	15	16
Pioneer 3978					3.16	0.30	3.56	0.52	0.27	58	129	49	63	27	17	14
Significance					**	**	**	**	**	*	**	**	*	*	**	NS
Population (plants per acre)																
28,000					3.15	0.32	3.21	0.48	0.28	57	124	53	66	27	16	14
42,000					2.94	0.30	3.18	0.47	0.28	54	120	55	65	26	16	16
Significance					**	**	NS	NS	NS	NS	*	+	NS	NS	NS	NS
Fertility																
220 + 60 + 220					3.12	0.31	3.13	0.48	0.29	55	122	54	63	26	16	14
330 + 90 + 330					2.97	0.32	3.26	0.48	0.28	56	123	54	68	27	16	16
Significance					*	NS	*	NS	*	NS	NS	NS	+	NS	NS	NS
Variety X Population																
Pioneer 3901 28					3.04	0.34	2.86	0.43	0.29	53	117	57	68	26	16	15
Pioneer 3978 28					3.26	0.31	3.56	0.54	0.28	60	131	48	63	28	17	13
Pioneer 3901 42					2.81	0.31	2.81	0.45	0.30	58	113	60	68	25	15	16
Pioneer 3978 42					3.06	0.29	3.55	0.50	0.27	58	127	51	62	27	16	16
Significance					NS	NS	NS	+	+	NS	NS	NS	NS	NS	NS	NS
Variety X Fertility																
Pioneer 3901 220+60+220					3.04	0.32	2.72	0.46	0.31	51	114	57	67	26	16	15
Pioneer 3978 220+60+220					3.19	0.30	3.55	0.51	0.27	59	129	50	60	27	17	13
Pioneer 3901 330+90+330					2.80	0.33	2.95	0.42	0.28	56	116	60	70	26	15	17
Pioneer 3978 330+90+330					3.13	0.30	3.57	0.53	0.27	56	129	49	66	28	17	15
Significance					NS	NS	*	**	*	+	NS	NS	NS	NS	NS	NS
Population X Fertility																
28 220+60+220					3.24	0.32	3.17	0.50	0.30	57	125	52	64	27	17	13
42 220+60+220					3.00	0.30	3.10	0.47	0.28	53	118	56	62	26	15	15
28 330+90+330					3.06	0.32	3.25	0.47	0.27	57	123	53	67	27	16	15
42 330+90+330					2.88	0.31	3.26	0.48	0.28	55	122	55	68	27	15	16
Significance					NS	*	NS	+	+	NS	NS	NS	NS	NS	NS	NS
Variety X Pop. X Fertility																
Significance					+	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Influence of fertilizer treatment, variety, and plant population on the elemental concentration of forage grain at physiological maturity. Becker, MN - 1982.

Treatments					Forage Grain 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	P3901	1.50	0.25	0.32	.002	0.12	0.56	17	6	5	21	2	5
220	60	220	28	P3901	1.50	0.28	0.35	.002	0.13	0.57	19	9	6	22	2	6
220	60	220	28	P3978	1.36	0.23	0.35	.003	0.11	0.56	18	6	5	23	3	5
220	60	220	42	P3901	1.39	0.23	0.31	.003	0.11	0.56	16	7	5	19	3	6
220	60	220	42	P3978	1.32	0.19	0.31	.003	0.09	0.75	14	6	4	18	2	5
330	90	330	28	P3901	1.45	0.27	0.34	.002	0.12	0.87	17	8	6	21	3	6
330	90	330	28	P3978	1.34	0.18	0.30	.003	0.08	1.12	13	8	4	18	3	5
330	90	330	42	P3901	1.37	0.25	0.33	.003	0.12	0.63	18	5	6	22	3	5
330	90	330	42	P3978	1.28	0.22	0.33	.003	0.10	0.56	16	10	5	21	3	6
Significance					**	**	+	**	**	NS	*	NS	*	*	NS	NS
BLSD (.05)					0.12	0.05	0.02	.001	0.02	--	4	--	1	4	--	--
Factorial Statistics																
Variety																
Pioneer 3901					1.43	0.26	0.33	.002	0.12	0.66	18	7	6	21	3	6
Pioneer 3978					1.32	0.20	0.32	.003	0.10	0.75	15	7	5	20	2	5
Significance					**	**	NS	**	**	NS	**	NS	**	NS	NS	*
Population (plants per acre)																
28,000					1.41	0.24	.34	.002	0.11	0.78	16	8	5	21	2	5
42,000					1.34	0.22	.32	.003	0.10	0.63	16	7	5	20	2	5
Significance					**	NS	NS	**	NS	NS	NS	NS	NS	NS	NS	NS
Fertility																
220 + 60 + 220					1.39	0.23	0.33	.003	0.11	0.61	17	7	5	20	2	5
330 + 90 + 330					1.36	0.23	0.32	.003	0.11	0.80	16	8	5	21	3	5
Significance					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Variety X Population																
Pioneer 3901			28		1.47	0.27	0.34	.002	0.13	0.72	18	8	6	21	3	6
Pioneer 3978			28		1.35	0.21	0.33	.003	0.10	0.84	15	7	5	20	3	5
Pioneer 3901			42		1.38	0.24	0.32	.003	0.11	0.60	17	6	5	21	3	5
Pioneer 3978			42		1.30	0.20	0.32	.003	0.10	0.66	15	8	5	20	2	5
Significance					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	+
Variety X Fertility																
Pioneer 3901			220+60+220		1.44	0.25	0.33	.002	0.12	0.57	18	8	5	21	3	6
Pioneer 3978			220+60+220		1.34	0.21	0.33	.003	0.10	0.66	16	6	5	20	2	5
Pioneer 3901			330+90+330		1.41	0.26	0.33	.002	0.12	0.75	17	7	6	22	3	5
Pioneer 3978			330+90+330		1.31	0.20	0.32	.003	0.10	0.84	14	9	5	20	3	5
Significance					NS	NS	NS	NS	NS	NS	NS	+	NS	NS	NS	NS
Population X Fertility																
28			220+60+220		1.43	0.25	0.35	.002	0.12	0.57	18	8	6	22	3	5
42			220+60+220		1.35	0.21	0.31	.003	0.10	0.66	15	6	4	19	2	5
28			330+90+330		1.40	0.22	0.32	.002	0.10	0.99	15	8	5	20	3	5
42			330+90+330		1.32	0.23	0.33	.003	0.11	0.60	17	8	5	22	3	5
Significance					NS	*	*	NS	*	+	**	NS	*	**	NS	NS
Variety X Pop. X Fertility																
Significance					NS	NS	NS	NS	NS		NS	NS	NS	NS	NS	+

Table 4. Influence of fertilizer treatment variety and plant population on the elemental concentration of forage stover at physiological maturity. Becker, MN - 1982.

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	P3901	0.72	0.05	1.95	0.31	0.24	239	273	60	52	25	10	32
220	60	220	28	P3901	0.78	0.05	2.25	0.32	0.18	119	111	66	45	17	9	15
220	60	220	28	P3978	0.69	0.05	2.45	0.38	0.23	168	141	55	60	14	7	15
220	60	220	42	P3901	0.78	0.05	2.66	0.33	0.18	133	120	64	52	14	9	14
220	60	220	42	P3978	0.79	0.06	2.53	0.40	0.23	176	177	61	60	13	7	15
330	90	330	28	P3901	0.84	0.05	2.73	0.33	0.17	168	147	66	62	15	8	17
330	90	330	28	P3978	0.68	0.05	2.53	0.38	0.21	178	152	56	62	13	7	16
330	90	330	42	P3901	0.94	0.05	3.04	0.33	0.18	169	170	77	57	17	8	16
330	90	330	42	P3978	0.69	0.04	2.71	0.32	0.20	138	129	55	62	11	6	15
Significance					**	NS	**	NS	**	NS	NS	NS	NS	NS	*	NS
BLSD (.05)					0.09	--	0.36	--	0.04	--	--	--	--	--	3	--
Factorial Statistics																
Variety																
Pioneer 3901					0.84	0.05	2.67	0.33	0.18	147	137	68	54	16	8	15
Pioneer 3978					0.71	0.05	2.56	0.37	0.22	165	150	57	61	12	7	15
Significance					**	NS	NS	NS	**	NS	NS	*	NS	*	**	NS
Population (Plants per acre)																
28,000					0.75	0.05	2.49	0.35	0.20	158	138	60	57	14	8	16
42,000					0.80	0.05	2.73	0.35	0.20	153	149	64	57	14	8	15
Significance					*	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fertility																
220 + 60 + 220					0.76	0.05	2.47	0.36	0.20	149	173	61	54	14	8	14
330 + 90 + 330					0.79	0.05	2.75	0.34	0.19	163	150	64	60	14	7	16
Significance					NS	NS	**	NS	NS	NS	NS	NS	NS	NS	NS	NS
Variety X Population																
Pioneer 3901 28					0.81	0.05	2.49	0.32	0.17	143	129	66	53	16	9	16
Pioneer 3978 28					0.69	0.05	2.49	0.38	0.22	173	147	55	61	13	7	16
Pioneer 3901 42					0.86	0.05	2.85	0.33	0.18	151	145	71	54	15	8	15
Pioneer 3978 42					0.74	0.05	2.62	0.36	0.21	157	153	58	61	12	7	15
Significance					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Variety X Fertility																
Pioneer 3901 220+60+220					0.78	0.05	2.45	0.32	0.18	126	115	65	49	15	9	14
Pioneer 3978 220+60+220					0.74	0.05	2.49	0.39	0.23	172	159	58	60	13	7	15
Pioneer 3901 330+90+330					0.89	0.05	2.89	0.33	0.17	168	159	72	59	16	8	16
Pioneer 3978 330+90+330					0.69	0.04	2.62	0.35	0.21	158	141	55	62	12	6	15
Significance					**	NS	NS	NS	NS	*	*	NS	NS	NS	NS	NS
Population X Fertility																
28 220+60+220					0.74	0.05	2.35	0.35	0.20	144	126	60	53	15	8	15
42 220+60+220					0.78	0.05	2.59	0.36	0.20	154	149	63	56	13	8	14
28 330+90+330					0.76	0.05	2.63	0.36	0.19	173	149	61	62	14	7	16
42 330+90+330					0.81	0.04	2.88	0.33	0.19	153	150	66	59	14	7	16
Significance					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Variety X Pop X Fertility																
Significance					*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 5. Influence of fertilizer treatment, variety and plant population on the total elemental removal of corn at physiological maturity. Becker, MN - 1982.

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	P3901	202.8	27.5	193.1	26.7	31.6	2.1	2.5	0.6	0.5	0.41	0.11	0.31
220	60	220	28	P3901	199.3	29.3	213.3	25.8	26.2	1.0	1.1	0.6	0.4	0.33	0.09	0.17
220	60	220	28	P3978	171.8	24.8	190.6	25.0	25.1	1.1	1.1	0.4	0.4	0.30	0.07	0.14
220	60	220	42	P3901	209.0	27.6	275.8	31.0	27.1	1.2	1.3	0.6	0.5	0.31	0.10	0.18
220	60	220	42	P3978	177.2	21.1	212.7	29.4	24.4	1.3	1.4	0.5	0.5	0.26	0.07	0.15
330	90	330	28	P3901	207.0	29.3	264.5	29.3	25.9	1.5	1.4	0.6	0.6	0.33	0.09	0.19
330	90	330	28	P3978	166.4	19.5	186.0	24.0	20.9	1.1	1.1	0.4	0.4	0.24	0.06	0.15
330	90	330	42	P3901	215.2	28.2	308.6	30.5	27.6	1.5	1.7	0.8	0.6	0.36	0.10	0.20
330	90	330	42	P3978	175.4	23.6	246.9	25.9	25.7	1.1	1.2	0.5	0.5	0.28	0.08	0.17
Significance					**	**	**	NS	*	NS	NS	**	NS	*	**	NS
BLSD (.05)					17.5	5.0	25.6	--	5.1	--	--	0.2	--	0.11	0.02	--
Factorial Statistics																
Variety																
Pioneer 3901					207.6	28.6	265.6	29.1	26.7	1.3	1.4	0.7	0.5	0.33	0.10	0.19
Pioneer 3978					172.7	22.2	209.1	26.1	24.0	1.3	1.2	0.5	0.5	0.27	0.07	0.15
Significance					**	**	**	NS	*	NS	NS	**	NS	**	**	**
Population (plants per acre)																
28,000					186.1	25.7	213.6	26.0	24.5	1.2	1.2	0.5	0.5	0.30	0.08	0.16
42,000					194.2	25.1	261.0	29.2	26.2	1.3	1.4	0.6	0.5	0.30	0.09	0.18
Significance					**	NS	**	NS	*	NS	+	+	NS	**	**	**
Fertility																
220 + 60 + 220					189.4	25.7	223.1	27.8	25.7	1.1	1.2	0.5	0.5	0.30	0.08	0.16
330 + 90 + 330					191.0	25.2	231.5	27.4	25.0	1.3	1.3	0.6	0.5	0.30	0.08	0.18
Significance					NS	NS	**	NS	NS	NS	NS	NS	NS	NS	NS	+
Variety X Population																
Pioneer 3901 28					203.2	29.3	238.9	27.6	26.0	1.2	1.2	0.6	0.5	0.33	0.09	0.18
Pioneer 3978 28					169.1	22.2	188.3	24.5	23.0	1.1	1.1	0.4	0.4	0.27	0.07	0.14
Pioneer 3901 42					212.1	27.9	292.2	30.7	27.3	1.4	1.5	0.7	0.5	0.34	0.10	0.19
Pioneer 3978 42					176.3	22.3	229.8	27.6	25.0	1.2	1.3	0.5	0.5	0.27	0.07	0.16
Significance					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Variety X Fertility																
Pioneer 3901 220+60+220					204.2	28.4	244.6	28.4	26.6	1.1	1.2	0.6	0.5	0.32	0.10	0.18
Pioneer 3978 220+60+220					174.5	23.0	201.7	27.2	24.8	1.2	1.2	0.5	0.5	0.28	0.07	0.15
Pioneer 3901 330+90+330					211.1	28.8	286.5	29.9	26.7	1.5	1.6	0.7	0.6	0.35	0.10	0.19
Pioneer 3978 330+90+330					170.9	21.6	216.5	25.0	23.3	1.1	1.1	0.4	0.5	0.26	0.07	0.16
Significance					NS	NS	+	NS	NS	*	*	NS	NS	NS	NS	NS
Population X Fertility																
28 220+60+220					185.6	27.1	202.0	25.4	25.6	1.0	1.1	0.5	0.4	0.32	0.08	0.16
42 220+60+220					193.1	24.3	244.3	30.2	25.8	1.3	1.3	0.6	0.5	0.29	0.09	0.17
28 330+90+330					186.7	24.4	225.3	26.7	23.4	1.3	1.2	0.5	0.5	0.29	0.08	0.17
42 330+90+330					195.3	25.9	277.7	28.2	26.6	1.3	1.4	0.6	0.6	0.32	0.09	0.18
Significance					NS	+	NS	NS	NS	NS	NS	NS	NS	*	NS	NS
Variety X Pop. X Fertility																
Significance					NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS	NS

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 - 1982.

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	66.8	5.41	0.54	2.72	0.85	0.44	36	119	13	107	47	15	72
0	60	220	5	H	67.7	5.11	0.55	3.50	0.81	0.40	35	103	14	101	45	13	70
0	60	220	5	S	55.0	5.15	0.49	3.28	0.80	0.40	36	109	13	91	46	14	69
0	60	220	10	H	66.5	4.98	0.44	2.67	0.82	0.42	43	123	19	106	44	12	84
0	60	220	10	S	56.6	4.58	0.40	2.92	0.79	0.40	43	109	17	89	39	12	74
0	90	330	5	H	69.0	5.32	0.55	3.26	0.83	0.42	38	114	15	120	50	13	75
0	90	330	5	S	60.7	5.04	0.50	3.34	0.77	0.41	36	107	11	103	49	13	74
0	90	330	10	H	64.8	4.96	0.48	2.91	0.82	0.42	36	118	14	135	45	12	78
0	90	330	10	S	59.6	4.27	0.40	2.82	0.74	0.39	41	113	12	108	42	12	71
Significance					*	**	**	**	+	*	*	*	*	**	+	**	*
BLSD (0.5)					11.7	0.47	0.05	0.29	.05	0.03	7	13	4	23	8	1	11
Variety																	
Hodgson-78					67.0	5.09	0.51	3.09	0.82	0.42	38	114	15	115	46	12	77
Simpson					57.9	4.76	0.45	3.09	0.78	0.40	39	109	13	98	44	12	72
Significance					**	*	**	NS	**	*	NS	+	*	**	NS	NS	*
Population																	
5 plant/ft					63.1	5.15	0.52	3.34	0.80	0.41	36	108	13	104	47	13	72
10 plant/ft					61.9	4.70	0.43	2.83	0.79	0.41	41	115	15	109	42	12	77
Significance					NS	**	**	**	NS	NS	**	*	*	NS	**	**	**
Fertility																	
0 + 60 + 220					61.4	4.95	0.47	3.09	0.80	0.40	39	111	15	97	43	12	74
0 + 90 + 330					63.5	4.90	0.48	3.08	0.79	0.41	38	113	13	116	46	12	74
Significance					NS	NS	NS	NS	NS	NS	NS	NS	*	**	NS	NS	NS
Variety X Population																	
Hodgson-78			5/ft		68.3	5.21	0.55	3.38	0.82	0.41	36	109	14	110	47	13	72
Simpson			5/ft		57.8	5.10	0.49	3.31	0.79	0.40	36	108	12	97	47	13	71
Hodgson-78			10/ft		65.6	4.97	0.46	2.79	0.82	0.42	40	120	16	120	44	12	81
Simpson			10/ft		58.1	4.42	0.40	2.87	0.77	0.39	42	110	14	99	40	12	73
Significance					NS	+	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	+
Variety X Fertility																	
Hodgson-78			0+60+220		67.1	5.04	0.50	3.09	0.81	0.41	39	113	16	104	44	12	77
Simpson			0+60+220		55.8	4.86	0.44	3.10	0.80	0.40	39	109	15	90	42	12	71
Hodgson-78			0+90+330		66.9	5.14	0.52	3.08	0.83	0.42	37	116	14	127	48	13	76
Simpson			0+90+330		60.1	4.66	0.45	3.08	0.76	0.40	38	110	12	106	45	12	73
Significance					NS	NS	NS	NS	+	NS	NS	NS	NS	NS	NS	NS	NS
Population X Fertility																	
5/ft			0+60+220		61.3	5.13	0.52	3.39	0.80	0.40	35	106	14	96	45	13	69
10/ft			0+60+220		61.5	4.78	0.42	2.79	0.80	0.41	43	116	18	98	41	12	79
5/ft			0+90+330		64.8	5.18	0.53	3.30	0.80	0.42	37	110	13	111	49	13	74
10/ft			0+90+330		62.2	4.62	0.44	2.87	0.78	0.41	39	115	13	121	44	12	74
Significance					NS	NS	NS	NS	NS	NS	+	NS	*	NS	NS	NS	*
Variety X Pop. X Fertility																	
Significance					NS	NS	NS	+	NS	NS	NS	+	NS	NS	NS	NS	NS

MICRONUTRIENT FERTILIZATION OF POTATOES AND CORN UNDER IRRIGATION

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

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

Experimental Procedures

Seven treatments, including a control, four micronutrient treatments, and two macronutrient treatments were established in a randomized complete block design with four replications. Rates and types of fertilizer included: 5 lbs. of Copper/A as $CuSO_4 5H_2O$, 2 lbs. of Boron/A as Borax 68, 25 lbs. of Sulfur/A as $CaSO_4$, 75 lbs. of Magnesium as $MgCl_2$, 10 lbs. of Zinc/A as $ZnCl_2$ and 3 lbs. of Manganese/A as $MnCl_2$. Application of materials were made to the same plots as in the past 4 years. The corn and potato areas were rotated in 1982 so the corn was planted in the 1981 potato area (four replication) and potatoes were planted into the corn area, (four replications of each variety).

Fertilizer treatments were broadcast, incorporated by plowing on April 20, and the potatoes planted on April 22. Norlands were planted in 9 inch spacing utilizing 36 inch rows, while Russet Burbanks were planted in 12 inch spacing with the same row width. A starter was used at the rate of 1000 lbs/A of 8-10-30 and the insecticide Temik 15 G was banded at 14 #/A at planting time. A tank mix of Lorox 2 # ai/A and Lasso 2 # ai/A was used for weed control. Sidedressing treatments of nitrogen were made on May 24 (190 #/A 34-0-0) and on June 8 (200 #/A 34-0-0), along with hilling at the last sidedressing. Samples of the youngest mature potato leaves were obtained 82 days after planting for nutrient concentration. The Norland potatoes were harvested on September 7 and the Russet Burbanks on September 30. Irrigation water was applied during the period of June 4 through August 25 with a total addition of 13.50 inches. Precipitation during the growing season was 14.28 inches for the Norlands and 17.03 inches for the Russet Burbanks. Utilizing the 1981 potato experiment area, four replications of the aforementioned treatments were planted to corn. The experimental area had been fertilzed with 800 lbs./A 8-10-30 prior to planting on May 3. A commercial corn variety (Pioneer 3901) was planted in 30" rows at a population of 30,700 seeds/A. Starter fertilizer at the rate of 165 lbs/A of 8-10-30 was banded at planting. Lasso at (2 # ai/A) was used for weed control. The insecticide Sevin (1 # ai/A) was used on June 28 to minimize corn bore damage. Sidedressing applications of nitrogen were made on May 25 (210 lbs/A 34-0-0) and on June 16 (300 lbs/A 34-0-0) for the season.

Leaf samples from opposite and below the ear at mid-silking were taken on July 19, dried, ground and analyzed for elemental concentrations. Total dry matter production was determined on September 17 by hand harvesting 50 ft^2. Ears wre separated from the stalks, field weights obtained, and samples removed for moisture determination and elemental concentration. Additional corn yield estimtates were taken on October 19 by hand harvesting an additional 100 ft^2. Final yield estimates for grain were obtained by considering the total 150 ft^2 harvested. Final grain yields were adjusted to 15.5% moisture. The irrigation program was started on June 11 and continued through August 25 with a total of 11.50 inches of water being applied through irrigation. An additional 21.05 inches of water was obtained during the growing season through rainfall.

GENERAL RESULTS

This concludes the fifth consecutive year for the establishement of these plots on the same experimental area. Yield of both the potatoes and the corn were excellent in 1982. Tuber yield increases were obtained with applications of zinc and manganese with the Norland variety, but no yield increases were obtained with any fertilizer treatment to the Russet Burbank potatoes. Leaf concentrations of zinc, copper and boron were significantly increased with the Norland variety when the respective treatments wre applied, but of these only zinc provided a yield response. Application of manganese did not increase the leaf concentration but did increase yield. The significant yield response to manganese with Norland potatoes should be viewed cautiously. Leaf concentrations of copper and boron were increased in the Russet Burbank variety, but these increases did not result in increased yields.

Corn yields and dry matter production were not increased by any fertilizer treatment in 1982. Nutrient concentrations in the leaf and silage dry matter components would suggest that zinc application resulted in increase availability and uptake of zinc. Previous soil tests in the experimental area indicate that zinc availabiity is marginal. Small and inconsistent yield responses to zinc have been obtained in this experiment in previous years.

Table 1. Influence of micronutrient fertilization (also Mg and S) on tuber yield and nutrient concentration on the youngest mature leaves 82 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
			Leaf Concentration											
	#/A	cwt/A	%					ppm						
			Norland Potatoes											
Control	-	459	4.24	0.31	5.41	2.29	0.89	68	110	77	327	16	14	30
Cu	5	454	4.01	0.33	5.32	2.08	0.78	58	106	72	366	18	22	31
B	2	489	4.36	0.34	5.34	2.13	0.83	71	131	72	390	19	16	43
S	25	458	4.12	0.31	5.50	2.21	0.84	66	117	49	312	18	14	30
Mg	75	493	3.90	0.33	5.19	1.88	0.88	56	109	62	307	20	15	32
Zn	10	500	4.30	0.35	5.33	2.20	0.85	55	121	71	337	28	15	32
Mn	3	504	4.32	0.33	5.38	2.24	0.90	66	121	57	340	19	14	33
Significance		*	*	NS	NS	NS	NS	NS	NS	NS	NS	**	**	**
BLSD (.05)		37	0.33	--	--	--	--	--	--	--	--	4	3	4
			Russet Burbank Potatoes											
Control	-	534	5.09	0.37	4.61	0.98	0.59	50	109	36	215	22	15	25
Cu	5	560	4.99	0.38	4.63	1.29	0.74	56	108	44	246	22	22	30
B	2	504	4.97	0.35	4.58	1.07	0.62	54	104	41	228	20	15	35
S	25	504	4.87	0.35	4.51	1.12	0.62	56	111	39	236	20	15	28
Mg	75	494	5.09	0.36	4.46	0.95	0.66	48	104	40	212	21	15	28
Zn	10	580	4.87	0.34	4.74	1.08	0.63	52	98	46	204	24	16	30
Mn	3	519	4.97	0.35	4.62	1.07	0.62	52	99	41	213	20	16	27
Significance		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**	**
BLSD (.05)		--	--	--	--	--	--	--	--	--	--	--	2	6

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

Treatment	Rate/A	Yield	Dry Matter Production: Stover	Grain	Cob	Total
	#/A	Bu/a	T/A			
Control	-	196.1	3.30	4.64	0.63	8.56
Cu	5	196.7	3.35	4.65	0.68	8.69
B	2	200.3	3.52	4.73	0.66	8.92
S	25	200.3	3.49	4.74	0.64	8.87
Mg	75	201.7	3.57	4.77	0.65	8.99
Zn	10	199.8	3.43	4.73	0.64	8.81
Mn	3	191.6	3.41	4.53	0.60	8.55
Significance		NS	NS	NS	NS	NS
BLSD (.05)		--	--	--	--	--

Table 3. Influence of micronutrient fertilization (also Mg and S) on the elemental concentration of silage stover, silage grain and 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	B
	#/A	------%					------ ppm						
Control	-	0.83	0.06	2.43	0.34	0.12	226	214	83	96	12	8	11
Cu	5	0.87	0.06	2.57	0.34	0.12	301	256	87	106	12	10	11
B	2	0.88	0.06	2.45	0.37	0.11	255	225	91	113	14	8	14
S	25	0.91	0.06	2.52	0.36	0.12	319	282	88	117	12	9	11
Mg	75	0.91	0.05	2.47	0.30	0.15	280	252	78	85	13	8	10
Zn	10	0.93	0.06	2.40	0.42	0.12	330	303	97	106	50	8	11
Mn	3	0.83	0.06	2.41	0.40	0.14	366	317	98	109	13	9	11
Significance		NS	NS	NS	NS	NS	NS	NS	NS	NS	**	NS	NS
BLSD (.05)		--	--	--	--	--	--	--	--	--	6	--	--
		Silage Grain											
Control	-	1.35	0.25	0.34	0.002	0.11	1	16	4	6	18	2	6
Cu	5	1.44	0.26	0.35	0.002	0.12	1	17	2	7	19	2	6
B	2	1.46	0.27	0.34	0.002	0.12	1	18	3	7	20	2	7
S	25	1.42	0.27	0.35	0.002	0.12	1	18	2	7	20	2	6
Mg	75	1.44	0.26	0.34	0.002	0.12	1	17	3	6	19	2	5
Zn	10	1.42	0.26	0.34	0.002	0.12	1	18	2	6	26	2	5
Mn	3	1.44	0.25	0.33	0.002	0.11	1	17	2	6	17	2	5
Significance		*	NS	NS	NS	NS	NS	NS	NS	NS	**	NS	NS
BLSD (.05)		0.07	--	--	--	--	--	--	--	--	2	--	--
		Leaf											
Control	-	3.09	0.31	2.73	0.52	0.18	55	119	81	127	24	13	
Cu	5	3.17	0.31	2.71	0.56	0.18	58	122	85	140	23	17	
B	2	3.15	0.31	2.85	0.51	0.18	61	122	84	136	23	14	
S	25	3.07	0.33	2.89	0.57	0.18	58	123	88	153	24	14	
Mg	75	3.04	0.32	2.64	0.54	0.27	58	121	91	111	24	13	
Zn	10	3.20	0.31	2.67	0.53	0.20	59	123	84	116	50	13	
Mn	3	3.11	0.31	2.72	0.54	0.20	58	120	81	124	23	14	
Significance		NS	NS	NS	NS	*	NS	NS	NS	NS	**	NS	
BLSD (.05)		--	--	--	--	0.06	--	--	--	--	6	--	

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

Treatment	Rate/A	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
		Total Elemental Removal											
		Silage Stover											
	#/A	lbs/A											
Control	-	65.7	4.4	191	26.5	9.2	1.7	0.43	0.65	0.76	0.09	0.07	0.08
Cu	5	70.0	4.8	208	27.1	9.7	2.4	0.51	0.70	0.84	0.10	0.08	0.09
B	2	73.4	4.8	205	31.0	9.6	2.2	0.45	0.76	0.95	0.12	0.07	0.11
S	25	75.6	4.9	209	30.1	9.8	2.7	0.56	0.73	0.97	0.10	0.08	0.09
Mg	75	77.2	4.5	209	25.8	13.2	2.4	0.50	0.66	0.72	0.11	0.06	0.09
Zn	10	76.3	5.1	196	33.9	10.0	2.7	0.61	0.79	0.86	0.41	0.07	0.09
Mn	3	66.9	4.8	193	31.8	11.3	3.1	0.63	0.80	0.89	0.10	0.08	0.09
Significance		NS	NS	NS	NS	NS	NS	NS	NS	NS	**	NS	NS
BLSD (.05)		--	--	--	--	--	--	--	--	--	0.05	--	--
		Silage Grain											
Control	-	125.7	23.7	31	0.20	10.3	0.01	0.15	0.04	0.06	0.17	0.02	0.06
Cu	5	134.0	24.8	33	0.22	11.2	0.01	0.16	0.02	0.06	0.18	0.02	0.05
B	2	138.4	25.5	33	0.23	11.1	0.01	0.17	0.03	0.07	0.19	0.02	0.06
S	25	135.1	25.2	33	0.22	11.1	0.01	0.17	0.02	0.07	0.19	0.02	0.06
Mg	75	137.3	24.6	32	0.20	11.1	0.01	0.16	0.03	0.05	0.18	0.02	0.05
Zn	10	134.4	24.7	32	0.22	11.1	0.01	0.17	0.02	0.06	0.25	0.02	0.05
Mn	3	132.0	22.8	30	0.21	9.8	0.01	0.16	0.02	0.05	0.16	0.02	0.05
Significance		NS	NS	NS	NS	NS	NS	NS	NS	NS	**	NS	NS
BLSD (.05)		--	--	--	--	--	--	--	--	--	0.03	--	--
		Total											
Control	-	191.4	28.2	222	26.7	19.5	1.7	0.58	0.69	0.82	0.26	0.09	0.14
Cu	5	204.0	29.6	240	27.3	20.9	2.4	0.67	0.73	0.91	0.28	0.10	0.14
B	2	211.8	30.3	237	31.2	20.7	2.2	0.62	0.79	1.02	0.31	0.10	0.18
S	25	210.7	30.2	241	30.3	20.8	2.7	0.73	0.75	1.04	0.30	0.10	0.15
Mg	75	214.5	19.2	241	26.0	24.3	2.4	0.67	0.69	0.78	0.29	0.09	0.14
Zn	10	210.6	29.9	228	34.1	21.2	2.7	0.77	0.81	0.92	0.66	0.09	0.14
Mn	3	199.0	27.7	223	32.0	21.1	3.1	0.79	0.82	0.94	0.27	0.10	0.14
Significance		NS	NS	NS	NS	NS	NS	NS	NS	NS	**	NS	*
BLSD (.05)		--	--	--	--	--	--	--	--	--	0.05	--	0.02

THE EFFECT OF TILLAGE, N RATE, AND NITRAPYRIN ON CORN GROWTH BECKER, MN. 1982

J. F. Moncrief, G. L. Malzer, J. A. True, M. J. O'Leary, and T. J. Graff

INTRODUCTION

Conservation tillage systems for corn production have become increasingly popular in recent years because of short term gains such as conservation of time, labor and energy. A more important consideration is the long term potential for soil and water conservation. If conservation tillage is to be readily adopted by farmers grain yields must be as high as those obtained with conventional tillage. It is generally conceded that increased N fertilization is required for conservation tillage. Researchers speculate that this is due to reduced mineralization or increased immobilization, denitrification and leaching. The purpose of this study is to evaluate the potential for increased N availability with nitrification inhibitors. If the reduction in N availability is primarily due to denitrification and/or leaching, recovery should be enhanced.

OBJECTIVES

1. To assess the effect of tillage on the availability of nitrogen to corn.

2. To evaluate the potential for increased N availability with nitrification inhibitors.

METHODS AND MATERIALS

The experimental plots are located on the Sand Plains Experiment Station at Becker, Minnesota. The soil is a Udorthentic Haploboroll, sandy, mixed (Hubbard, loamy sand). Soil properties are as follows: organic matter 40 Mg/ha, pH - 6.0, P - 100 kg/ha, and K - 275 kg/ha. Tillage was done during the last two weeks of April. Corn was planted (Pioneer 3901 - single cross, 100 day) on May 3 and 5 at a population of 75,000 plants/ha. Anhydrous ammonia was applied on May 10 at 0, 85, 170, and 340 kg/ha. Plots were split with an application of .56 kg/ha of nitrapyrin. Weeds were controlled with a pre-emergence application of Atrazine (2.2 kg/ha) and Alachlor (5 l/ha). Grain and stover yields were measured at physiological maturity and tissue samples analyzed for N.

The plot area was previously utilized for tillage-rotation study. The rotation variable was dropped in 1982. Alfalfa was grown in 1980 in a alfalfa, potatoes, corn, oats rotation. Residual N from this rotation treatment made it necessary to drop these plots from the analysis.

RESULTS AND DISCUSSION

The effect of tillage, nitrapyrin, and applied N on corn yield and N uptake is shown in table 1. The grain yields of corn grown under the no-till and till plant systems responded to the highest rate of applied N (340 kg/ha). The chisel and moldboard plow tillage showed a response maximum of about half this rate. A similar trend occurred with stover yield. Nitrogen uptake generally increased for all systems over the range of applied N studied. The corn grown under till plant tillage equalled grain yields with chisel or moldboard plow tillage but at twice the rate of applied N. The no-till system yielded less grain even at the 340 kg/ha N rate. Nitrogen removal by stover is similar at a given N rate regardless of tillage. Grain N removal at optimum N rates are also similar. This suggests (with high rates of applied N) corn grown under a no-till system yield less due to other factors (temperature or alleopathy).

The effect of tillage, nitrogen rate, and nitrapyrin on harvest and nitrogen indices is shown in table 2. With N applied, there is no obvious relationship between N rate and harvest or N indeces. It is interesting to note that where there is an inhibitor response of grain there also seems to be a trend in favorable changes in harvest and N indices.

Table 1. The effect of tillage, nitrogen rate, and nitrapyrin on corn yield and N uptake at Becker, MN. 1982*.

	No-Till		Till Plant		Chisel		Moldboard	
	W/O	W	W/O	W	W/O	W	W/O	W
	Grain Yields (dry weight)							
N Rate Kg/ha	Mg/ha							
0	1.63	-	3.79	-	3.70	-	2.79	-
85	7.86	7.55	5.35	6.91	7.96	8.11	6.96	8.03
170	8.20	8.17	9.24	9.69	9.83	10.9	10.3	11.0*
340	9.00	9.44+	10.5	10.3	9.83	9.65	10.3	10.9
	Stover Yields (dry weight)++							
	Mg/ha							
0	2.66	-	4.52	-	4.55	-	3.40	-
85	7.36	7.12	5.84	6.16	7.92	7.13	6.33	6.43
170	7.42	7.14	7.03	7.94	8.83	8.38	8.13	8.46
340	8.11	7.53	8.83	8.12	8.83	8.46	8.12	8.21
	N uptake - Grain							
	Kg/ha							
0	18.4	-	38.3	-	37.7	-	32.1	-
85	97.4	94.4	60.5	81.2	99.8	102	67.9	96.2
170	108	113	126	139	135	154	138	151*
340	133	142*	158	155	148	142*	150	163
	N uptake - Stover+++							
	Kg/ha							
0	12.6	-	15.9	-	18.7	-	14.0	-
85	42.6	37.7*	25.3	29.4	42.0	40.8	31.5	30.8
170	59.5	57.0	51.4	56.4	55.6	61.4	46.4	52.7
340	73.0	62.4	78.8	75.3	73.3	71.7	66.3	70.5

* Alfalfa, potatoes, corn oats rotation is omitted from this analysis.

\+ Treatment means (W = with and W/O = without nitrapyrin) significantly different at $\alpha = .10$ as the result of a paired t test, N = 3.

++ Cob mass is included in stover estimates

+++ Cobs are assumed to have the same N content as stover.

Table 2. The effect of tillage, nitrogen rate, and nitrapyrin on harvest and nitrogen indices.

	Tillage							
	No-Till		Till Plant		Chisel		Moldboard	
	W/O	W	W/O	W	W/O	W	W/O	W
N Rate Kg/ha	Harvest Index+							
0	.372	-	.434	-	.443	-	.452	-
85	.514	.515	.457	.528	.502	.533	.522	.554*
170	.526	.534	.568	.550	.527	.563	.560	.566
340	.526	.556	.544	.560	.527	.533	.560	.570
	N Index++							
0	.589	-	.689	-	.668	-	.697	-
85	.697	.719	.682	.735	.706	.716	.671	.756*
170	.649	.666	.710	.710	.708	.713	.750	.743
340	.648	.696	.670	.673	.669	.664	.694	.699

+ Harvest index is defined as grain/total dry matter.

++ Nitrogen index is defined as N removal by grain/total N removal(see table 1 foot notes).

* Nitrapyrin treatment means (W = with and W/O = without) are significantly different at $\alpha = .10$ as the result of a paired t test, N = 3.

SUMMARY

Corn grown under no tillage or a till plant tillage system responded to twice the rate of N than that of a chisel or moldboard plow system. This trend was similar with grain and stover yields as well as with N removal. There was significant grain responses to nitrapyrin with corn grown under the no-till and moldboard systems. A similar trend due to nitrapyrin was also seen in favorable changes in harvest and N indeces.

This is one year's data confounded by differing cropping history. Any conclusions would be purely speculative.

SOIL TEST LAB COMPARISON ON IRRIGATED CORN - BECKER, 1982

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

Several commercial laboratories test soils and make fertilizer recommendations in Minnesota. The experiment was established to compare soil test results, recommended fertilizer rates and costs, and yields of irrigated 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 in 1980 on a Hubbard loamy sand at the Sand Plains Irrigation Farm at Becker, MN. 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.

In the spring of 1982 samples were taken from each lab area and sent to the corresponding soil testing lab for analysis and fertilizer recommendations. The same procedure was followed as in previous years. In 1982 Pioneer 3901 variety was planted at a population of 30,700. 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 differences in amounts of P and K and in which secondary and micronutrients were recommended.

Elemental analysis of earleaf are given in Table 3, only the check showed major differences.

Grain yield, grain moisture, and an economic comparison are shown in Table 4. Grain yields varied from 177 to 183 bu/acre, compared to 72 bu/acre on the check. The cost of fertilizer recommended by the various labs ranged from $64 to $107/acre. The return over cost for the five fertilizer programs varied by about $60.

Table 1. Soil test results for 1982 after 2 years of fertilization and cropping. Becker, MN.

Test	A	B	C	D	E (U.M.)	Check (U.M.)
	Soil Tests in ppm by Labs					
pH	6.8	6.4	7.1	6.6	6.6	6.7
Buffer Index	-	6.9	-	7.2	-	-
P_1	23	32	25	15	20	21
K	51	108	110	85	73	74
Ca	817	1030	1000	4000	-	-
Mg	165	189	210	650	153	170
S	20	6	7	15	1	1
Fe	19.7	50	.7	8	-	-
Mn	5	9	5	2	-	-
Zn	1.7	5	3.2	1.6	2.2	2.2
Cu	0.4	0.8	0.6	0.4	-	-
B	0.3	0.8	0.4	1.8	-	-
NO_3N(0-6")	1	-	2	-	-	-
O.M.%	1.4	2	-	1.7	2	1.9
C.E.C. (meg/100g)	5.6	7.7	-	12.9	-	-

Table 2. Fertilizer recommended from 5 soil testing labs for 200 bu/acre irrigated corn following corn. Becker, MN 1982.

Nutrient	A	B	C	D	E
	Laboratory				
	lbs/acre recommended				
N 1/	270	295	235	240	220
P_2O_5	90	55	16	133	16
K_2O	200	170	145	316	200
S	0	20	30	0	20
Zn	0	0	0	0	0
Mn	2	2	0	0	0
Cu	1.5	1	1	0	0
B	1.5	1	1	0	0
Lime	0	1000	0	0	0

1/ Split into 3 applications, ⅓ preplant, ⅓ at 8-leaf, ⅓ at 12-leaf stage.

Table 3. Plant analysis of earleaf at silking as influenced by fertilization program from 5 labs. Becker, MN 1982.

	%					ppm				
Lab	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
A	3.22	.29	2.55	.57	.34	108	56	27	8	8
B	3.19	.28	2.54	.52	.35	102	50	31	10	6
C	3.24	.29	2.48	.56	.31	105	53	26	9	7
D	3.05	.30	2.75	.49	.31	104	49	22	7	5
E	3.07	.27	2.54	.50	.33	107	49	25	9	5
Check	1.50	.27	2.17	.41	.28	69	21	14	5	5
Signif.	**	**	**	**	ns	**	**	**	**	**
BLSD (.05)	.25	.02	.27	.07	-	10	7	3	1	1
C.V.	6.2	4.4	6.7	9.3	12.3	7.2	10.2	8.6	11.2	13.9

Table 4. Corn yield, grain moisture at harvest, and economic return over fertilizer costs for 6 fertilization programs. Becker, MN 1982.

Lab	Corn Yield	Grain Moisture	Crop Value @ $2.25/bu	Fertilizer[1/] Cost	Return Over Fertilizer Cost
	bu/A	%	$/A	$/A	$/A
A	183	34	411.75	96.13	315.62
B	181	34	407.25	95.78	311.47
C	183	34	411.75	66.75	345.00
D	174	34	391.50	107.17	284.33
E	177	34	398.25	64.60	333.65
Check	72	38	162.00	-	162.00
Signif.	**	**			
BLSD (.05)	14.5	3			
C.V.	6.5	4.1			

1/ Fertilizer costs/lb. N = .15, P_2O_5 = .25, K_2O = .12, S = .18, Zn = .89, Mn = 1.04, Cu = 2.80, B = 1.90.

1982 WEATHER

Spring arrived during the second week of March in the Red River Valley with temperatures in the middle 30's to lower 40's. By March 28, the winter snow pack had melted and 39 inches of ground frost started to thaw during the second week of April with temperatures in the 50-60°F range. Field preparation for the 1982 growing season commenced during the last week of April and spring planting began. One inch of rain on May 4 halted all field work and for the next 16 days, rain showers delayed planting. From May 4 through May 19, 3.02 inches of precipitation occurred.

The record cold month of June will be remembered by many people as the culprit involved in reducing what appeared to be an excellent growing season for 1982. The mean monthly temperature recorded for June (58.2°F) was the coldest ever recorded in the past 93-year history of climatological data for Crookston.

The mean temperature for the year was 1.4° below normal with January, June and November 4° to 11° below normal. September and December were the only two months well above normal with average readings of +4.2° and +6.9°, respectively. A new record high temperature was set on December 2 with 54°F surpassing the old record of 51°F in 1962. On August 27, a record low temperature of 35°F equalled the low temperature recorded on August 27, 1941. The last spring frost was recorded on May 8 (31°F) which initiated a 135-day growing season ending September 20 (31°) when the first fall frost occurred. The normal frost-free period for Crookston (temperature $\geq$ 32°F) is 125 days.

Table 1. Temperature Extremes for 1982.

	Temperature	Date
Lowest Minimum Temperature	-32°F	1/3/82 & 2/2/82
Lowest Maximum Temperature	-19°F	1/9/82
Highest Minimum Temperature	68°F	7/24/82
Highest Maximum Temperature	91°F	8/19/82

The precipitation for 1982 totaled 20.71 inches of which 18.86 inches were recorded as rain and 1.85 inches of precipitation were contained in 38.2 inches of snow. The water equivalent of the snow for 1982 was .048 inches/1 inch of snow. During the growing season of April 1 - September 30, 76.6% of the total precipitation (15.87 inches) occurred. February, April, June, August, September and December had below normal precipitation while the remaining months had above normal precipitation. The 4.97 inches of precipitation received during October, set a new precipitation record for the month with the old record being 4.95 inches during October of 1900. The total precipitation for the year was only .04 inches above the 90-year average although it was not normally distributed throughout the year.

Table 2. Weather summary for 1982 with averages for precipitation and mean temperature (1890-1979) and accumulated degree days.

Month	Precipitation					Mean Temperatures		Degree Days Accumulated		
	Snow	Precip.	Rain	Total	1890-1979	1982	1890-1979	Base 40°	Base 45°	Base 50°/86°
	Inches					°F				
January	18.4	.65	--	.65	.56	-7.5	3.7	--	--	--
February	2.4	.12	--	.12	.59	9.2	8.1	--	--	--
March	8.8	.31	.78	1.09	.84	23.4	22.9	--	--	--
April	1.0	.08	.69	.77	1.57	41.1	41.4	177	101	124
May	--	--	3.16	3.16	2.59	56.5	54.6	689	461	404
June	--	--	2.49	2.49	3.56	58.2	64.4	1228	849	707
July	--	--	3.28	3.28	3.09	69.1	69.6	2129	1596	1295
August	--	--	1.55	1.55	2.90	65.6	67.4	2924	2235	1811
September	--	--	1.50	1.50	2.16	55.7	51.5	3396	2563	2095
October	--	--	4.97	4.97	1.43	44.3	45.3	3557	2627	2155
November	5.5	.58	.26	.84	.78	22.3	26.7	--	--	--
December	2.1	.11	.18	.29	.60	18.4	11.5	--	--	--
TOTAL	38.2	1.85	18.86	20.71	20.67	38.0	39.4	3557	2627	2155

STARTER FERTILIZER STUDY--SPRING WHEAT

G. E. Varvel and H. Meredith

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

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

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

P Rate: 50 and 100 lb P_2O_5/A.

Methods: All treatments were applied with the seed. The test variety was Era and all treatments (seed + fertilizer) were applied on May 20, 1982. Emergence (stand counts) were taken on June 4, 1982. Whole plant samples were taken at late tillering (June 22, 1982), boot (July 8, 1982) and maturity (Aug. 11, 1982). Grain was harvested on Aug. 24, 1982. Soil test data for the study which was located on a Wheatville loam were: pH-8.3, $NaHCO_3$ P-15 lb/A, exchangeable K-300 lb/A, and NO_3-N (0-2')-105 lb/A.

Results: Elemental analyses of whole plant samples taken at late tillering and boot are shown in Tables 1 and 2, respectively. Significant differences in N at tillering (Table 1) and in P at boot (Table 2) were obtained between carriers. Significant differences in N, P, K, Zn, and Cu at tillering (Table 1) and K and Cu at boot (Table 2) were obtained between the two rates of applied P.

Elemental analyses of whole plant samples at maturity (soft dough) are shown in Table 3. Significant differences in P, Al, Fe, Zn, Cu, and B were obtained between carriers and in K, Ca, Zn, Cu, and B between the two rates of applied P.

Stand counts, grain yield, protein, test weight, forage yield, N, P and K uptake at maturity (soft dough) are shown in Table 4. No significant differences were obtained between carriers but increasing the amount of applied P significantly increased K uptake.

Discussion: Soil test levels were sufficient for crop production in 1982 at this location. Significant differences in elemental analyses at the various crop stages were apparently the result of luxury consumption. These results indicate that each of the carriers could be used as a starter fertilizer.

Most importantly, no reductions in stand were obtained, even though N rates in excess of 40 lb/A were applied with the seed. These results support those obtained in 1981 with the same materials. Further studies will be used to evaluate these materials.

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

Carrier[1/]	Elemental Analyses											
	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	%					ppm						
1	4.44	0.42	4.79	0.55	0.40	160	216	322	102	31	6	5
2	4.39	0.43	4.87	0.58	0.37	143	201	246	99	31	6	5
3	4.47	0.44	4.90	0.58	0.37	133	187	248	97	33	6	5
4	4.59	0.46	4.84	0.54	0.40	151	208	271	100	34	7	5
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)	0.13											
P_2O_5 Rate (lb/A)												
50	4.35	0.42	4.72	0.55	0.38	148	204	282	97	31	6	5
100	4.59	0.45	4.99	0.57	0.39	146	202	262	102	33	7	5
Significance	**	**	**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	**	**	N.S.

1/ Refers to number given to carrier in text.

Table 2. The effect of starter fertilizer on elemental analyses in whole plant samples of spring wheat taken at the boot stage.

Carrier	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	Elemental Analyses											
	%					ppm						
1	2.96	0.35	3.77	0.39	0.37	61	144	251	70	23	4	6
2	2.90	0.35	3.64	0.44	0.34	77	154	228	66	22	3	6
3	2.96	0.36	3.86	0.44	0.35	64	154	195	66	24	3	6
4	2.96	0.37	3.86	0.41	0.37	62	156	216	71	22	4	8
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)		0.02										
P_2O_5 Rate (lb/A)												
50	2.87	0.35	3.66	0.40	0.35	65	155	201	67	23	3	6
100	3.02	0.36	3.90	0.44	0.37	67	149	244	70	23	4	7
Significance	N.S.	N.S.	**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.

Table 3. The effect of starter fertilizer on elemental analyses in whole plant samples of spring wheat taken at maturity (soft dough).

Carrier	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	Elemental Analyses											
	%					ppm						
1	1.44	0.22	1.32	0.13	0.17	52	74	26	29	15	1.3	2.3
2	1.52	0.26	1.24	0.11	0.15	25	49	24	28	18	2.0	1.5
3	1.47	0.22	1.47	0.13	0.15	42	64	26	26	15	1.8	2.0
4	1.52	0.23	1.37	0.13	0.17	48	71	28	28	15	1.5	2.3
Significance	N.S.	*	N.S.	N.S.	N.S.	*	*	N.S.	N.S.	**	**	*
B.L.S.D. (.05)		0.03				18	19			2	0.5	0.6
P_2O_5 Rate (lb/A)												
50	1.48	0.24	1.25	0.11	0.16	37	60	25	28	17	1.8	1.8
100	1.50	0.22	1.45	0.13	0.16	46	69	29	27	15	1.4	2.3
Significance	N.S.	N.S.	*	*	N.S.	N.S.	N.S.	N.S.	N.S.	*	*	**

Table 4. The effect of starter fertilizer on emergence (stand count), grain yield, protein, test weight, forage yield, N, P, and K uptake of spring wheat.

Carrier	Stand Count	Grain Yield	Grain Protein	Grain Test Weight	Forage Dry Matter Yield	Forage Uptake N	Forage Uptake P	Forage Uptake K
	Plants/A	Bu/A	%	lb/Bu	lb/A			
1	1,059,440	56.9	14.3	58.7	7812	112	17	103
2	1,035,045	53.6	14.3	58.9	7857	120	20	98
3	1,062,925	55.9	14.5	58.7	7987	118	17	117
4	1,007,165	53.9	14.4	58.7	7962	122	18	110
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
P_2O_5 Rate (lb/A)								
50	1,062,925	55.6	14.3	59.0	7732	115	18	97
100	1,017,620	54.6	14.4	58.5	8078	121	18	117
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	**

BROADCAST FERTILIZER STUDY--SPRING WHEAT

G. E. Varvel and H. Meredith

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

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

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

N Rates: 30 and 60 lb N/A.

Methods: The treatments were applied and incorporated immediately on May 20, 1982 on a Wheatville loam soil. Phosphorus rates were equalized between all treatments with superphosphate (0-44-0). Era wheat was planted that same day. Emergence was evaluated on June 4, 1982 by taking stand counts. Whole plant samples were taken at late-tillering (June 22, 1982), boot (July 8, 1982), and maturity (Aug. 11, 1982). Grain was harvested on Aug. 24, 1982. Soil test data for the study were: pH-8.3, NO_3-N(0-2')-105 lb/A, $NaHCO_3$ P-15 lb/A, and exchangeable K-300 lb/A.

Results: Elemental analyses of plant samples taken at the late tillering, boot, and soft dough (maturity) stages are shown in Tables 1, 2, and 3, respectively. No significant differences between carriers were obtained at any sampling stage. Nitrogen significantly increased N at the late-tillering stage (Table 1), P, K, Mg, Na, Mn, and Cu at the boot stage (Table 2), and K, Mg, and Na at the soft dough stage (Table 3).

Stand count, grain yield, protein, test weight, grain N removal, forage yield, N, P, and K uptake are shown in Table 4. No significant differences were obtained between carriers while N significantly increased K uptake, but nothing else.

Discussion: Effective evaluation of the N carriers in this study was not obtained. Preliminary soil samples from the area had indicated relatively low residual NO_3-N levels but soil samples taken when the treatments were applied showed sufficient levels of N available for optimum production. The absence of a N response made it impossible to determine if any losses were obtained.

Table 1. The effect of broadcast N carriers and N rates on elemental analyses in whole plant samples of spring wheat taken at late-tillering.

	Elemental Analyses											
Carrier	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	%					ppm						
38-12-0	4.72	0.40	5.04	0.57	0.44	279	329	218	98	31	6	6
28-28-0	4.74	0.40	5.10	0.57	0.44	304	345	227	100	31	7	6
18-44-0	4.75	0.41	5.01	0.58	0.45	335	378	229	99	29	7	6
15-28-0	4.74	0.40	5.06	0.57	0.44	294	343	213	100	30	7	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 Rate (lb/A)												
30	4.69	0.40	5.07	0.57	0.44	306	355	208	99	30	6	6
60	4.79	0.40	5.04	0.57	0.45	300	342	235	100	30	7	6
Significance	**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 2. The effect of broadcast N carriers and N rates on elemental analyses in whole plant samples of spring wheat taken at the boot stage.

Carrier	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	Elemental Analyses											
	- - - - - - - % - - - - - - -					- - - - - - - - - - ppm - - - - - - - - - - -						
38-12-0	3.07	0.38	3.87	0.42	0.36	68	161	233	70	24	4	8
28-28-0	2.88	0.38	3.84	0.41	0.38	73	171	273	73	24	5	7
18-44-0	2.92	0.39	3.93	0.42	0.38	68	196	237	74	23	5	7
15-28-0	2.92	0.38	3.80	0.42	0.36	71	168	238	69	23	4	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 Rate (lb/A)												
30	2.89	0.38	3.76	0.42	0.35	71	168	209	68	23	4	7
60	3.01	0.39	3.96	0.41	0.39	69	180	282	75	24	5	8
Significance	N.S.	*	*	N.S.	**	N.S.	N.S.	*	*	N.S.	**	N.S.

Table 3. The effect of broadcast N carriers and N rates on elemental analyses in whole plant samples of spring wheat taken at maturity (soft dough).

Carrier	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	Elemental Analyses											
	- - - - - - - % - - - - - - -					- - - - - - - - - - ppm - - - - - - - - - - -						
38-12-0	1.60	0.23	1.34	0.14	0.16	58	82	34	29	14	1	2
28-28-0	1.48	0.22	1.27	0.15	0.17	74	98	30	29	14	1	2
18-44-0	1.46	0.21	1.40	0.16	0.17	56	76	27	27	12	1	2
15-28-0	1.45	0.21	1.36	0.14	0.16	72	85	29	27	13	2	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 Rate (lb/A)												
30	1.48	0.23	1.28	0.14	0.16	61	84	25	28	14	1	2
60	1.51	0.21	1.40	0.16	0.17	64	87	35	28	13	1	2
Significance	N.S.	N.S.	*	*	N.S.	N.S.	N.S.	*	N.S.	N.S.	N.S.	N.S.

Table 4. The effect of broadcast N carriers and N rates on emergence (stand count), grain yield, protein, grain N removal, forage yield, N, P, and K uptake of spring wheat.

Carriers	Stand Count	Grain: Yield	Grain: Protein	Grain: Test Weight	Grain: N Removal	Forage: Dry Matter Yield	Forage: Uptake N	Forage: Uptake P	Forage: Uptake K
	Plants/A	Bu/A	%	lb/Bu	lb/A	- - - - - - - lb/A - - - - - - -			
38-12-0	917,895	49.5	13.9	58.3	72	7480	120	17	100
28-28-0	904,655	51.7	14.0	58.9	76	7695	114	17	98
18-44-0	963,545	50.0	13.9	58.5	73	7792	114	16	109
15-28-0	897,335	50.6	14.1	58.8	75	7692	112	16	105
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
N Rate (lb/A)									
30	926,435	49.9	13.9	58.7	73	7589	113	17	98
60	915,285	50.9	14.0	58.5	75	7741	117	16	109
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*

HIGH PHOSPHORUS AND POTASSIUM RATES ON CONTINUOUS SPRING WHEAT

G. E. Varvel and R. K. Severson

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

Experimental Procedure:

Ten treatments consisting of P and K combinations have been used. Treatment combinations and applications made to date are shown in Table 1. Treatment combinations for the fall of 1981 were broadcast and plowed down. An additional 70 lb N/A as urea was broadcast and incorporated with a field cultivator on May 3, 1982 because soil tests had indicated that it was needed. Era wheat was planted on May 8, 1982 and harvested August 17, 1982. Whole plant samples were taken at the late-tillering (June 15, 1982), boot (June 30, 1982), and soft dough stage (August 3, 1982) for elemental analyses. Samples taken at the soft dough stage were used to determine forage yields and nutrient uptake. Soil samples taken August 24, 1982 were analyzed for P and K content to measure the residual effects of the treatments.

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

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

Results:

Elemental analyses of the whole plant samples taken at the 3 stages listed earlier are shown in Tables 2, 3, and 4. Significant differences in P, K, Mg, and Zn at late-tillering (Table 2), in N, P, K, Zn, and Cu at boot (Table 3), and in K and Zn at soft dough (Table 4) were obtained between treatments.

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

Treatment No. [1/]	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	- - -	- - -	%	- - -	- - -	- - -	- - -	- - -	ppm	- - -	- - -	- - -
1	4.43	.35	4.38	.51	.43	168	228	197	81	29	6	6
2	4.44	.36	4.57	.51	.38	164	222	147	78	30	5	5
3	4.36	.45	4.64	.54	.38	193	253	198	83	27	6	5
4	4.44	.52	4.92	.51	.40	131	219	221	87	24	6	5
5	4.46	.44	4.92	.54	.39	148	227	187	80	29	6	5
6	4.41	.51	4.28	.54	.48	146	221	290	86	24	6	5
7	4.52	.54	4.53	.55	.42	127	203	278	85	25	6	6
8	4.33	.54	4.39	.55	.41	137	209	260	78	23	5	5
9	4.40	.43	4.29	.55	.42	142	200	271	80	26	6	5
10	4.49	.41	4.55	.55	.42	171	229	258	88	28	6	6
Significance	N.S.	**	**	N.S.	**	N.S.	N.S.	N.S.	N.S.	**	N.S.	N.S.
B.L.S.D. (.05)		.03	.21		.05					4		
C.V. (%)	3.9	5.2	3.3	7.6	7.1	29.2	18.8	30.6	7.4	8.8	9.2	10.1

[1/] Corresponds to treatments shown in Table 1.

Table 3. Effect of P and K rate combinations on the elemental analyses of whole plant samples of spring wheat taken at boot.

Treatment No.	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	-------		% -------			----------			ppm ----------			
1	2.60	.34	3.68	.32	.35	40	85	192	66	27	6	7
2	2.59	.34	4.08	.36	.33	45	95	142	63	26	4	5
3	2.24	.35	3.66	.36	.32	45	91	114	69	18	4	6
4	2.19	.39	3.73	.34	.33	48	107	150	72	17	4	5
5	2.26	.33	3.83	.36	.31	40	86	158	61	18	4	7
6	2.15	.39	3.38	.33	.35	46	92	161	73	16	4	5
7	2.12	.38	3.46	.33	.32	43	89	175	66	16	4	6
8	2.18	.40	3.57	.41	.33	46	164	149	69	17	3	6
9	2.42	.33	3.45	.39	.35	50	100	206	69	19	4	7
10	2.37	.35	3.74	.37	.35	41	89	218	69	21	5	7
Significance	**	**	**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	**	**	N.S.
B.L.S.D. (.05)	.28	.03	.26							2	1	
C.V. (%)	7.8	5.1	4.8	14.2	12.3	22.5	44.3	26.6	9.0	8.9	15.5	25.2

Table 4. Effect of P and K rate combinations on the elemental analyses of whole plant samples of spring wheat taken at soft dough (maturity).

Treatment No.	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	-------		% -------			----------			ppm ----------			
1	1.36	.23	.87	.10	.18	40	61	27	30	21	2	2
2	1.32	.23	1.13	.11	.15	36	55	22	27	20	2	2
3	1.25	.25	1.02	.12	.16	34	53	20	30	15	2	2
4	1.17	.27	.89	.10	.16	28	48	21	31	17	2	2
5	1.27	.23	1.04	.12	.16	37	56	23	28	16	2	2
6	1.22	.22	.84	.14	.18	41	57	30	32	12	2	3
7	1.34	.25	.97	.13	.16	48	69	20	31	14	2	2
8	1.23	.25	.96	.14	.16	40	58	19	30	15	2	2
9	1.21	.24	.89	.12	.16	26	43	24	29	17	2	2
10	1.39	.24	1.04	.13	.17	44	64	27	30	17	2	3
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)			.16							3		
C.V. (%)	8.7	9.0	10.5	20.8	12.5	32.6	21.6	42.0	9.6	13.7	16.2	22.8

Grain yield, protein, test weight, forage yield, N, P, and K uptake values are shown in Table 5. Significant differences in grain yield, protein, and K uptake were obtained between the treatments.

Soil test results from the fall of 1982 sampling date are shown in Table 6. Samples were analyzed by both the University of Minnesota and North Dakota State University soil testing labs. Significant differences in residual P and K levels were obtained by both labs.

Discussion:

Plant samples taken at the first 2 sampling dates tend to do a good job of reflecting the levels of applied P and K while the samples taken at soft dough did not. This information agrees with that in the literature and indicates the importance of early sampling. Grain yield responses appear to be mainly due to P, but even this increase is not large.

Soil test results in the fall of 1982, after 3 years of fertilization and cropping, are providing some basic information. The $NaHCO_3$ P test results from the N.D.S.U. lab indicate that after 3 years of application to the same plots, approximately 15 lb of applied P_2O_5 were needed to raise the soil test level 1 unit. Potassium results are not as consistent, but levels have been increased.

Table 5. Effect of P and K rate combinations on grain yield, protein, test weight, forage yield, N, P, and K uptake of spring wheat.

Treatment No.	Grain Yield	Grain Protein	Grain Test Weight	Forage Dry Matter Yield	Forage Uptake N	Forage Uptake P	Forage Uptake K
	Bu/A	%	lb/Bu	lb/A	- - - - lb/A - - - -		
1	55.0	11.9	60.2	7735	105.1	18.0	67.3
2	54.4	12.1	59.6	8015	105.7	18.4	91.0
3	58.0	10.8	59.3	8317	104.4	20.7	85.7
4	59.4	10.6	60.2	8175	96.4	22.0	73.1
5	60.1	11.5	59.1	8337	106.3	19.0	87.0
6	58.0	10.7	59.6	8112	99.0	17.9	68.4
7	57.5	10.8	60.2	8213	109.8	20.6	79.1
8	61.6	11.1	60.0	8498	103.8	21.3	82.4
9	58.2	11.0	59.5	8125	98.0	19.1	72.8
10	59.8	11.4	59.3	8546	119.4	19.9	89.9
Significance	*	**	N.S.	N.S.	N.S.	N.S.	*
B.L.S.D. (.05)	4.6	0.9					19.4
C.V. (%)	4.6	5.1	1.8	4.6	10.0	10.9	14.0

Table 6. Effect of P and K rate combinations on residual P and K soil test levels as determined by two soil testing laboratories.

Treatment No.	North Dakota State University $NaHCO_3$-P 0-6"	$NaHCO_3$-P 6-12"	Exchangeable K 0-6"	Exchangeable K 6-12"	University of Minnesota Bray P-1 10:1 0-6"	Bray P-1 10:1 6-12"	Bray P-1 50:1 0-6"	Bray P-1 50:1 6-12"	$NaHCO_3$-P 0-6"	$NaHCO_3$-P 6-12"	Exchangeable K 0-6"	Exchangeable K 6-12"
	- - - -	- - - -	- - - -	- - - -	- - - -	- - lb/A - -	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
1	8	5	230	200	16	5	53	32	10	6	263	222
2	8	5	294	221	30	19	58	39	11	7	317	245
3	19	10	270	210	47	18	93	44	20	10	296	236
4	28	17	278	218	46	16	101	58	35	18	306	244
5	17	7	296	236	46	19	90	43	21	10	318	260
6	24	13	233	191	35	11	105	44	30	16	256	205
7	27	15	244	213	58	29	126	62	35	20	268	239
8	29	14	276	241	70	31	128	66	36	19	281	262
9	13	9	258	221	42	24	96	51	19	11	275	231
10	11	6	250	194	34	20	81	43	15	9	273	214
Significance	**	**	**	N.S.	**	*	**	**	**	**	**	**
B.L.S.D. (.05)	7	7	39		25	18	27	16	6	4	38	34
C.V. (%)	29.5	44.5	9.4	13.0	37.0	52.8	20.1	21.5	19.4	24.2	8.4	8.9

EFFECTS OF NITROGEN AND PHOSPHORUS APPLICATION METHODS ON SPRING WHEAT

G. E. Varvel and R. K. Severson

The objective of this study was to compare N and P fertilizer application methods for spring wheat. Recent equipment developments have made it possible to apply liquid and dry fertilizer materials 5 to 7 inches deep in the soil at various spacings. Comparison of conventional broadcast application with deep band application has produced variable results from around the country. This study was conducted to evaluate these fertilizer application methods in northern Minnesota on spring wheat.

Experimental Procedures:

Ten treatment combinations were used to evaluate the application methods. A randomized complete block design with 4 replications was used. Urea (46-0-0) and triple super-phosphate (0-44-0) were used for the fertilizer sources. Deep band applications were made at 4-6 inches deep 12 inches apart. All fertilizer applications were made on May 21, 1982. Era wheat was planted on May 24, 1982 and harvested August 26, 1982. Whole plant samples were taken at late-tillering (June 30, 1982), boot (July 16, 1982), and soft dough (August 16, 1982) for elemental analyses. The samples taken at soft dough (maturity) were used to calculate forage yields and N, P, and K uptake. Soil test results for the study were: pH - 8.3, NO_3-N (0-2') - 92 lb/A, $NaHCO_3$ P - 5 lb/A, and exchangeable K - 168 lb/A.

Results:

The treatment combinations and their effect on elemental analyses at late-tillering, boot, and soft dough are shown in Tables 1, 2, and 3. Significant differences in P, Ca, and Zn levels at late-tillering (Table 1), N, P, Ca, Mg, Mn, Zn, and Cu levels at boot (Table 2), and P, Mg, Zn, and Cu levels at soft dough (Table 3) were obtained between treatments.

The effects of the treatments on the grain and forage variables are shown in Table 4. Significant differences in grain yield, test weight, and N removal were obtained between the treatments.

Discussion:

Analyses of the results indicated that grain yields were not increased by any of the application methods or the fertilizer that was applied. An actual yield decrease was obtained, but this was mainly due to excessive N levels. Differences in elemental analyses of the plant samples taken at the various stages show the importance of sampling early for best results. Treatment by treatment comparisons indicate that most of the differences obtained were when the 0 N treatments were compared to all the other treatments.

Table 1. Effects of N and P rates and application methods on elemental analyses of whole plant samples of spring wheat taken at late-tillering.

N		P_2O_5		Elemental Analyses								
Rate	Method	Rate	Method	N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A		lb/A		- - - - - - - - % - - - - - - - -					- - - - - - - ppm - - - - -			
0	--	0	--	4.23	0.33	3.89	0.55	0.45	54	30	5	4
0	--	40	DB[1/]	4.16	0.33	3.56	0.52	0.44	48	26	6	4
50	DB	40	DB	4.56	0.36	3.52	0.63	0.48	60	30	5	5
100	DB	40	DB	4.56	0.38	3.35	0.66	0.55	62	32	5	5
50	DB	80	DB	4.41	0.40	3.09	0.69	0.52	59	30	5	4
100	DB	80	DB	4.56	0.45	3.22	0.73	0.56	68	36	5	4
50	B	40	B [2/]	4.46	0.35	3.70	0.60	0.46	54	27	4	5
100	B	80	B	4.58	0.40	3.29	0.61	0.53	56	31	4	4
50	DB	80	B	4.44	0.38	3.22	0.61	0.50	54	29	5	4
50	B	40	DB	4.54	0.35	3.56	0.59	0.48	61	28	5	4
Significance				N.S.	**	N.S.	**	N.S.	N.S.	**	N.S.	N.S.
B.L.S.D. (.05)					0.04		0.11			5		
C.V. (%)				4.7	7.5	14.6	11.3	11.6	13.9	9.7	24.4	13.2

1/ Deep Band

2/ Broadcast

Table 2. Effects of N and P rates and application methods on elemental analyses of whole plant samples of spring wheat taken at boot.

N Rate	N Method	P_2O_5 Rate	P_2O_5 Method	N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A		lb/A		%					ppm			
0	--	0	--	2.41	0.32	2.60	0.37	0.35	39	33	6	5
0	--	40	DB	2.44	0.32	2.78	0.40	0.38	36	25	4	6
50	DB	40	DB	2.56	0.35	2.90	0.49	0.44	46	30	5	5
100	DB	40	DB	2.54	0.32	2.42	0.48	0.45	47	30	5	5
50	DB	80	DB	2.49	0.35	2.22	0.54	0.47	49	25	4	6
100	DB	80	DB	2.80	0.39	2.57	0.65	0.55	57	30	4	6
50	B	40	B	2.70	0.37	2.77	0.50	0.44	49	30	5	6
100	B	80	B	2.56	0.35	2.32	0.52	0.49	46	26	4	5
50	DB	80	B	2.52	0.38	2.36	0.51	0.48	47	27	4	6
50	B	40	DB	2.73	0.36	2.78	0.54	0.51	55	33	5	6
Significance				*	**	N.S.	**	**	**	**	**	N.S.
B.L.S.D. (.05)				0.24	0.04		0.09	0.10	9	5	1	
C.V. (%)				5.7	7.6	18.3	12.7	14.0	12.8	10.6	16.9	12.0

Table 3. Effects of N and P rates and application methods on elemental analyses of whole plant samples of spring wheat taken at soft dough (maturity).

N Rate	N Method	P_2O_5 Rate	P_2O_5 Method	N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A		lb/A		%					ppm			
0	--	0	--	1.59	0.22	0.92	0.12	0.16	14	25	3	2
0	--	40	DB	1.64	0.23	0.93	0.12	0.17	14	21	2	3
50	DB	40	DB	1.73	0.23	0.94	0.13	0.17	15	24	2	2
100	DB	40	DB	1.65	0.22	0.84	0.17	0.20	17	23	3	3
50	DB	80	DB	1.72	0.25	0.80	0.14	0.19	18	20	2	3
100	DB	80	DB	1.77	0.26	0.84	0.14	0.19	16	21	2	3
50	B	40	B	1.73	0.24	0.98	0.14	0.19	17	21	2	3
100	B	80	B	1.77	0.26	0.85	0.16	0.20	17	19	2	3
50	DB	80	B	1.67	0.26	0.91	0.15	0.20	15	20	2	2
50	B	40	DB	1.71	0.24	0.88	0.13	0.19	18	23	3	3
Significance				N.S.	*	N.S.	N.S.	*	N.S.	**	*	N.S.
B.L.S.D. (.05)					0.03			0.03		3	1	
C.V. (%)				5.9	8.0	14.9	20.0	10.4	13.7	9.6	20.4	18.8

Table 4. Effects on N and P rates and application methods on grain yield, test weight, protein, N removal, forage yield, N, P, and K uptake of spring wheat.

N Rate	N Method	P_2O_5 Rate	P_2O_5 Method	Grain Yield	Grain Test Weight	Grain Protein	Grain N Removal	Forage Dry Matter Yield	Forage Uptake N	Forage Uptake P	Forage Uptake K
lb/A		lb/A		Bu/A	lb/Bu	%	lb/A	lb/A	lb/A		
0	--	0	--	42.8	57.0	14.3	64.3	4768	75.9	10.4	43.6
0	--	40	DB	43.5	56.0	14.5	66.5	5330	87.9	12.4	50.0
50	DB	40	DB	39.9	56.0	15.1	63.6	4957	85.5	11.5	47.2
100	DB	40	DB	42.5	55.1	14.8	66.5	4806	79.4	10.6	40.5
50	DB	80	DB	38.2	56.3	14.0	56.5	5060	87.0	12.8	40.7
100	DB	80	DB	40.0	54.6	14.8	62.4	5358	94.2	13.7	44.6
50	B	40	B	42.2	55.3	15.2	67.3	4759	82.4	11.6	46.8
100	B	80	B	37.9	54.5	14.8	59.0	5028	88.8	13.0	42.5
50	DB	80	B	41.0	55.3	14.2	61.2	5049	84.3	13.0	46.6
50	B	40	DB	40.4	55.9	15.0	63.5	4753	81.2	11.3	42.4
Significance				*	**	N.S.	*	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)				4.6	1.4		7.0				
C.V. (%)				6.3	1.5	3.8	6.6	9.8	11.3	14.2	21.9

EFFECTS OF HIGH NITROGEN RATES IN STARTER FERTILIZERS ON SPRING WHEAT

G. E. Varvel and R. K. Severson

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

Experimental Procedure:

Two materials, urea (46-0-0) and diammonium phosphate (18-46-0), were used in the study. Four treatments were randomized in a complete block design with four replications. Era wheat was seeded on May 20, 1982 and harvested August 24, 1982. Emergence (stand counts) were taken on June 4, 1982. Whole plant samples taken at soft dough (Aug. 11, 1982) were analyzed for nutrient content and used to calculate forage yield and nutrient uptake. Soil test results for the study were: pH - 8.3, $NaHCO_3$ P - 15 lb/A, exchangeable K - 300 lb/A, and NO_3-N (0-2') - 105 lb/A.

Results:

The treatments used are shown in Table 1. No significant differences in the elemental analyses of the samples taken at soft dough were obtained between the treatments (Table 1). Significant differences in stand count, grain yield, protein, test weight, and N removal were obtained between the treatments (Table 2).

Discussion:

Addition of high rates of N with the seed at planting time did reduce germination, but conditions were such that this reduction did not translate into a yield loss. Soil conditions promoted increased tillering which compensated for the loss in stand and generally resulted in higher yield and protein. The high rate of urea did decrease test weight, but since the N level in the soil was high, this was expected. Further studies will be conducted to evaluate the effects of large amounts of N in starter fertilizers on spring wheat.

Table 1. Effects of starter fertilizers on the elemental analyses of whole plant samples of spring wheat taken at soft dough (maturity).

		Elemental Analyses											
Source	N Rate	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	lb/A	%					ppm						
Check	0	1.46	0.25	1.10	0.12	0.13	41	57	13	26	17	2	2
18-46-0	50	1.43	0.24	1.27	0.14	0.14	46	65	19	26	14	1	2
Urea	48	1.38	0.25	1.16	0.12	0.13	51	68	17	26	17	2	2
Urea	80	1.60	0.24	1.31	0.13	0.14	36	54	23	25	17	2	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.
C.V. (%)		8.5	13.8	15.8	29.9	7.0	67.7	46.8	23.2	8.2	16.9	27.2	34.0

Table 2. Effects of starter fertilizers on emergence, grain yield, protein, test weight, N removal, forage yield, N and P uptake of spring wheat.

			Grain				Forage		
		Stand			Test	N	Dry Matter	Uptake	
Source	N Rate	Count	Yield	Protein	Weight	Removal	Yield	N	P
	lb/A	Plants/A	Bu/A	%	lb/Bu	lb/A	lb/A		
Check	0	1,047,240	47.0	12.8	58.9	63.7	7126	105.3	17.4
18-46-0	50	939,210	51.2	13.4	58.6	72.2	7908	112.7	18.8
Urea	48	955,760	46.1	12.5	59.0	60.8	7343	101.5	18.4
Urea	80	798,940	49.8	13.9	56.8	73.1	7271	115.9	17.3
Significance		**	*	*	**	**	N.S.	N.S.	N.S.
B.L.S.D. (.05)		72,060	4.5	0.8	1.1	5.7			
C.V. (%)		4.9	5.2	3.7	1.1	5.2	8.1	13.1	14.9

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

G. E. Varvel and R. K. Severson

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

Experimental Procedure: Five treatments with 4 replications were arranged in a randomized complete block design. Each of these 5 fertilizer treatments was based upon soil test data from the plots on which that treatment had been applied to in the previous year. All of the treatments were applied in the fall of 1981 and plowed down. Era wheat was planted May 8, 1982 and harvested Aug. 17, 1982. Whole plant samples were taken at late-tillering (June 15, 1982) for elemental analyses. Whole plant samples taken Aug. 3, 1982 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 Aug. 24, 1982 were analyzed for N, P, and K to determine the effects of the treatments and to establish the 1983 treatments.

Results: The effects of the treatments on elemental analyses of whole plant samples taken at the late-tillering and soft dough stages are shown in Tables 1 and 2, respectively. Significant differences in N, P, K, Na, Cu, and B levels at late-tillering and in N, P, K, Mg, Na, Zn, and B levels at maturity were obtained between the treatments. The effects of the treatments on grain and forage are shown in Table 3. Significant differences were obtained with respect to all the measured variables at grain and forage harvest except for protein content.

Soil test results from the fall of 1982 sampling are shown in Tables 4 and 5. Table 4 contains results from the samples taken for NO_3-N at the various depths and total NO_3-N for the 0-2' and 0-5' depths. No significant differences were obtained between NO_3-N levels at any depth or total NO_3-N in the 0-2' and 0-5' depths. Table 5 contains P and K soil test results for samples taken from the 0-6" and 6-12" depths. These samples were analyzed by both the University of Minnesota and North Dakota State University soil testing labs and results are presented from both of them. Significant differences in P levels between treatments were obtained by both labs except when the Bray 1 was used with the 10:1 extraction ratio. No differences in exchangeable K were obtained by either lab.

Discussion: All of the fertilizer programs have increased yields and some soil test levels over those of the check plot. Nitrogen has given the largest yield increases, but very little buildup in the soil has occurred to date. Phosphorus appears to be having a slight affect on yield and soil test levels are significantly higher than the check in all cases. Potassium has had no affect on yield or soil test levels. Yields have been extremely good, even though wheat has been grown for 5 years in a row.

Table 1. The effect of the different fertilizer programs on elemental analyses of whole plant samples taken at the late-tillering stage in a continuous wheat cropping system.

Treatment			Elemental Analyses											
N	P_2O_5	K_2O	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
lbs/A			%					ppm						
0	0	0	3.64	0.38	4.55	0.55	0.44	154	212	157	93	39	6	10
80	45	25	4.41	0.52	5.44	0.64	0.50	158	232	299	102	43	7	8
90	45	55	4.37	0.49	5.54	0.58	0.48	165	241	237	100	39	7	8
110	45	25	4.48	0.50	5.37	0.64	0.46	254	325	252	105	42	7	8
90	75	25	4.32	0.55	5.16	0.66	0.49	163	281	295	96	37	7	8
Significance			**	**	**	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.	**	*
B.L.S.D. (.05)			0.20	0.03	0.40					93			1	1
C.V. (%)			3.2	4.7	5.0	8.8	7.9	47.5	39.8	22.7	5.5	8.3	5.9	8.6

Table 2. The effect of the different fertilizer programs on elemental analyses of whole plant samples taken at the soft dough stage in a continuous wheat cropping system.

Treatment N	Treatment P_2O_5	Treatment K_2O	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
- - - lbs/A - - -			- - - - - - - % - - - - - - -					- - - - - - - - - - ppm - - - - - - - - - -						
0	0	0	1.02	0.20	1.61	0.17	0.17	102	127	31	34	18	1	3
80	45	25	1.15	0.17	2.07	0.20	0.20	69	89	58	33	16	1	4
90	45	55	1.10	0.17	2.15	0.18	0.20	74	96	50	33	15	1	4
110	45	25	1.26	0.15	2.13	0.24	0.22	64	84	71	32	16	1	4
90	75	25	1.09	0.16	2.20	0.22	0.21	60	78	57	31	13	1	4
Significance			*	**	**	N.S.	*	N.S.	N.S.	*	N.S.	**	N.S.	*
B.L.S.D. (.05)			0.17	0.02	0.23		0.04			27		3		1
C.V. (%)			13.1		11.3	24.5	15.5	49.0	42.9	43.6	11.1	15.7	33.9	19.0

Table 3. The effect of the different fertilizer programs on grain yield, test weight, protein, N removal, forage yield, N, P, and K uptake in a continuous wheat cropping system.

Treatment			Grain				Forage			
				Test		N	Dry Matter	Uptake		
N	P_2O_5	K_2O	Yield	Weight	Protein	Removal	Yield	N	P	K
- - - lbs/A - - -			Bu/A	lb/Bu	%	lb/A	- - - - - - - lb/A - - - - - - -			
0	0	0	37.0	59.6	12.5	48.2	4906	50.4	9.6	79.4
80	45	25	66.1	59.0	12.7	88.5	8458	97.5	14.3	175.1
90	45	55	65.6	60.4	12.4	85.2	8464	93.9	14.4	182.4
110	45	25	61.6	57.4	12.6	81.0	8678	108.8	13.2	185.1
90	75	25	68.0	58.8	12.2	87.0	8843	96.6	13.9	194.6
Significance			**	**	N.S.	**	**	**	**	**
B.L.S.D. (.05)			5.6	1.3		11.0	791	16.1	2.2	22.2
C.V. (%)			10.1	2.1	13.7	14.8	10.7	18.7	16.5	14.5

Table 4. The effect of different fertilizer programs on residual NO_3-N soil test levels after 5 years in a continuous wheat cropping system.

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'
- - - lbs/A - - -			- - - - - - - - - - - - lb/depth - - - - - - - - - - - -					- - - lb/A - - -	
0	0	0	24	10	9	11	3	34	66
80	45	25	21	10	23	26	17	31	96
90	45	55	20	13	15	21	19	33	87
110	45	25	23	15	24	22	16	38	99
90	75	25	18	12	20	26	19	30	94
Significance			N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)			24.1	47.7	67.2	51.9	34.4	30.0	35.3

Table 5. The effect of different fertilizer programs on residual P and K soil test levels after 5 years in a continuous wheat cropping system as determined by two soil testing laboratories.

			N.D.S.U.				University of Minnesota							
Treatment			$NaHCO_3$ P		Exchangeable K		Bray P-1				$NaHCO_3$ P		Exchangeable K	
							10:1		50:1					
N	P_2O_5	K_2O	0-6"	6-12"	0-6"	6-12"	0-6"	6-12"	0-6"	6-12"	0-6"	6-12"	0-6"	6-12"
- - - lb/A - - -			- - - - - - - lb/A - - - -				- - - - - - - - - - - - - - lb/A - - - - - - - - - - - -							
0	0	0	8	5	294	245	3	2	40	22	8	5	258	204
80	45	25	18	9	295	250	5	2	59	31	16	9	249	209
90	45	55	14	10	294	256	4	2	58	36	16	11	262	215
110	45	25	16	11	298	259	6	6	66	43	16	11	253	205
90	75	25	22	14	285	249	14	7	75	38	24	16	247	197
Significance			**	**	N.S.	N.S.	N.S.	N.S.	**	+	**	**	N.S.	N.S.
B.L.S.D. (.05)			5	5					15		4	5		
C.V. (%)			19.9	31.3	5.7	7.1	114.5	117.3	16.3	29.5	17.5	31.9	4.7	8.2

NITROGEN FERTILIZATION AND UTILIZATION BY TWELVE SMALL GRAIN VARIETIES - CROOKSTON, MN - 1982*

G.L. Malzer, S. Comfort, G. Varvel, 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. 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 other, is not well understood, but it has been suggested that it may be related to favorable plant characteristics both above and below the ground. Experiments were established in 1982 to examine some of the differences which exist between wheat varieties in their ability to provide a yield response to nitrogen fertilization and to ascertain differences in nitrogen utilization. Existing popular varieties as well as older varieties and experimental varieties were included for comparison in responsiveness to added fertilizer nitrogen as well to overall nitrogen utilization. Similar trials were conducted at Morris as well as Crookston, MN.

EXPERIMENTAL PROCEDURES

Twelve 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, MN. 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 twelve varieties planted within a uniformly fertilized area. All treatments were replicated four times. Experimental plots were planted into areas 5' x 20' on April 29, utilizing a cone seeder.

Total plant dry matter production was determined at approximately the "soft dough" stage of growth (August 2nd) and samples were collected for nitrogen content and calculation of nitrogen uptake. Yield grain was harvested August 11 by harvesting 14 ft^2 of plot area. The above ground growth (grain and straw) was removed from the experimental plot and placed in a forced air dryer. After drying the samples were weighed, thrashed and the grain reweighed 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 at Crookston in 1982 were excellent. Grain yields ranged from 38-76 bu/A. Grain yields were influenced by both variety and nitrogen rate. A significant nitrogen rate by variety interaction suggested that all varieties did not respond to nitrogen application in the same manner. One of the more interesting aspects of the interaction was the ability of certain varieties to continue to respond to additional nitrogen fertilizer when other "good" varieties did not increase in yield. Varieties which stood out in this respect included Marshall, Mn 7125, Olaf, MN 7357, MN 73167 and James. These varieties were capable of increasing their yields 7, 7, 7, 12, 12 and 10 bu/A when the nitrogen rate was increased from 60 # N/A to 120 # N/A. Other varieties either showed very little increase or yield reductions.

The nitrogen content of the grain which provides an index of grain protein, was significantly influenced by both nitrogen rate and variety. Grain protein was increased up through the highest rate of N application. Of the varieties mentioned above with good yielding characteristics at the 120 # N/A rate of application Olaf and James had a substantially higher N (protein content) concentration in the grain. In a similar comparison, MN 7125, MN 73167 and Olaf were the most effective in total N removal from the soil when 120 # N/A were applied.

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

Table 1. Influence of nitrogen fertilizer and variety on yield, N content and test weight of 12 hard red spring wheat varieties from Crookston, MN - 1982.

Nitrogen Rate	Variety	Grain Yield	Grain N Content	Test wt.	Forage Total Dry Matter	Forage N Content
#/A		bu/A	%	#/bu	T/A	%
0		43.3	2.13	59.1	3.35	0.63
60		58.6	2.35	59.5	4.46	0.89
120		62.9	2.61	58.6	4.62	1.13
Significance			**	NS	**	**
BLSD (.05)			0.01	--	0.11	0.05
-	Butte	54.8	2.33	60.8	4.56	0.76
-	Coteau	49.3	2.92	59.8	4.17	0.88
-	Era	54.2	2.19	59.4	3.68	0.91
-	Marshall	59.4	2.36	60.6	4.21	0.94
-	MN 7125	62.1	2.22	58.5	4.20	0.88
-	Mn 7222	52.8	2.25	57.9	3.99	0.87
-	Olaf	49.6	2.70	57.8	4.14	0.96
-	Thatcher	42.6	2.46	58.3	3.97	0.81
-	MN 7357	59.4	2.15	58.5	4.17	0.88
-	MN 73167	61.6	2.21	59.5	4.18	0.79
-	MN 73168	59.9	2.18	58.1	4.21	1.04
-	James	53.9	2.45	59.2	4.23	0.86
Significance			**	**	**	**
BLSD (.05)			0.01	0.9	0.24	0.12
Interaction - N rate x Variety						
0	Butte	47.8	1.98	60.4	4.08	0.62
0	Coteau	46.3	2.73	60.1	3.55	0.54
0	Era	40.1	1.98	59.0	2.85	0.58
0	Marshall	44.5	2.17	60.1	3.27	0.71
0	MN 7125	45.6	1.97	58.6	3.31	0.65
0	MN 7122	40.7	2.01	58.5	3.32	0.72
0	Olaf	37.8	2.51	57.9	3.26	0.62
0	Thatcher	38.0	2.16	58.2	3.27	0.57
0	MN 7357	43.1	1.88	58.2	3.30	0.61
0	MN 73167	45.5	2.03	59.6	3.40	0.59
0	MN 73168	47.1	1.97	59.0	3.18	0.66
0	James	43.8	2.22	58.9	3.42	0.64
60	Butte	61.3	2.31	61.0	4.84	0.70
60	Coteau	52.0	3.02	59.7	4.57	1.00
60	Era	59.6	2.12	60.1	4.14	0.94
60	Marshall	63.3	2.40	61.1	4.58	0.91
60	Mn 7125	67.0	2.23	59.1	4.69	0.89
60	MN 7222	56.1	2.15	58.5	4.12	0.87
60	Olaf	52.0	2.72	57.4	4.57	0.94
60	Thatcher	47.6	2.30	58.9	4.36	0.78
60	MN 7357	61.6	2.18	58.8	4.50	0.86
60	MN 37167	63.5	2.18	60.1	4.27	0.75
60	MN 73168	65.3	2.15	58.8	4.47	1.22
60	James	54.3	2.41	60.1	4.36	0.85

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 by 12 hard red spring wheat varieties from Crookston - 1982.

Nitrogen Rate	Variety	Harvest Straw Dry Matter	Harvest Straw N Content	Nitrogen Removal Forage	Nitrogen Removal Straw	Nitrogen Removal Grain	Grain α Straw
#/A		T/A	%	---------------#/A---			
0		1.61	0.27	42.3	8.7	48.4	57.1
60		2.25	0.40	80.2	18.0	58.6	76.6
120		2.58	0.59	104.1	30.8	62.9	93.7
Significance		**	**	**	**		
BLSD (.05)		0.09	0.03	5.2	1.8		
-	Butte	2.32	0.34	69.8	16.5	67.0	83.5
-	Coteau	2.45	0.45	75.4	22.7	75.4	98.1
-	Era	1.94	0.45	69.6	18.8	62.8	81.6
-	Marshall	2.19	0.38	82.3	17.5	74.0	91.5
-	MN 7125	2.12	0.46	76.5	20.7	73.5	94.2
-	MN 7222	1.93	0.45	70.6	18.7	62.8	81.5
-	Olaf	2.30	0.44	82.9	22.2	70.8	93.0
-	Thatcher	2.16	0.36	66.1	16.2	54.8	71.0
-	MN 7357	1.97	0.43	76.6	18.2	68.1	86.3
-	MN 73167	2.11	0.43	68.6	19.1	71.9	91.1
-	MN 73168	2.04	0.45	92.8	19.9	68.8	88.7
-	James	2.25	0.40	74.8	19.4	69.8	89.2
Significance		**	**	**	*		
BLSD (.05)		0.20	0.06	12.7	5.4		
Interaction - N rate x Variety							
0	Butte	1.89	0.22	51.6	8.5	49.5	58.0
0	Coteau	2.06	0.28	39.0	11.7	66.8	78.5
0	Era	1.44	0.27	33.4	7.8	41.6	49.4
0	Marshall	1.73	0.25	47.2	8.6	50.5	59.1
0	MN 7125	1.55	0.30	42.8	9.2	47.2	56.4
0	MN 7222	1.27	0.35	48.1	8.9	42.5	51.4
0	Olaf	1.63	0.23	40.1	7.6	49.7	57.3
0	Thatcher	1.66	0.25	37.3	8.5	43.2	51.7
0	MN 7357	1.35	0.28	40.9	7.4	42.3	49.7
0	MN 73167	1.64	0.29	40.4	9.5	48.0	57.5
0	MN 73168	1.48	0.25	42.6	7.4	48.5	55.9
0	James	1.62	0.30	44.0	9.8	51.0	60.8
60	Butte	2.42	0.30	68.4	14.5	73.5	88.0
60	Coteau	2.59	0.51	91.9	26.4	82.1	108.5
60	Era	2.06	0.43	79.2	17.7	65.7	83.4
60	Marshall	2.22	0.34	83.4	15.0	79.4	94.4
60	MN 7125	2.22	0.45	84.9	19.9	78.2	98.1
60	MN 7222	2.07	0.36	72.4	15.1	63.0	78.1
60	Olaf	2.45	0.43	87.8	21.7	74.4	96.1
60	Thatcher	2.45	0.36	67.7	17.5	57.4	74.9
60	MN 7357	1.99	0.38	77.9	15.1	70.4	85.5
60	MN 73167	2.13	0.41	64.0	17.7	72.5	90.2
60	MN 73168	2.15	0.45	110.0	19.7	73.4	93.1
60	James	2.26	0.34	74.1	15.6	68.4	84.0

Table 2 continued on next page

Table 1. Influence of nitrogen fertilizer and variety on yield, N content and test weight of 12 hard red spring wheat varieties frum Crookston, MN - 1982. (cont.)

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	Butte	55.3	2.69	60.9	4.76	0.94
120	Coteau	49.6	3.00	59.6	4.40	1.08
120	Era	62.9	2.47	59.2	4.03	1.20
120	Marshall	70.4	2.51	60.5	4.78	1.21
120	MN 7125	73.6	2.46	57.8	4.58	1.11
120	MN 7222	61.7	2.58	56.7	4.54	1.01
120	Olaf	59.0	2.87	58.1	4.60	1.31
120	Thatcher	42.3	2.90	57.7	4.28	1.09
120	MN 7357	73.7	2.37	58.4	4.71	1.18
120	MN 73167	75.7	2.41	58.9	4.87	1.04
120	MN 73168	67.2	2.41	56.6	4.97	1.26
120	James	63.8	2.72	58.5	4.91	1.08
Significance		**	NS	NS	NS	NS

Table 2. Influence of nitrogen fertilization and variety on straw production and nitrogen uptake (cont.) by forage, straw, and grain by 12 hard red spring wheat varieties from Crookston - 1982.

Nitrogen Rate	Variety	Harvest Straw Dry Matter	Harvest Straw N Content	Nitrogen Removal Forage	Nitrogen Removal Straw	Nitrogen Removal Grain	Grain α Straw
#/A		T/A	%	#/A			
120	Butte	2.66	0.49	89.4	26.5	77.8	104.3
120	Coteau	2.70	0.56	95.4	30.2	77.3	107.5
120	Era	2.32	0.66	96.3	30.7	81.1	111.8
120	Marshall	2.61	0.56	115.8	28.9	92.1	121.0
120	MN 7125	2.60	0.62	101.8	33.0	94.9	127.9
120	MN 7222	2.45	0.65	91.3	32.1	82.9	115.0
120	Olaf	2.81	0.65	120.9	37.3	88.4	125.7
120	Thatcher	2.37	0.48	93.3	22.6	63.9	86.5
120	MN 7357	2.58	0.62	110.9	31.9	91.5	123.4
120	MN 73167	2.57	0.59	101.4	30.5	95.3	125.8
120	MN 73168	2.48	0.64	126.0	32.8	84.5	117.3
120	James	2.86	0.57	106.4	32.7	90.2	122.9
Significance		NS	NS	NS	NS	**	*

COMPARISON OF NITROGEN SOURCES ON SPRING WHEAT AND BARLEY

G. E. Varvel and R. K. Severson

Nitrogen fertilization is one of the largest investments for small grain farmers in northern Minnesota. Information on the source and amount to use is available, but the release of new varieties presents the need for additional evaluation of N rates and sources. These studies were designed to evaluate N sources on both spring wheat and barley.

Experimental Procedure:

Four sources, each at 2 N levels, were used. The 4 sources were anhydrous ammonia (82-0-0), urea (46-0-0), UAN solution (28-0-0), and ammonium nitrate (34-0-0). A check plot was also included. A randomized complete block design with 4 replications was used in both studies. All fertilizer treatments were applied on May 7, 1982 and incorporated with a field cultivator. Era wheat and Robust barley were seeded on May 8, 1982 in the respective studies. Whole plant samples were taken on June 21, 1982 for total N analyses on both studies. Whole plant samples taken at soft dough (July 23, 1982 for barley and August 9, 1982 for wheat) were analyzed for total N and used to calculate forage yields and N uptake. Grain was harvested August 9, 1982 from the barley and August 23, 1982 from the wheat study. Soil test NO_3-N (0-2') results from the two studies were 50 lb/A for the barley study and 40 lb/A for the wheat study.

Results:

The effects of the treatments are shown in Tables 1 and 2 for the barley and wheat studies, respectively. Significant differences were obtained in all the measured variables except test weight for both crops when the check plot was included in the analyses. Elimination of the check plot from the analyses enabled the treatments to be broken down into the N rate and source effects. These analyses indicated that most of the differences were due to the N rates. Some differences were obtained between sources, but these were obtained because of an application error with anhydrous ammonia.

Table 1. The effect of N source and rate on barley yield and quality.

N		Early Plant	Grain					Forage			
Source	Rate	N	Yield	Test Weight	Plumps	Protein	N Removal	Dry Matter Yield	N	N Uptake	Lodging
		%	Bu/A	lb/Bu	%	%	lb/A	lb/A	%	lb/A	
--	0	2.76	57.7	48.6	91.5	11.1	49.6	5352	0.98	52.6	1.6
82-0-0	50	3.05	80.0	48.1	90.3	10.9	67.0	6657	0.96	63.6	3.5
	100	3.91	79.7	47.4	86.0	11.8	72.4	7499	1.23	91.6	5.5
46-0-0	50	3.63	77.2	48.4	87.4	11.6	68.8	7229	1.29	92.3	3.5
	100	3.98	77.5	47.3	83.6	12.2	72.8	7711	1.18	90.8	6.6
28-0-0	50	3.59	81.0	47.9	85.5	11.9	74.0	7766	1.14	88.4	4.9
	100	4.19	76.0	47.7	84.1	12.5	73.4	7365	1.42	103.3	5.9
34-0-0	50	3.59	72.2	48.0	87.5	11.3	62.6	6986	1.14	78.6	3.9
	100	3.87	76.3	47.8	85.3	11.8	69.5	7528	1.25	94.9	6.4
Significance		**	**	N.S.	**	**	**	**	**	**	**
B.L.S.D. (.05)		0.39	9.8		3.8	0.8	11.3	1013	0.21	14.5	2.7
C.V. (%)		10.4	11.8	2.0	3.8	6.1	14.9	12.8	15.6	16.4	49.8
Main Effects											
Source											
82-0-0		3.48	79.9	47.8	88.1	11.4	69.7	7078	1.09	77.6	4.5
46-0-0		3.80	77.3	47.8	85.5	11.9	70.8	7470	1.23	91.5	5.1
28-0-0		3.89	78.5	47.8	84.8	12.2	73.7	7565	1.28	95.8	5.4
34-0-0		3.73	74.2	47.9	86.4	11.6	66.1	7257	1.20	86.8	5.1
Significance		N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.	N.S.	*	N.S.
N Rate (lb/A)											
50		3.52	77.3	48.1	87.3	11.5	68.2	7231	1.16	83.2	4.0
100		4.00	77.0	47.6	84.6	12.1	72.0	7530	1.28	95.7	6.2
Significance		**	N.S.	*	**	*	N.S.	N.S.	*	**	**

Discussion:
Results from the study on barley indicated that the 50 lb/A N application was sufficient for maximum yields with all the N sources used. Additional N reduced quality and increased lodging with all of the N sources.

Results from the study on wheat indicated that the 50 lb/A N application was insufficient for maximum yield, but the 100 lb/A application was probably too high with all of the N sources. Maximum yield and suitable quality could probably have been obtained with 70 lb/A N applied which would correspond very well with current N recommendations for spring wheat.

Further studies will be used to compare application methods of the N sources in an attempt to increase N efficiency.

Table 2. The effect on N source and rate on spring wheat yield and quality.

N Source	Rate	Early Plant N	Grain: Yield	Grain: Test Weight	Grain: Protein	Grain: N Removal	Forage: Dry Matter Yield	Forage: N	Forage: N Uptake
	lb/A	%	Bu/A	lb/Bu	%	lb/A	lb/A	%	lb/A
--	0	2.80	31.8	59.4	11.0	36.9	4685	1.79	55.4
82-0-0	50	2.80	45.1	59.0	10.7	50.5	6789	1.02	69.4
	100	3.49	59.9	59.5	11.5	72.2	8902	1.38	122.3
46-0-0	50	3.28	52.2	59.9	11.4	62.9	7655	1.18	90.7
	100	3.83	59.2	59.6	12.1	75.3	8873	1.37	121.3
28-0-0	50	3.41	53.2	59.5	11.2	62.6	7905	1.19	94.2
	100	4.00	56.4	59.2	12.6	74.9	8670	1.40	120.1
34-0-0	50	3.36	52.3	59.7	11.3	62.0	7514	1.27	94.7
	100	3.90	57.8	58.8	12.3	74.4	8674	1.32	114.7
Significance		**	**	N.S.	**	**	**	**	**
B.L.S.D. (.05)		0.34	3.8		0.7	5.5	764	0.18	15.1
C.V. (%)		9.5	7.4	1.5	5.8	8.7	9.9	11.9	15.1
Main Effects									
Source									
82-0-0		3.15	52.5	59.2	11.1	61.4	7845	1.20	95.9
46-0-0		3.55	55.7	59.8	11.8	69.1	8264	1.28	106.0
28-0-0		3.70	54.8	59.3	11.9	68.9	8287	1.29	107.2
34-0-0		3.63	55.0	59.2	11.8	68.2	8094	1.30	104.7
Significance		**	N.S.	N.S.	*	**	N.S.	N.S.	N.S.
N Rate (lb/A)									
50		3.27	51.5	59.6	11.2	60.8	7562	1.19	89.8
100		3.85	58.1	59.3	12.2	74.5	8763	1.36	119.2
Significance		**	**	N.S.	**	*	**	**	**

EFFECTS OF NITROGEN RATE AND PLACEMENT ON TWO MALTING BARLEY VARIETIES

G. E. Varvel and R. K. Severson

The importance of malting barley in Northwestern Minnesota has generated the need for additional information on N fertilization with the release of new higher yielding varieties. The higher yield potential of these varieties is due in part to greater straw strength and disease resistance, which may allow greater N fertilization. This study was established to evaluate two varieties, Morex and Glenn, under various N management programs.

Experimental Procedure:

The treatments consisted of N from UAN solution (28-0-0) at rates of 0, 50, 100, and 150 lb/A both surface applied (broadcast) and injected (6 inches deep, 12 inches apart), on two malting barley varieties in a factorial arrangement. A randomized complete block design with 4 replications was used. Initial soil test results indicated 50 lb NO_3-N/A available in the top 2 feet.

The fertilizer was applied and varieties planted on May 8, 1982. Whole plant samples were taken at late-tillering (June 21, 1982) and soft dough (July 23, 1982) for N analyses. The samples taken at soft dough (maturity) were used to calculate forage yield and N uptake. Grain was harvested August 9, 1982 for yield and quality determinations. Lodging ratings were made on July 26, 1982.

Results:

The effects of variety, N rate, placement, and the variety by N rate interaction are shown in Table 1. All possible interactions were analyzed, but only the variety by N rate interaction was significant with respect to any of the measured variables. Those variables were grain yield, test weight, plump kernels, and lodging. Lodging differences between the varieties at the various N levels appeared to be the main cause of the interaction. Glenn was able to withstand the higher N rates without lodging as greatly as Morex under the same conditions. The lodging differences then caused most of the differences in grain yield, test weight, and plump kernels which resulted in the interaction being significant for those variables also.

Significant differences in early plant N content, forage yield, and forage N content were obtained between varieties (Table 1). Morex had a significantly higher early plant N and forage yield but Glenn was significantly higher in forage N content.

Early plant N content, forage yield, forage N content, N uptake, protein, and grain N removal were all significantly increased with increased N rate (Table 1).

Nitrogen placement had no effect on any of the measured variables in 1982 (Table 1).

Discussion:

Results obtained in 1982 were similar to those obtained in the 1981 study except that lodging appeared to be more of a problem in 1982. Results from both years emphasize the importance of N management and the need for additional information with respect to the new varieties.

Table 1. Effects of variety, N rate, N placement, and variety by N rate interaction on early plant N content, forage yield, forage N content, N uptake, grain yield, test weight, protein, plump kernels, grain N removal, and lodging of barley.

Interaction			Forage			Grain					
Variety	N-Rate	N[1/]	D.M. Yield	N[2/]	N Uptake	Yield	Test Weight	Protein	Plump Kernels	N Removal	Lodging[3/]
	lb/A	%	lb/A	%	lb/A	Bu/A	lb/Bu	%	%	lb/A	
Morex	0	3.22	5217	1.40	72.6	64.4	46.6	11.7	84.2	57.8	1.7
Morex	50	3.78	6122	1.45	87.8	65.7	45.8	11.9	79.5	60.1	3.0
Morex	100	4.25	6297	1.69	106.8	66.4	43.9	13.1	69.5	66.6	6.0
Morex	150	4.35	6681	1.81	121.3	62.7	42.4	13.7	57.2	66.0	7.5
Glenn	0	3.23	5340	1.45	77.3	54.9	45.7	11.6	87.3	49.1	1.0
Glenn	50	3.84	5235	1.61	84.2	62.6	44.8	11.9	84.3	57.1	1.7
Glenn	100	3.97	5907	1.88	110.8	64.3	43.9	12.9	77.0	64.0	1.7
Glenn	150	3.96	5570	1.96	108.2	68.2	43.7	12.8	78.5	67.2	3.2
Significance		N.S.	N.S.	N.S.	N.S.	*	**	N.S.	*	N.S.	**
Main Effects											
Variety											
Morex		3.90	6079	1.59	97.1	64.8	44.7	12.6	72.6	62.6	4.5
Glenn		3.75	5513	1.72	95.1	62.5	44.5	12.3	81.8	59.4	1.9
Significance		*	**	*	N.S.	--	--	N.S.	--	N.S.	--
N Rate (lb/A)											
0		3.22	5279	1.42	74.9	59.6	46.1	11.7	85.8	53.5	1.3
50		3.81	5679	1.53	86.0	64.1	45.3	11.9	81.9	58.6	2.3
100		4.11	6102	1.79	108.8	65.3	43.9	13.0	73.3	65.3	3.8
150		4.15	6125	1.88	114.8	65.4	43.0	13.3	67.8	66.6	5.3
Significance		**	*	**	**	--	--	**	--	**	--
N Placement											
Surface		3.78	5912	1.62	96.0	63.3	44.8	12.4	76.5	60.3	3.2
Injected		3.87	5680	1.69	96.3	63.9	44.4	12.5	77.9	61.7	3.3
Significance		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

1/ Kjeldahl N (whole plant at late-tillering)

2/ Kjeldahl N

3/ Lodging scores (1=erect, 10=flat)

EFFECTS OF NITROGEN ON SUNFLOWER

G. E. Varvel and R. K. Severson

The objective of these studies was to evaluate various N management practices on sunflower. These practices included determining the effect of anhydrous ammonia applied at planting time on the germination of sunflower and comparison of N carriers, broadcast and injected, on sunflower.

Experimental Methods:

Experiment 1 consisted of 4 rates of N (0, 50, 100, and 150 lb/A) as anhydrous ammonia. A randomized complete block design with 4 replications was used. The anhydrous application was made at a depth of 4-5 inches with a knife spacing of 12 inches on May 27, 1982. Sunflower, Dahlgren 844, was planted in 30 inch rows immediately after the anhydrous was applied. Stand counts were taken on June 8, 1982 to determine the effects of the treatments on germination.

Experiment 2 contained 12 treatments in a randomized complete block design with 4 replications. The treatment consisted of a broadcast and injected check (applicator pulled through), anhydrous ammonia (82-0-0) injected at 2 N rates, urea (46-0-0) broadcast and injected at 2 N rates, and UAN solution (28-0-0) broadcast and injected at 2 N rates. Sunflower, Dahlgren 844, was planted in 30 inch rows on May 27, 1982. Soil test results for the study were: pH - 8.4, $NaHCO_3$ P - 11 lb/A, exchangeable K - 260 lb/A, and NO_3-N (0-2') - 108 lb/A.

Leaf samples were taken from both experiments on August 2, 1982 to evaluate the effects of the treatments.

Results:

Sunflower midge destroyed both experiments so only stand counts and leaf N analyses information was obtained.

The effect of N as anhydrous ammonia on stand counts (germination) and leaf N analyses in experiment 1 is shown in Table 1. A significant reduction in germination was obtained with the highest N rate and the N in the leaf increased significantly as N rate increased.

The effect of the treatments on leaf N analyses in experiment 2 is shown in Table 2. Leaf N content increased with N rate, but carrier and placement had no effect.

Discussion:

The reduction (approximately 10%) in stand with anhydrous ammonia at planting time was obtained at the 150 N/A rate which indicates that N rates commonly applied to sunflower could be made safely at planting time. Further studies are planned to evaluate these effects.

Table 1. The effects of anhydrous ammonia at planting time on sunflower germination and leaf nitrogen analyses

N Rate	Stand Count	Leaf N
lb/A	Plants/Plot	%
0	454	2.47
50	453	2.72
100	447	3.30
150	415	3.51
Significance	*	*
B.L.S.D. (.05)	36	0.8
C.V. (%)	4.6	15.8

Table 2. The effects of nitrogen rate, carrier, and application method on sunflower leaf nitrogen analyses.

N Rate	Leaf N
lb/A	%
0	3.10
50	3.16
100	3.43
Significance	*
Carrier	
82-0-0	3.35
46-0-0	3.36
28-0-0	3.20
Significance	N.S.
Placement	
Broadcast	3.36
Injected	3.25
Significance	N.S.

NITROGEN, PHOSPHORUS, AND POTASSIUM FERTILITY STUDIES ON OILSEED SUNFLOWER

G. E. Varvel and R. K. Severson

Fertilizer response data for sunflower in Minnesota is limited in nature and amount. These studies were designed to generate additional information on the effects of N, P, and K fertilization on sunflower growth and yield.

Experimental Procedure:

Two experiments were established in the spring of 1982. These experiments were located near Fertile (location 1) and Fosston (location 2). Additional information on the two experiments is shown in the table below:

	Soil Tests						Date (1982)	
Location	pH	NO_3-N	$NaHCO_3$ P	Exch. K	Variety	Plant Population	Planting	Harvest
		lb/A-2'	lb/A	lb/A		Plants/A		
1	7.3	34	14	170	Cargill 205	22,590	6-6	10-12
2	8.4	75	6	240	USDA 894	17,860	6-9	10-15

Preliminary information from the 2 sites indicated that location 1 was low in soil test K and location 2 was low in soil test P. Based upon this information, the treatments at location 1 consisted of 2 N levels (0 and 100 lb/A), 2 P_2O_5 levels (0 and 80 lb/A), and 3 K_2O levels (0, 100, and 200 lb/A) in a factorial arrangement. The treatments at location 2 consisted of 2 N levels (0 and 100 lb/A), 3 P_2O_5 levels (0, 40, and 80 lb/A), and 2 K_2O levels (0 and 100 lb/A) in a factorial arrangement. Location 1 also had 100 lb/A N applied by the farmer-cooperator.

Whole plant samples were taken twice at location 1 and once at location 2 for elemental analyses and total dry matter yields. Leaf samples were also taken at 50% pollination for elemental analyses. Seed yields were taken on the dates shown in Table 1. Seed from the various treatments was then used for oil and elemental analyses.

Results:

All results will be reported with respect to the main effects since no significant interactions were obtained.

Location 1: The effects of the N, P, and K treatments on sunflower are shown in Tables 1 through 5.

Nitrogen significantly increased N, Na, and Mn content in the plant and N and K uptake at the first sampling (Table 1), had no effect at the second sampling (Table 2), significantly increased N and Zn content and decreased K and Ca content in the leaf (Table 3), significantly decreased oil content in the seed and increased N removal at harvest (Table 4), and significantly increased N, Fe, Mn, and Zn content and decreased K, Mg, Ca, Al, and Cu content in the seed at harvest (Table 5).

Phosphorus significantly increased early plant growth, N, P, and K uptake, and P, Mg, and B content and decreased Al, Fe, and Zn content in the plant at the first sampling (Table 1), had no effect at the second sampling (Table 2), significantly increased P and Mg content and decreased K, Zn, and Cu content in the leaf (Table 3), significantly increased seed yield, and P and K removal at harvest (Table 4), and significantly increased P and Mg content and decreased Cu content in the seed at harvest (Table 5).

Potassium significantly increased K uptake and K content and decreased Ca and Mg content in the plant at the first sampling (Table 1), significantly decreased Al and Fe content in the plant at the second sampling (Table 2), significantly increased K and B content and decreased Mg content in the leaf (Table 3), significantly increased seed yield, oil content, oil yield, N removal, and K removal at harvest (Table 4) and significantly increased Mn content and decreased Mg content in the seed at harvest (Table 5).

Location 2: The effects of N, P, and K treatments on sunflower are shown in Tables 6 through 9.

Nitrogen had no effect at the early sampling (Table 6), significantly increased Zn content in the leaf (Table 7), had no effect on any of the yield variables at harvest (Table 8), and significantly increased N content and decreased Al content in the seed at harvest (Table 9).

Phosphorus significantly increased early plant growth, N, P, and K uptake and decreased Mn content in the plant at the early sampling (Table 6), significantly increased P and B content and decreased K, Zn, and Cu content in the leaf (Table 7), significantly increased seed yield, oil yield, and N, P, and K removal by the seed at harvest (Table 8), and significantly increased P, Mg, and Mn content and decreased Ca, Al, Zn, and Cu content in the seed at harvest (Table 9).

Potassium significantly decreased N uptake, and N and Na content in the plant at the early sampling (Table 6), significantly decreased Ca content in the leaf (Table 7), had no effect on any of the yield variables at harvest (Table 8), and significantly decreased Al content in the seed at harvest (Table 9).

Discussion:
The results obtained in 1982 are similar to those reported in previous years. Phosphorus increases early plant growth when soil test levels are in the low to medium range as they were in 1982 at both locations. At later samplings, the difference in growth is usually lost and only by using elemental analyses can differences be obtained. Even then, increased seed yield cannot be predicted. From leaf analyses one does appear to be able to discern differences, but these may be the result of luxury consumption, so precautions must be taken. The best method to predict the probability of a response to N, P, and K is to use a soil test. In 1982, as well as in previous years, if the soil test was in the low to medium range, significant increases in yield were usually obtained. The plant and seed analyses does provide valuable information which can be used to evaluate the effectiveness of the fertilizer treatments and also provides information on nutrient uptake and removal by sunflower.

Table 1. Effects of N, P, and K on early plant growth, nutrient uptake, and elemental analyses of sunflower at location 1 at the V13-R1 stage.[1/]

Main Effects	T.D.M. Yield	Uptake N	Uptake P	Uptake K	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	lbs/A				%					ppm						
N Rate (lb/A)																
0	596	23.9	2.6	30.9	4.03	.44	5.14	2.81	1.18	355	431	142	122	58	5	69
80	635	26.6	2.9	34.3	4.20	.45	5.37	2.89	1.26	361	416	176	155	60	5	63
Significance	N.S.	**	N.S.	+	**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	*	N.S.	N.S.	N.S.
P_2O_5 Rate (lb/A)																
0	547	22.7	2.4	29.0	4.16	.43	5.26	2.80	1.16	394	453	147	131	59	5	65
80	684	27.9	3.2	36.2	4.06	.46	5.26	2.90	1.28	322	394	172	146	58	4	68
Significance	**	**	**	**	N.S.	**	N.S.	N.S.	*	**	*	N.S.	N.S.	N.S.	**	**
K_2O Rate (lb/A)																
0	596	24.5	2.8	27.3	4.12	.46	4.59	2.99	1.36	375	426	164	122	55	5	66
100	625	25.5	2.8	32.8	4.10	.44	5.20	2.84	1.24	356	425	151	143	59	5	65
200	626	25.8	2.7	37.7	4.12	.43	5.99	2.72	1.06	343	421	162	151	62	5	67
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.

Columns N through B: Elemental Analyses.

[1/] Schneiter, A.A. and J.F. Miller. 1981. Description of sunflower growth stages. Crop Sci. 21:901-903.

Table 2. Effects of N, P, and K on plant growth, nutrient uptake, and elemental analyses of sunflower at location 1 at the R 5.5 stage.

Main Effects	T.D.M. Yield	Uptake N	Uptake P	Uptake K	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	- - - - lbs/A - - -				- - - - - - - % - - - - - -					- - - - - - - - ppm - - - - - - -						
N Rate (lb/A)																
0	5401	95.8	15.3	137.9	1.77	.28	2.56	1.75	.78	140	176	49	85	27	5	44
80	5158	87.1	14.2	137.9	1.68	.27	2.67	1.76	.75	131	166	45	79	26	4	44
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.	N.S.
P_2O_5 Rate (lb/A)																
0	5304	89.2	14.9	132.6	1.67	.28	2.50	1.74	.78	135	168	52	77	25	5	43
80	5255	93.7	14.6	143.2	1.78	.28	2.73	1.77	.76	137	174	41	87	27	5	45
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.	N.S.
K_2O Rate (lb/A)																
0	5173	90.0	14.5	137.2	1.73	.28	2.66	1.77	.76	144	179	48	82	27	5	43
100	5460	92.8	14.6	134.4	1.69	.27	2.46	1.70	.77	142	178	41	89	26	5	43
200	5206	91.6	15.1	142.0	1.75	.29	2.72	1.79	.77	122	155	51	76	26	5	47
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.	N.S.

Table 3. Effects of N, P, and K treatments on elemental analyses of sunflower leaves at location 1 at the R 5.5 stage.

Main Effects	N	P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
	- - - - - - - - % - - - - - - - -					- - - - - - - - - - ppm - - - - - - - - -					
N Rate (lb/A)											
0	3.56	0.39	3.25	3.67	0.97	30	84	148	32	9	60
80	3.91	0.40	3.08	3.34	1.05	28	84	172	39	9	54
Significance	**	N.S.	**	**	N.S.	N.S.	N.S.	N.S.	**	N.S.	N.S.
P_2O_5 Rate (lb/A)											
0	3.74	0.39	3.25	3.41	0.95	29	85	157	37	10	58
80	3.73	0.41	3.08	3.60	1.08	30	84	163	34	8	56
Significance	N.S.	*	**	+	**	N.S.	N.S.	N.S.	**	**	N.S.
K_2O Rate (lb/A)											
0	3.75	0.41	2.84	3.65	1.16	29	84	143	35	9	55
100	3.68	0.38	3.07	3.44	1.02	31	85	169	35	9	51
200	3.78	0.40	3.59	3.43	0.86	28	83	168	36	9	64
Significance	N.S.	+	**	N.S.	**	N.S.	N.S.	N.S.	N.S.	N.S.	*

Table 4. Effect of N, P, and K treatments on seed and oil yield, oil content, nutrient removal, and plant population at harvest at location 1.

	Seed						
Main Effects	Yield	Oil	Oil Yield	N Removal	P Removal	K Removal	Total Population
	lb/A	%	lb/A	lb/A	lb/A	lb/A	Plants/A
N Rate (lb/A)							
0	1843	48.1	887	45.9	10.8	17.3	22,772
80	1939	46.6	904	53.3	11.1	17.6	22,409
Significance	N.S.	**	N.S.	**	N.S.	N.S.	N.S.
P_2O_5 Rate (lb/A)							
0	1828	47.5	868	48.0	10.2	16.9	22,554
80	1954	47.2	923	51.2	11.7	18.0	22,627
Significance	+	N.S.	N.S.	N.S.	**	+	N.S.
K_2O Rate (lb/A)							
0	1810	46.5	842	47.3	10.8	16.6	22,724
100	1856	47.8	886	48.0	10.4	17.0	22,724
200	2007	47.8	958	53.5	11.6	18.8	22,325
Significance	+	**	*	+	N.S.	*	N.S.

Table 5. Effects of N, P, and K treatments on elemental analyses of the seed at harvest at location 1.

	Elemental Analyses										
Main Effects	N	P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
	%					ppm					
N Rate (lb/A)											
0	2.47	.58	.94	.21	.34	4.9	48	24	42	9.4	14.6
80	2.75	.57	.91	.19	.33	4.4	52	26	50	8.7	14.9
Significance	**	N.S.	*	**	+	**	**	**	**	+	N.S.
P_2O_5 Rate (lb/A)											
0	2.61	.56	.92	.20	.33	4.6	50	25	47	9.5	14.6
80	2.61	.60	.92	.20	.34	4.7	50	26	45	8.6	14.9
Significance	N.S.	**	N.S.	N.S.	**	N.S.	N.S.	N.S.	N.S.	*	N.S.
K_2O Rate (lb/A)											
0	2.61	.59	.92	.20	.35	4.4	49	24	47	9.3	14.8
100	2.57	.56	.92	.21	.33	4.6	50	26	45	9.3	14.4
200	2.66	.58	.94	.21	.33	4.9	52	26	47	8.7	15.0
Significance	N.S.	N.S.	N.S.	N.S.	**	N.S.	N.S.	*	N.S.	N.S.	N.S.

Table 6. The effects of N, P, and K treatments on early plant growth, nutrient uptake, and elemental analyses of sunflower at location 2 at the V13-R1 stage.

Main Effects	T.D.M. Yield	Uptake N	Uptake P	Uptake K	Elemental Analyses N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	lbs/A				%							ppm				
N Rate (lb/A)																
0	321	11.7	.97	14.3	3.61	.30	4.51	3.48	1.33	.33	.27	362	169	37	8.9	44
80	314	11.2	.93	14.3	3.55	.29	4.53	3.68	1.35	.33	.28	351	174	39	9.3	43
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.	N.S.
P_2O_5 Rate (lb/A)																
0	282	10.1	.82	12.8	3.54	.29	4.58	3.78	1.38	.35	.29	371	177	38	9.5	43
40	326	11.8	.98	14.5	3.61	.30	4.47	3.48	1.29	.32	.27	344	171	39	9.0	43
80	346	12.4	1.05	15.7	3.59	.30	4.51	3.47	1.35	.32	.26	354	166	36	8.7	44
Significance	**	**	**	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.	N.S.
K_2O Rate (lb/A)																
0	331	12.0	.99	14.4	3.62	.30	4.40	3.57	1.37	.34	.27	373	170	37	9.0	44
100	305	10.8	.90	14.3	3.54	.29	4.65	3.59	1.32	.33	.27	340	173	39	9.1	43
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.

Table 7. The effects of N, P, and K treatments on elemental analyses of sunflower leaves at location 2 at the R 5.5 stage.

Main Effects	Elemental Analyses N	P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
	%					ppm					
N Rate (lb/A)											
0	4.43	.41	3.37	2.36	1.09	29	90	71	45	19	105
80	4.50	.41	3.36	2.35	1.11	33	93	71	48	19	104
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	**	N.S.	N.S.
P_2O_5 Rate (lb/A)											
0	4.54	.38	3.52	2.30	1.06	37	94	70	52	21	100
40	4.45	.41	3.32	2.37	1.09	27	90	73	45	18	104
80	4.41	.44	3.26	2.38	1.14	29	92	71	43	17	109
Significance	N.S.	**	*	N.S.	N.S.	N.S.	N.S.	N.S.	**	**	**
K_2O Rate (lb/A)											
0	4.43	.41	3.25	2.40	1.13	36	96	72	47	19	104
100	4.50	.41	3.48	2.31	1.07	26	87	70	46	18	104
Significance	N.S.	N.S.	N.S.	+	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 8. The effects of N, P, and K treatments on seed and oil yield, oil content, nutrient removal by the seed, and plant population at location 2 at harvest.

Main Effects	Seed: Yield	Seed: Oil	Seed: Oil Yield	Seed: N Removal	Seed: P Removal	Seed: K Removal	Total Population
	lb/A	%	lb/A	lbs/A	lbs/A	lbs/A	Plants/A
N Rate (lb/A)							
0	1388	41.5	577	37.4	6.8	13.0	17,530
80	1378	41.5	572	38.5	6.6	12.9	18,190
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
P_2O_5 Rate (lb/A)							
0	1162	41.5	483	31.4	5.0	11.0	18,392
40	1412	41.4	585	38.9	6.8	13.1	17,206
80	1602	41.6	667	44.3	8.4	15.2	18,049
Significance	**	N.S.	**	**	**	**	N.S.
K_2O Rate (lb/A)							
0	1387	41.5	577	38.1	6.8	13.0	18,058
100	1379	41.5	573	37.8	6.6	13.0	17,662
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 9. The effects of N, P, and K treatments on elemental analyses of sunflower seed at location 2 at harvest.

Main Effects	N	P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
	%	%	%	%	%	ppm	ppm	ppm	ppm	ppm	ppm
N Rate (lb/A)											
0	2.70	.49	.94	.17	.32	3.2	56	18.3	73	19	15
80	2.79	.47	.94	.17	.31	2.6	54	18.1	74	18	15
Significance	*	N.S.	N.S.	N.S.	N.S.	**	N.S.	N.S.	N.S.	N.S.	N.S.
P_2O_5 Rate (lb/A)											
0	2.71	.44	.95	.18	.30	3.1	55	17.5	77	20	15
40	2.76	.48	.93	.17	.32	2.9	55	18.3	74	18	15
80	2.76	.52	.95	.17	.34	2.6	55	18.8	68	17	15
Significance	N.S.	**	N.S.	**	**	+	N.S.	**	**	**	N.S.
K_2O Rate (lb/A)											
0	2.75	.48	.94	.17	.32	3.1	55	18.2	73	19	15
100	2.74	.47	.94	.17	.31	2.7	56	18.2	73	81	15
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.

LONG-TERM SOIL MOISTURE RECORD

D.G. Baker, Soil Science Dept., and W.W. Nelson, S.W. Expt. Sta.

A most interesting and valuable soil moisture record is the 23 year-sequence from the Southwest Agricultural Experiment Station, Lamberton. This is shown in Fig. 6. The progression of the total plant-available soil moisture for each season (the darker of the two lines) can be compared to the 1960-1976 mean (the lighter line). Several features can seen at a glance:

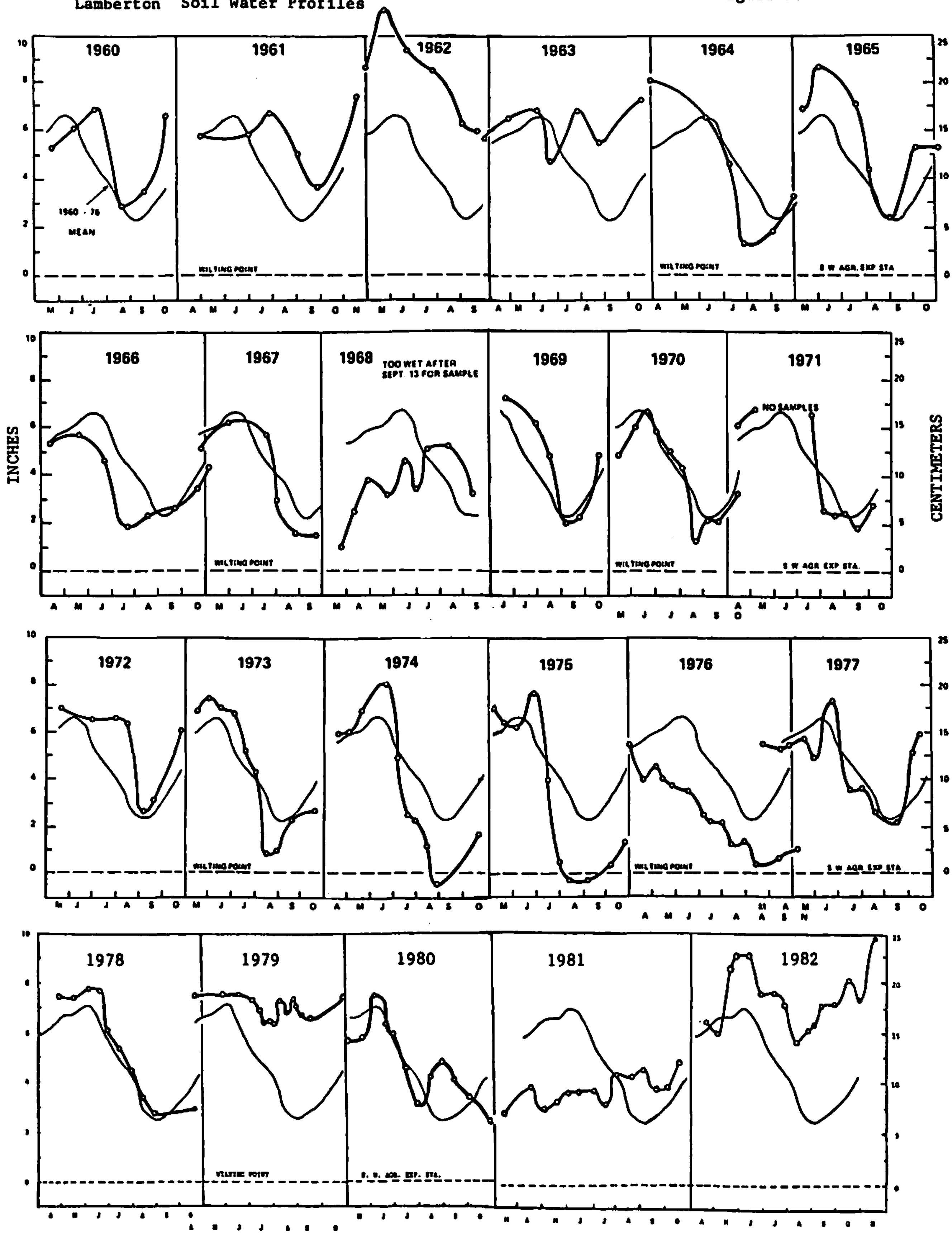
1. Years of highest soil moisture: 1962, 1972, and 1979.and 1982

2. Years of most average condition: 1969, 1970, and 1978

3. Years of lowest soil moisture: 1975 and 1976

Lamberton Soil Water Profiles

Figure 6.



TWENTY-THREE 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 112 and some of this information will not be included here).

The fertilizer treatments have now been applied annually to the same plot area for 23 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' by 77.5' and the 4 replications 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 plants/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 broadcast in June.

The yields obtained in 1982 were above average when considering the long term previous average for this experiment. Treatment averages in 1982 appeared to follow the trends which had been established with the long term average yields.

TWENTY-TWO YEAR AVERAGE

The average grain yields for the twenty-one years of this experiment are shown in Table 2. Only modest differences were obtained between nitrogen forms, time of application, and incorporation in the 1982 experiment. In 1982 with 40 # N/A applied, urea fall plow down was superior to ammonium nitrate fall plow down. When both materials were applied at the same rate to the surface there was essentially no difference. When urea was applied as a spring top dressed treatment, ammonium nitrate was superior to urea. This is not observed in the long term average.

Plowing down 80 # 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. Urea applied in the fall produced similar yields to the 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 6th leaf, and grain yield at 15.5% moisture from a Webster loam fertilized annually with NH_4NO_3 or Urea - Lamberton Mn - 1982.

N applied annually #/A[1]	Leaf %N	Yield Grain Bu/A Rep I	Rep II	Rep III	Rep IV	Ave
Check	1.68	91.9	61.5	64.4	66.0	71.0
40 NH_4NO_3 - fpd[2]	1.93	96.9	94.2	82.0	92.8	91.5
40 Urea - fpd	2.20	121.7	119.6	108.9	126.2	119.1
40 NH_4NO_3 - fps[3]	2.15	124.9	100.2	89.5	114.9	107.4
40 Urea - fps	2.25	109.8	112.1	122.3	108.0	113.0
80 NH_4NO_3 - fpd	2.60	139.2	127.9	129.5	131.2	132.0
80 Urea - fpd	2.81	127.4	134.1	129.5	134.5	131.4
160 NH_4NO_3 - fpd	3.04	131.5	133.9	151.0	136.4	138.2
160 Urea - fpd	3.06	144.5	130.7	130.3	129.8	133.8
40 NH_4NO_3 - std[4]	2.32	115.6	129.4	99.9	115.1	115.0
40 Urea - std	2.29	107.4	99.3	102.7	100.2	102.4
80 NH_4NO_3 - std	2.80	121.5	136.2	150.1	131.8	134.9
80 Urea - std	2.69	124.7	120.0	128.1	130.8	125.9
40 NH_4NO_3 - sd[5]	2.45	119.3	114.5	121.6	108.9	116.1
40 Urea - sd	2.23	104.6	105.0	146.2	109.0	116.2
80 NH_4NO_3 - sd	2.70	138.2	126.9	138.2	137.4	135.2
80 Urea - sd	2.60	145.2	127.3	128.5	122.9	131.0
160 NH_4NO_3 - sd	2.82	142.1	126.0	144.0	133.1	136.3
Significance	**					**
BLSD (.05)	0.22					12.6

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

[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 22 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	1970	1971	1972
	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	85.7	40.8	75.6
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	96.3	88.7	113.6
40 Urea-fpd	55.1	78.2	29.1	148.8	100.3	38.8	19.8	86.9	132.5	124.5	120.4	100.7	113.9
40 NH_4NO-fps[3]	49.0	96.7	29.6	140.1	101.5	45.6	24.3	75.1	135.2	124.6	122.5	81.5	109.9
40 Urea-fps	62.3	101.3	37.0	140.7	84.1	57.4	30.9	87.2	134.0	136.1	121.2	82.4	106.7
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	134.7	108.0	143.1
80 Urea-fpd	61.7	76.9	36.7	154.5	104.9	73.0	37.8	117.2	142.6	144.3	141.4	107.8	140.1
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	141.7	120.2	147.6
160 Urea-fpd	79.4	112.5	43.5	152.8	112.4	73.5	37.7	121.3	149.9	161.0	140.4	110.6	151.7
40 NH_4NO_3-std[4]	66.2	92.0	45.4	152.2	99.8	63.4	23.7	99.8	128.0	142.0	125.6	84.0	117.0
40 Urea-std	45.4	91.1	31.4	147.6	100.6	59.8	33.8	95.0	140.5	143.4	118.9	94.6	116.5
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	140.4	122.7	142.7
80 Urea-std	57.7	99.1	40.5	149.3	115.7	84.4	41.8	128.6	138.7	155.9	146.2	116.0	142.1
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	127.1	104.5	136.0
40 Urea-sd	57.7	95.6	24.9	142.3	94.1	48.4	50.4	86.1	132.2	143.3	117.1	100.5	133.9
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	127.7	97.6	124.7
80 Urea-sd	76.9	86.4	48.2	143.8	121.4	64.7	47.3	117.0	146.9	166.2	140.5	124.4	149.8
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	136.9	104.2	150.0
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	127.0	99.4	128.6

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

[2]2fpd - fall plow down

[3]fps - fall plow surface

[4]std - spring topdress

[5]sd - sidedress

Table 2. (cont.)

	1973	1974	1975§	1977	1978	1979	1980	1981	1982	22 yr. Ave.
Check	69.2	53.4	58.3	141.2	64.6	37.6	46.5	65.8	71.0	63.5
40 NH_4NO_3-fpd[2]	92.0	80.5	88.6	145.1	98.1	63.1	67.6	77.4	91.5	81.4
40 Urea-fpd	101.5	96.9	96.6	165.2	110.2	76.7	65.2	87.0	119.1	89.0
40 NH_4NO_3-fps[3]	93.0	88.3	78.2	149.4	101.3	64.6	69.7	89.4	107.4	84.8
40 Urea-fps	97.8	85.0	78.9	156.8	101.4	80.2	63.8	80.5	113.0	87.7
80 NH_4NO_3-fpd	121.7	103.6	89.2	156.9	128.4	94.8	90.3	89.6	132.0	101.5
80 Urea-fpd	117.9	107.2	96.9	146.0	123.6	86.2	84.7	101.8	131.4	100.3
160 NH_4NO_3-fpd	121.0	113.1	90.4	149.8	129.3	108.7	109.3	91.3	138.2	106.0
160 Urea-fpd	114.9	105.1	82.4	163.0	124.4	127.3	103.7	97.6	133.8	107.8
40 NH_4NO_3std[4]	104.0	82.8	88.0	160.0	97.4	86.6	77.2	90.0	115.0	92.1
40 Urea-std	97.1	94.5	89.0	165.2	103.9	74.5	64.3	86.6	102.4	90.4
80 NH_4NO_3-std	118.0	92.9	97.6	162.9	117.1	87.3	74.4	101.4	134.9	103.0
80 Urea-std	117.6	108.5	93.6	162.2	127.4	100.3	84.4	102.8	125.9	104.9
40 NH_4NO_3-sd[5]	99.1	82.7	91.8	153.8	106.8	99.2	71.9	83.6	116.1	93.4
40 Urea-sd	103.9	80.4	92.6	165.4	104.8	94.2	80.4	87.4	116.2	93.0
80 NH_4NO_3-sd	109.4	87.6	95.3	163.2	110.6	106.3	76.9	79.3	135.2	97.2
80 Urea-sd	124.0	95.6	90.1	162.8	126.7	118.1	89.6	87.4	131.0	106.0
160 NH_4NO_3	117.1	105.5	91.3	160.3	126.0	148.0	109.8	96.7	136.3	108.0
Ave. annual corn yield in bu/A	106.6	92.4	88.3	157.2	111.2	91.9	79.4	88.6	119.5	95.0
Significance									**	**
C.V. (%)									8.1	10.0
BLSD (.05)									12.6	5.0

§ 1976 No Yields Taken

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

[2]fpd - fall plow down

[3]fps - fall plow surface

[4]std - spring topdress

[5]sd - sidedress

AVAILABILITY OF RESIDUAL NITRATE-N TO CORN

Lamberton, 1980-82

G.W. Randall and W.W. Nelson

Application of fertilizer N at rates exceeding crop removal can result in rather significant amounts of residual N left in the soil for the succeeding crop. For instance, after a very dry season, the quantity of residual N may be such that crop response to added fertilizer N may not be obtained. The purpose of this study is to determine crop response to residual NO_3-N and to measure loss of this N to tile lines.

Experimental Procedures

Nitrogen fertilizer was applied as urea annually from 1973-1979 to tile drained plots each measuring 45' x 50' and lined with plastic at Lamberton. Rates of 18, 100, 200, and 400 lb N/A were replicated three times. Two additional treatments (true check, which did not receive N, a herbicide or an insecticide; and 200# N/A as soybean meal) were not applied to isolated plots and thus were not included in the original replications. Consequently, statistical analyses have been performed only on the former four treatments.

Corn has been continuously grown from 1973 thru 1982. The grain has been removed and all residue plowed down annually. Nitrogen removal in the grain has been calculated. In addition, N losses thru the tile lines have been determined by measuring flow rate and NO_3-N concentrations when tile flow occurred. Each fall (when possible) soil samples have been taken to a 10-foot depth to determine residual NO_3-N in the soil.

Because some of the N treatments exceeded the N removal rates, substantial amounts of NO_3-N accumulated from 1973-1979. Consequently, no fertilizer N has been applied to the plots since May 1979. Research efforts since 1979 have attempted to monitor the availability of the residual NO_3-N to corn and to follow the movement of NO_3-N either in the soil or into the tile lines.

In 1981 and 1982, 125 lb N/A as anhydrous ammonia was applied to an isolated 6-row strip between the plots so that crop response to the residual N could be compared to this annual application. Weeds and insects have been controlled adequately on all plots (except the true check) by pesticides. All plots have been moldboard plowed each fall.

Results

The effects of the annual N applications over the seven-year period can be seen on the amount of residual NO_3-N remaining in the 0-10' profile after harvest of the 1979 crop (Table 1). A substantial amount of N carried over from the 400-lb treatment while significant amounts were also present with the 200-lb rate. Less NO_3-N was found with the organic N source than with the inorganic source. Most NO_3-N accumulated between 1 and 6'. Almost no NO_3-N was found below 8' at this time.

Corn grain yields shown in Table 2 indicate responses of 52 and 31 bu/A to residual N in 1980 and 1981, respectively. In the first year following N application, yield was improved significantly by the carryover from the 100-lb rate even though NO_3-N in the soil profile at the start of the season was not high. Yields were further improved by carryover from the 200 and 400-lb rates with no difference between them. The carryover from the 200-lb organic N treatment produced the highest yield but not more than from the 400-lb N rate.

In the second residual year (1981), conditions were so dry in the beginning of the season that germination and emergence were uneven and weed control was poor. These conditions led to a very high CV (18%) for yield. Thus, even though a 30.6 bu/A advantage was obtained with carryover NO_3-N, the grain yields were not significantly different from the check. Yields from the 6-row strip where N was applied during 1981 averaged 121.5 bu/A.

Table 1. Soil NO_3-N in the 0-10' profile in the fall of 1979 as influenced by seven consecutive years of N application at Lamberton.

Profile depth	Annual N rate (lb/A)				
	18	100	200	400	200 org.
feet	ppm				
0-1	1.0	1.8	5.7	29.4	4.2
1-2	0.2	1.0	4.8	40.0	1.7
2-3	0.3	2.3	10.7	39.9	9.0
3-4	0.7	5.6	18.5	61.6	12.2
4-5	0.9	8.1	18.9	56.2	13.0
5-6	1.3	4.4	12.6	34.3	9.4
6-7	1.4	2.9	7.5	20.9	4.9
7-8	1.6	2.2	4.9	9.7	2.8
8-9	1.8	1.7	3.3	5.4	1.7
9-10	1.7	1.7	3.5	3.4	1.3
Total (lb NO_3-N in 10-foot profile)	44.	127.	362.	1203.	241.

Table 2. Corn grain yields as influenced by residual NO_3-N at Lamberton in 1980 and 1981.

Annual[1/] N rate	Total N Applied	Year 1980	1981
lb N/A		Yield (bu/A)	
18	126	39.7	68.2
100	700	65.9	83.3
200	1400	83.2	90.6
400	2800	91.4	98.8
Signif. Level(%):		99	80
BLSD(.05) :		11.6	
CV (%) :		8.7	18.
0[2/]	0	51.5	50.5
200 org.	1400 org.	96.0	91.7

1/ Seven-year period (1973-1979).

2/ True check = no N, herbicide or insecticide.

Residual NO_3-N levels after the 1981 season indicate about 2x, 4x, and 14x as much NO_3-N in the 0-10' profile from the 100, 200 and 400-lb rates, respectively, as from the 18-lb treatment (Table 3). The nitrate-N level following the 200-lb organic N treatment was slightly less than with the 200-lb treatment as urea. Little NO_3-N was found above the 3-foot depth with the 100 and 200-lb N treatments (< 11% of that in the 10-foot profile). With the 400-lb rate most of the NO_3-N (78%) was found between 2' and 7'. Nitrates were found at the 10' depth with only the 400-lb treatment.

Results from 1982 show significant differences in leaf N, silage yield, N uptake in the silage, grain yield, grain N and N removal in the grain due to carryover from the previous 200 and 400-lb N rates (Table 4). Leaf N and silage yield were increased by the carryover from the 200-lb rate, but additional increases were not significant (95% level) with the 400-lb rate. Silage N uptake, grain yield, grain N, and N removal in the grain were increased significantly over the 200-lb rate by the carryover from the 400-lb N rate. Apparently, the greater total amount of NO_3-N and the fact that significantly more was found in the 2-3' zone at the beginning of the season led to this response. Even though the amount of residual NO_3-N with the 100-lb treatment at the beginning of the 1982 season was similar to that at the beginning of the 1980 season (Table 1), this amount was not sufficient to sustain high yields in 1982 when growing conditions were good. Differences in silage and grain yield were not observed between the fertilizer and organic N sources applied at the 200-lb rate.

Grain yield and grain N taken from the 6-row strip where N was applied in 1982 averaged 162.7 bu/A and 1.37% N. These were only slightly more than with the 400-lb rate.

Table 3. Residual NO_3-N in the 0-10' soil profile in the fall of 1981 as influenced by previous N application at Lamberton.

Profile depth	Annual N rate (lb/A)[1/]				
	18	100	200	400	200 org.
feet	ppm				
0-1	2.1	2.8	2.6	9.5	5.5
1-2	0.7	0.9	1.3	5.4	2.2
2-3	0.4	0.8	4.7	23.2	3.2
3-4	0.4	4.5	16.0	54.6	10.5
4-5	1.4	6.6	19.5	54.2	12.3
5-6	1.6	5.7	16.2	42.5	10.8
6-7	2.0	4.6	7.7	26.4	8.4
7-8	2.3	3.7	4.8	18.4	4.3
8-9	3.2	2.8	3.8	11.5	3.4
9-10	3.7	3.4	3.2	10.8	2.5
Total lb NO_3-N in 10-foot profile	71.	143.	319.	1026.	252.

[1/] Annual application over 7-year period (1973-1979).

Table 4. Corn production and N utilization in 1982 as influenced by residual NO_3-N from annual N applications from 1973-1979 at Lamberton.

Annual N rate	Final popl'n.	Leaf N	Silage Yield	Silage N uptake	Grain Yield	Grain N	Grain N removal
lb N/A	ppA x 10^{-3}	%	T DM/A	lb N/A	bu/A	%	lb N/A
18	22.0	1.57	4.23	59.0	84.0	1.04	41.2
100	21.3	1.82	4.24	61.2	86.1	1.07	43.6
200	21.6	2.16	6.06	107.4	130.7	1.17	72.2
400	21.6	2.35	6.86	139.4	155.3	1.31	96.5
Signif:[1/]	56	99	99	99	99	99	99
BLSD(.05):		.38	.81	20.0	16.6	.05	10.3
CV (%):	2.2	9.4	7.7	11.	7.5	2.3	8.4
0[2/]	21.7	1.52	3.96	51.5	78.2	1.04	38.5
200 org.	21.6	1.87	5.93	98.7	125.7	1.15	68.4

[1/] Probability level that a difference among the four means listed above is significant.
[2/] True check = no N, herbicide or insecticide.

The tile lines flowed during May, June, July, October, November and December in 1982. Total flow averaged 5.24 acre-inches with slight differences among rates (Table 5). Flow-weighted NO_3-N concentrations ranged from 9.3 with the 18-lb N treatment to 114.9 mg/L with the 400-lb treatment. Even the 100-lb treatment which did not contain enough residual NO_3-N to sustain yields resulted in an average NO_3-N concentration of 22.8 mg/L. Nitrate-N losses thru the tile lines were quite high and on a relative basis compared very closely to the amount of residual N found in the soil (Table 3). The 200-lb organic N treatment showed much lower NO_3-N concentrations and losses than did the 200-lb N treatment as urea.

Table 5. Tile line flow, average NO_3-N concentration and total NO_3-N losses into the tile lines in 1982 as related to annual N application rates from 1973-1979 at Lamberton.

Annual N rate	Total tile flow	Nitrate-N Avg. Concentration	Nitrate-N Losses
lb N/A	acre-inches	mg/L	lb/A
18	5.52	9.3	11.6
100	5.77	22.8	29.8
200	4.28	55.6	53.9
400	6.04	114.9	157.1
200 org.	4.57	26.6	27.5

Nitrate-N concentrations in the tile water decreased throughout the 1982 season (data not shown). Concentrations slipped from 13 in May to 8 mg/L in December with the annual 18-lb N treatment, from 30 to 16 mg/L with the 100-lb rate, from 66 to 53 with the 200-lb rate, from 136 to 93 with the 400-lb rate, and from 40 to 17 with the 200-lb rate as organic N.

Even though corn yields were not improved over the 18-lb treatment by the carryover N from the 100-lb rate, significantly higher NO_3-N concentrations and losses in the tile water were found. Apparently, the nitrates in the vicinity of the tile lines (3-5' zone) were not available to the corn crop but were susceptible to loss via tile drainage.

WEST CENTRAL EXPERIMENT STATION - MORRIS

WEATHER SUMMARY - 1982

Month	Period	Precipitation 1982	Precipitation 94-yr. av.	Precipitation Dev. from av.	Air Temperature 1982	Air Temperature 94-yr. av.	Air Temperature Dev. from av.	Soil Temperature (10 cm depth) 1982	Soil Temperature (10 cm depth) 10-yr. av.
January	1-31	1.31	.68	+ .63	-5.7	8.0	-13.7	19.0	20.7
February	1-28	.27	.67	- .40	9.5	12.6	- 3.1	20.3	23.9
March	1-31	2.07	1.09	+ .98	24.5	26.7	- 2.2	28.4	29.2
April	1-10	1.42	.58	+ .84	27.5	37.9	-10.4	34.0	
	11-20	.07	.65	- .58	44.2	44.4	- 0.2	42.1	
	21-30	.07	1.08	-1.01	49.4	48.2	+ 1.2	49.2	
Total or av.		1.56	2.31	- .75	40.4	43.5	- 3.1	41.7	41.4
May	1-10	.26	.78	- .52	57.1	51.9	+ 5.2	58.2	
	11-20	1.46	.95	+ .51	59.0	55.8	+ 3.2	60.1	
	21-31	.51	1.25	- .74	59.2	60.1	- 0.9	63.1	
Total or av.		2.23	2.98	- .75	58.5	56.1	+ 2.4	60.5	57.1
June	1-10	.47	1.26	- .79	56.2	63.1	- 6.9	63.0	
	11-20	.31	1.27	- .96	60.9	66.5	- 5.6	69.4	
	21-30	1.14	1.38	- .24	64.2	68.2	- 4.0	73.4	
Total or av.		1.92	3.91	-1.99	60.4	66.0	- 5.6	68.6	69.3
July	1-10	3.23	1.48	+1.75	70.5	70.0	+ 0.5	77.0	
	11-20	.63	1.03	- .40	70.2	71.3	- 1.1	75.6	
	21-31	.50	1.03	- .53	71.2	71.5	- 0.3	83.1	
Total or av.		4.36	3.54	+ .82	70.8	71.0	- 0.2	78.7	76.7
August	1-10	.65	1.05	- .40	72.5	70.3	+ 2.2	75.4	
	11-20	1.93	.90	+1.03	69.0	69.2	- 0.2	75.0	
	21-31	1.12	.98	+ .14	61.9	66.9	- 5.0	69.4	
Total or av.		3.70	2.93	+ .77	67.5	68.7	- 1.2	73.1	73.9
September	1-30	4.10	2.19	+1.91	56.4	59.1	- 2.7	60.1	61.5
October	1-31	4.22	1.62	+2.60	45.3	47.3	- 2.0	47.4	47.8
November	1-30	1.37	.96	+ .41	25.7	29.7	- 4.0	31.4	33.6
December	1-31	.65	.68	- .03	21.8	15.5	+ 6.3	26.3	23.4
April-August Growing Season		13.77	15.67	-1.90	59.6	61.1	- 1.5	65.1	63.8
January-December Annual		27.76	23.56	+4.20	39.7	42.0	- 2.3	46.7	46.7

MANURE RATE STUDY

West Central Experiment Station - Morris

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

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, 109, and Misc. Publ. 2-1982. The last manure applications were made in the fall of 1978, but fertilizer has been applied to the fertilized check each year. The plots were severely damaged by hail on August 31, 1982.

I. Planting Information

The plots were planted to Pioneer 3901 on May 4, 1982. 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 was applied to the fertilized plots to provide 110 lbs/acre of N on October 28, 1981. Lasso (2.5 lbs/acre) and Bladex (2.2 lbs/acre) were broadcast on May 5, 1982.

II. Soil Sampling and Analysis

A. 1981 Measurements

NO_3-N was the only variable measured in the fall of 1981. The values shown in Table 1 indicate some changes from those values one year earlier. In general the NO_3-N in the 0-4' zone increased slightly in the manure treated plots (except LB3) and decreased slightly in the fertilized treatment.

B. 1982 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 iron, copper, and boron. There were some significant effects of solid beef manure on increasing leaf levels of N, P, and K and decreasing leaf levels of Ca, Mg and Zn as compared to the fertilized check. The effects of liquid beef manure were similar to those of solid beef manure but the effects were reduced.

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 (except for LB1) than on the fertilized check.

B. Grain - Yields were smaller than in recent years due to the hail damage, but SB1, SB3, LB3 yielded significantly more than the fertilized check.

C. Silage - There were no significant differences between manure treated and fertilized plots.

V. Summary

The 1982 season was the fourth since manure had been applied. It appears that even the lowest rates of each manure were sufficient for grain 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 1981.

Depth	Treatment							
	CK	FE	SB1	SB2	SB3	LB1	LB2	LB3
- ft -	NO_3-N, ppm							
0-1	6.4	8.7	15.5	38.1	78.1	7.3	19.5	26.2
1-2	2.7	60.6	88.8	154.3	199.7	33.6	118.3	107.4
2-3	1.9	55.9	94.3	196.3	183.3	56.5	104.0	150.3
3-4	3.2	39.9	47.4	146.0	145.0	42.1	72.7	143.0

Table 2. Summary of analysis of corn leaves at silking - 1982.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	2.16	.23	1.67	.44	.41	145	17.3	4.4	68	5.2
FE	2.74	.25	1.65	.51	.44	142	22.6	4.4	102	5.2
SB1	2.71	.34	2.14	.45	.29	144	18.1	5.8	87	5.6
SB2	2.73	.51	2.43	.42	.24	140	18.6	4.0	70	5.4
SB3	2.84	.52	2.52	.40	.22	139	21.1	3.9	59	5.5
LB1	2.88	.29	1.80	.48	.39	144	17.1	5.3	93	5.0
LB2	2.70	.31	1.90	.47	.36	134	16.9	5.2	86	5.2
LB3	2.86	.38	2.09	.46	.33	155	15.1	4.2	87	5.4
Significance	**	**	**	*	**	NS	**	NS	*	NS
BLSD(.05)	.18	.07	.20	.06	.07	--	3.0	--	28	--
CV(%)	3.8	11.4	6.0	6.8	12.8	6.5	9.2	22.5	17.1	10.3

Table 3. Summary of plant measurements - 1982.

Treatment	Early plant height inches	Early plants (10) dry wt. grams	Grain			Silage		
			Moisture at harvest %	Yield at 15.5% M. Bu/A	Nitrogen %	Dry matter at harvest %	Silage yield (D.M.) lbs/A	Ear wt. ÷ silage wt. %
CK	16.4	28.7	29.8	55.9	1.11	37.8	7652	44.8
FE	21.4	43.7	27.5	68.3	1.38	30.3	10697	41.4
SB1	26.6	89.3	24.3	94.9	1.47	28.5	11717	42.7
SB2	28.5	88.0	27.3	75.2	1.63	24.8	10564	36.4
SB3	28.3	98.7	25.1	96.5	1.54	23.7	12156	37.8
LB1	20.7	40.0	25.6	82.6	1.37	34.6	10467	45.8
LB2	25.4	64.7	23.8	89.2	1.43	30.6	12398	43.8
LB3	27.6	83.0	26.7	95.2	1.44	22.1	9945	36.4
Significance	**	**	**	*	**	**	**	**
BLSD(.05)	2.2	13.3	2.2	24.4	0.07	4.1	1854	3.4
CV(%)	5.7	12.2	4.8	15.6	3.0	8.5	9.7	4.9

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 and R. C. Munter

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, 109, and Misc. Publ. 2-1982. Manure was applied in 1970 and 1971 only. Fertilizer has been applied to the fertilized checks each year. The plots were severely damaged by hail on August 31, 1982.

I. Planting Information

Twenty-four rows of corn (var. Pioneer 3901) were planted in each plot on May 4, 1982. 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 was applied to the fertilized plots to provide 110 lbs/acre of N on October 28, 1981. Lasso (2.5 lbs/acre) and Bladex (2.2 lbs/acre) were applied broadcast on May 5, 1982.

II. Soil Sampling and Analysis

A. 1981 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 total NO_3-N in the 0-4' profile was greater on all manure treatments than on the fertilized check.

B. 1982 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 1982 are given in Table 2. There were significant effects on most elements. The concentrations of N, P and K were higher and Mg lower in all manure treatments than in the fertilized treatment. There were significant differences between at least one manure treatment and the fertilized treatment for Zn.

IV. Growth and Yield Measurements (Table 3)

A. Early plant height and dry matter - Plants on the SB and LB manure treated plots were taller than those on the fertilized treatment. Dry matter differences were identical to those of plant height.

B. Grain - There were no significant differences in grain yield. The grain N content of the LH treatment was significantly lower than that of the fertilized check.

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

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, but grain yield is still not significantly lower than the fertilized check.

Table 1. Effect of high rates of manure and commercial fertilizer eleven years (fall 1981) after application of the NO_3-N level of a Tara soil profile.

Depth - ft -	Treatment CH	FE	SB	LB	LH
	NO_3-N, ppm				
0-1	5.0	7.8	8.7	10.4	28.4
1-2	3.4	69.5	40.4	58.1	13.5
2-3	1.1	73.9	76.2	116.8	55.0
3-4	4.0	46.9	67.8	132.5	44.9

Table 2. Summary of analysis of corn leaves at silking - 1982.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	2.10	.19	1.49	.47	.42	136	16.0	3.9	84	5.9
FE	2.97	.28	1.61	.46	.42	139	22.7	3.4	72	4.7
SB	2.63	.33	2.03	.45	.25	140	16.0	4.6	78	5.1
LB	2.73	.39	2.06	.45	.25	148	16.9	4.2	62	4.6
LH	2.42	.31	1.92	.46	.27	137	22.3	4.9	66	5.0
Significance	**	**	**	NS	**	NS	**	NS	+	+
BLSD(.05)	0.24	.05	0.24	--	0.08	--	2.5	--	18	0.9
CV(%)	5.0	8.7	7.0	7.4	14.0	7.1	7.3	16.7	12.0	9.0

Table 3. Summary of plant measurements - 1982.

Treatment	Early plant height inches	Early plants (10) dry wt. grams	Grain: Ear moisture at harvest %	Grain: Yield at 15.5% M. Bu/A	Grain: Nitrogen %	Silage: Dry matter at harvest %	Silage: Silage yield (D.M.) lbs/A	Silage: Ear wt. ÷ silage wt. %
CH	15.5	25.0	32.2	45.1	1.11	36.9	6690	43.6
FE	22.6	51.7	27.9	81.7	1.42	30.8	11136	42.7
SB	26.5	77.3	25.3	80.5	1.39	30.4	11804	44.0
LB	27.3	88.3	26.1	84.1	1.40	27.5	11276	41.0
LH	23.8	59.3	26.5	74.7	1.32	32.0	10077	45.1
Significance	**	**	*	*	**	+	**	NS
BLSD(.05)	1.7	20.3	4.6	25.0	0.08	7.1	1380	--
CV(%)	4.2	18.2	8.2	17.1	3.5	10.7	7.4	6.3

NITROGEN FERTILIZATION AND NITROGEN UTILIZATION BY TWELVE SMALL GRAIN VARIETIES - MORRIS, MN - 1982

G.L. Malzer, S. Comfort, 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 differences 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. Experiments were established in 1982 to examine some of the differences which exist between wheat varieties in their response to fertilizer nitrogen and their ability to utilize existing soil nitrogen. Existing popular varieties as well as older varieties and experimental varieties were included for comparison. Similar trials were conducted at Crookston as well as Morris, MN.

EXPERIMENTAL PROCEDURE

Twelve 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 application of ammonium nitrate broadcast and incorporated. The treatments were arranged in a split plot design with nitrogen as the main effect and the twelve varieties planted within a uniformly fertilized area. All treatments were replicated four times. Experimental plots were planted into areas 5' x 20' on April 23 utilizing a cone seeder.

Total plant dry matter was measured at approximately the "soft dough" stage of growth (July 22) and samples were collected for nitrogen content and calculation of nitrogen uptake. Yield grain was harvested on August 5 by harvesting 14 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

Grain yields at the Morris location were excellent in 1982. Grain yields were influenced by both nitrogen rate and variety. A significant nitrogen rate x variety interaction suggests that all varieties did not respond in a similar manner to nitrogen fertilization. A number of interesting observations can be made in evaluating the yield data: 1) varieties which produced more than 40 bu/A with no fertilizer N applied; 2) those varieties which produced more than 50 bu/A when 60 # N/A was applied and 3) those varieties which responded in yield by more than 5 bu/A when the nitrogen rate was increased from 60 to 120 # N/A. In assessing these three groupings, Era, Thatcher, and MN 7357 fit into group 1; Butte, Marshall, Olaf, MN 7357 and MN 73167 fit into group 2; and Coteau, Era, MN 7125, MN 7122 and MN 73168 fit into group 3. One interesting aspect of these groupings, which might be considered favorable yielding traits, is that no one variety appears in all three groups, and that very few varieties appear twice. This then tends to complex the issue of what varieties are the most efficient and most responsive to N fertilization.

Nitrogen content of the grain (protein) was influenced by both nitrogen rate and variety. Grain N was increased when going from 60-120 # N/A but was not increased when going from 0-60 # N/A. Total N uptake was substantially increased in going from 0-60 # N/A so the lack of a protein increase was due to a dilution effect caused by the increased grain yield. Grain N content due to varieties was highly significant and spanned a considerable range. The varieties Coteau, Olaf and James proved to have the highest overall protein content. This was especially true at the zero N rate, but when 120 # N/A was applied, many other varieties produced comparable protein concentration.

Total nitrogen removal was highly influenced by nitrogen rate, but a significant N rate x variety interaction suggested that not all varieties responded in a similar manner. With zero N fertilization Era and Thatcher proved to be the most effective in N removal. When 120 # N/A was applied Butte, Coteau, Olaf and MN 7222 and MN 73167 were the most effective in total N removal.

Table 1. Influence of nitrogen fertilizer and variety on yield, N content and test weight of 12 hard red spring wheat varieties from Morris, MN - 1982.

Nitrogen		Grain			Forage	
					Total	
Rate	Variety	Yield	N Content	Test wt.	Dry Matter	N Content
#/A		bu/A	%	#/bu	T/A	%
0		34.8	2.66	58.0	1.99	0.97
60		48.7	2.63	58.3	2.85	1.14
120		54.4	2.80	57.5	3.32	1.36
Significance			*	NS	**	
BLSD (.05)			0.04	--	0.12	
-	Butte	49.8	2.69	60.3	2.95	1.04
-	Coteau	45.0	3.02	59.1	2.72	1.18
-	Era	44.8	2.68	57.1	2.70	1.20
-	Marshall	43.3	2.64	58.7	2.41	1.22
-	MN 7125	43.4	2.52	58.0	2.81	1.15
-	MN 7222	44.2	2.62	57.1	2.62	1.17
-	Olaf	45.9	2.90	57.6	2.66	1.20
-	Thatcher	42.9	2.67	55.6	2.70	1.09
-	MN 7357	50.2	2.58	58.2	2.67	1.18
-	MN 73167	50.6	2.61	58.2	2.77	1.17
-	MN 73168	46.5	2.64	57.2	2.77	1.25
-	James	45.1	2.78	58.4	2.87	1.07
Significance			**	**	*	
BLSD (.05)			0.01	1.0	0.35	
Interaction - N Rate x Variety						
0	Butte	33.8	2.71	59.3	2.05	0.91
0	Coteau	29.8	3.13	57.7	2.11	1.11
0	Era	41.5	2.64	58.5	2.16	0.96
0	Marshall	30.0	2.63	58.9	1.78	0.99
0	MN 7125	33.2	2.47	58.4	2.03	0.89
0	MN 7222	26.4	2.54	57.5	1.71	0.92
0	Olaf	33.3	2.91	58.5	1.80	1.03
0	Thatcher	40.4	2.65	55.3	2.05	0.93
0	MN 7357	40.1	2.47	58.5	1.84	0.99
0	MN 73167	36.1	2.49	57.7	2.15	0.94
0	MN 73168	36.3	2.54	57.6	2.01	1.04
0	James	36.4	2.78	58.0	2.17	0.98
60	Butte	56.4	2.59	60.8	3.14	1.00
60	Coteau	49.3	2.94	59.3	2.78	1.11
60	Era	41.8	2.60	56.7	2.72	1.20
60	Marshall	50.1	2.51	59.9	2.71	1.20
60	MN 7125	42.8	2.54	58.3	3.02	1.14
60	MN 7122	44.9	2.57	57.4	2.72	1.10
60	Olaf	51.3	2.82	58.3	3.00	1.20
60	Thatcher	42.7	2.52	56.0	2.66	1.08
60	MN 7357	55.1	2.50	58.3	2.91	1.18
60	MN 73167	55.9	2.59	58.7	2.80	1.17
60	MN 73168	47.3	2.57	56.7	2.74	1.27
60	James	47.0	2.73	59.4	2.97	1.06

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 by 12 hard red spring wheat varieties from Morris, MN - 1982.

Nitrogen Rate	Variety	Harvest Straw Dry Matter	Harvest Straw N Content	Nitrogen Removal Forage	Nitrogen Removal Straw	Nitrogen Removal Grain	Grain α Straw
#/A		T/A	%	---------------#/A	-----------------		
0		1.21	0.47	38.9	11.2	48.2	59.4
60		1.70	0.54	65.1	18.2	66.8	85.0
120		1.94	0.70	89.7	27.0	79.6	106.6
Significance		**		**	**		
BLSD (.05)		0.08		3.4	1.6		
-	Butte	1.78	0.47	62.6	17.6	69.8	87.4
-	Coteau	1.81	0.51	64.7	18.8	70.9	89.7
-	Era	1.59	0.63	66.8	20.5	62.8	83.3
-	Marshall	1.37	0.61	60.1	17.1	59.6	76.7
-	MN 7125	1.61	0.58	66.8	19.0	57.5	76.5
-	MN 7222	1.39	0.64	64.6	19.0	61.1	80.1
-	Olaf	1.80	0.57	65.1	21.3	69.5	90.8
-	Thatcher	1.94	0.49	60.0	19.0	59.9	78.9
-	MN 7357	1.54	0.61	64.5	19.2	67.9	87.1
-	MN 73167	1.48	0.62	66.4	18.8	69.5	88.3
-	MN 73168	1.39	0.57	71.5	16.5	64.7	81.2
-	James	1.68	0.53	61.9	18.5	65.5	84.0
Significance		**		NS	NS		
BLSD (.05)		0.17		--	--		
<u>Interaction - N-Rate x Variety</u>							
0	Butte	1.19	0.38	37.3	9.0	47.7	56.7
0	Coteau	1.32	0.55	47.2	14.6	48.6	63.2
0	Era	1.13	0.53	41.9	11.9	57.7	69.6
0	Marshall	1.05	0.49	35.1	10.1	40.8	50.9
0	MN 7125	1.23	0.48	36.4	12.0	42.8	54.8
0	MN 7222	0.90	0.42	31.7	7.6	35.1	42.7
0	Olaf	1.26	0.46	36.7	11.6	50.6	62.2
0	Thatcher	1.68	0.43	38.4	14.3	55.4	69.7
0	MN 7357	1.26	0.50	36.4	12.5	51.6	64.1
0	MN 73167	1.17	0.49	40.6	11.4	47.2	58.6
0	MN 73168	1.04	0.44	41.8	9.0	48.0	57.0
0	James	1.24	0.42	42.7	10.2	53.0	63.2
60	Butte	2.01	0.45	63.2	18.2	76.4	94.6
60	Coteau	1.89	0.42	61.2	16.0	76.4	92.4
60	Era	1.76	0.59	65.5	20.5	56.6	77.1
60	Marshall	1.49	0.63	65.5	18.8	65.6	84.4
60	MN 7125	1.90	0.49	68.7	18.7	56.8	75.5
60	MN 7222	1.41	0.74	60.6	21.4	60.3	81.7
60	Olaf	1.88	0.48	71.7	17.8	75.6	93.4
60	Thatcher	1.84	0.47	58.0	17.1	56.0	73.1
60	MN 7357	1.64	0.56	68.7	18.4	72.3	90.7
60	MN 73167	1.46	0.64	65.1	18.9	75.7	94.6
60	MN 73168	1.40	0.60	69.2	16.9	63.9	80.8
60	James	1.77	0.44	63.4	15.4	67.1	82.5

Table 2 continued on next page

Table 1. Influence of nitrogen fertilizer and variety on yield, N content and test weight of 12 hard red spring wheat varieties from Morris, MN - 1982. (cont.)

Nitrogen Rate	Variety	Grain Yield	Grain N Content	Test wt.	Forage Total Dry Matter	Forage N Content
#/A		bu/A	%	#/bu	T/A	%
120	Butte	59.3	2.75	60.7	3.66	1.19
120	Coteau	55.9	2.99	60.2	3.27	1.33
120	Era	50.9	2.79	56.0	3.22	1.44
120	Marshall	49.7	2.79	57.2	2.74	1.47
120	MN 7125	54.3	2.57	57.3	3.38	1.42
120	MN 7222	61.2	2.76	56.3	3.41	1.50
120	Olaf	53.0	2.97	56.0	3.18	1.37
120	Thatcher	45.7	2.86	55.5	3.38	1.24
120	MN 7357	55.4	2.75	57.8	3.26	1.36
120	MN 73167	59.8	2.75	58.4	3.36	1.40
120	MN 73168	55.9	2.82	57.1	3.55	1.46
120	James	51.9	2.83	58.0	3.48	1.15
Signfiicance		**	NS	NS	NS	*

Table 2. (Cont.) Influence of nitrogen fertilization and variety on straw production and nitrogen uptake by forage, straw, and grain by 12 hard red spring wheat varieties from Morris, MN - 1982.

Nitrogen Rate	Variety	Harvest Straw Dry Matter	Harvest Straw N Content	Nitrogen Removal Forage	Nitrogen Removal Straw	Nitrogen Removal Grain	Grain α Straw
#/A		T/A	%	#/A			
120	Butte	2.14	0.59	87.3	25.4	85.3	110.7
120	Coteau	2.23	0.56	85.7	25.8	87.6	113.4
120	Era	1.90	0.77	92.9	29.3	74.0	103.3
120	Marshall	1.57	0.71	79.7	22.4	72.3	94.7
120	MN 7125	1.71	0.77	95.3	26.3	73.1	99.4
120	MN 7222	1.85	0.76	101.5	28.0	88.0	116.0
120	Olaf	2.27	0.77	86.7	34.6	82.4	117.0
120	Thatcher	2.30	0.56	83.4	25.6	68.0	93.6
120	MN 7357	1.72	0.77	88.4	26.7	79.7	106.4
120	MN 73167	1.79	0.73	93.4	26.0	85.6	111.6
120	MN 73168	1.74	0.68	103.4	23.7	82.2	105.9
120	James	2.04	0.73	79.6	29.8	76.6	106.4
Significance		NS	*	NS	NS	**	**

EFFECTS OF NITROGEN AND PHOSPHORUS APPLICATION METHODS ON SPRING WHEAT - 1982

West Central Experiment Station - Morris

S. D. Evans, W. E. Fenster, J. Grava and G. L. Malzer

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

Experimental Procedures

Soil sample results prior to plowing in November are given in Table 1. In the spring the plots were sampled by rep prior to fertilizer application and the results are given in Table 2. The entire area was field cultivated and drug on April 26. The anhydrous ammonia and 10-34-0 were applied with a dual applicator on April 29. The material was placed at about an 8-inch depth with a knife spacing of 12 inches. The broadcast 0-46-0 was applied by hand on April 30. The area was then dragged to level the seedbed and seeded to Era wheat @ 1 3/4 Bu/A. The drill applied fertilizers were made up from urea and 0-46-0. All treatment combinations are given in Table 4. The fertilizer bands were marked by red flags in reps 1, 3 and 5 of treatments 3 and 11 so that the bands could be located after harvest.

Whole plant samples were collected on July 20 and were used to calculate forage yield and N and P uptake. The plots were harvested on August 9 with a plot combine. On selected treatments soil samples after harvest were taken on September 3 and the results are given in Table 3.

Yield and Nutrient Uptake

The nutrient uptake and yield results are given in Table 4. Dry matter yield was significantly affected by N application but there were no significant differences between application methods. The highest D.M. yield was when all the P was drill applied.

The phosphorus concentration in the tissue at the soft dough stage decreased when N decreased and when no P was drill applied. When some P was drill applied, the % P increased slightly. There was no significant difference between application methods.

Phosphorus uptake did not increase with increased N except when some P was drill applied. At the 50 N rate there were no differences between placement method; whereas, at the 100 N rate the treatment with all P drill applied was significantly higher in P uptake than all other treatments.

The N concentration in the tissue at soft dough stage was closely related to N application rate, but there were no differences between placement methods.

Nitrogen uptake was significantly affected by N application rate. At the low N rate there were no significant differences. At the high N rate there were again no significant differences, but the maximum difference (18.4 lb/A) was between all P broadcast and all P drill applied.

Grain yield was closely related to N rate. At the low N rate there was a significant difference between all P with a knife (55.5 Bu/A) and all P drill applied (61.0 Bu/A). At the high N rate there was a significant difference between all P drilled applied (63.6 Bu/A) and only 25% of the P drill applied (58.2 Bu/A).

Grain protein levels were somewhat related to N rate. There were no significant differences in grain protein at either N rate, but the highest protein was where all P was drill applied.

The 1982 study on placement methods shows very little effect of placement on any of the variables measured. In most cases the best uptake and yield resulted from drill application of all the P. In no cases were there any differences between the deep band treatments (2 and 3) and the broadcast treatments (4 and 5).

Soil Sampling of the Deep Bands

One problem associated with deep banding of P is the method of obtaining accurate soil samples of the area banded. An attempt was made in 1982 to see if the P level in the bands was different than the P level between the bands after harvest. Results in Table 3 compare the band and between band

P levels with the check treatment (no P) and the broadcast P treatment. The P soil test level was determined by three methods.

There was a definite difference of the P soil test in the band compared to between the bands. The difference varied with soil test method. In all cases we could not detect the broadcast P by soil test (comparing the check P level with the broadcast P level). The between band P levels appeared to be slightly lower than the check and broadcast levels.

Table 1. Soil test results on November 3, 1981.

Soil Texture	Organic Matter	pH	Bray P 1:10	Exch. K	NO_3-N(lb/A) 0-1'	1-2'	2-3'	3-4'	4-5'
Cl	H	7.7	13 lb/A	224 lb/A	7	6	6	6	8

Table 2. Soil test results in April, 1982.

Rep	P Soil Test: Olson	Bray 1:10	Bray 1:50	Exch. K	Soil pH
	lb/A			lb/A	
1	13	23	55	283	7.9
2	15	21	50	294	7.8
3	12	20	50	242	7.8
4	12	20	45	270	8.0
5	14	21	50	235	7.9
6	13	24	50	257	7.8

Table 3. The effect of P application methods on P soil test (September 1982).

Trt. No.	P Placement Method	Sample Location	P_2O_5	P Soil Test Method[1]: Olson	Bray 1:10	Bray 1:50
			lb/A	lb/A		
1	Check	-	0	9	18	40
3	Deep Band	In Band	40	16	27	52
		Between Bands	40	6	14	37
11	Deep Band	In Band	30	14	19	40
		Between Bands	30	6	16	34
5	Broadcast	-	40	8	17	39
Significance:				*	**	*
BLSD(.05):				7	6	10
CV (%):				36.4	16.1	12.7

[1] Average of three replications, 4 subsamples per plot 0-10" deep.

Table 4. The effect of N and P application methods on spring wheat.

Trt. No.	Placement	Source[1]	N	P_2O_5	D.M. Yield	Phosphorus	Phosphorus Uptake	Nitrogen	Nitrogen Uptake	Grain Yield	Grain Protein
	Treatment Description:	Fertilizer Treatment			Whole Plants @ Soft Dough Stage						
			- lb/A -		lb/A	%	lb/A	%	lb/A	Bu/A	%
1	Check	-	0	0	2345	.237	5.53	0.93	21.7	27.2	12.5
2	Dual NP, Knife	AA,APP	50	40	6109	.208	12.73	1.08	66.5	55.5	12.6
3	Dual NP, Knife	AA,APP	100	40	6936	.182	12.61	1.43	98.9	62.3	13.5
4	N Knife, P BCST	AA,TSP	50	40	6273	.209	13.16	1.07	66.7	58.7	13.1
5	N Knife, P BCST	AA,TSP	100	40	6719	.199	13.35	1.39	93.1	60.2	13.7
6	N Knife, NP1 DRILL[2]	AA,UR,TSP	50	40	6216	.199	12.35	1.15	70.6	59.4	12.2
7	N Knife, NP1 DRILL[2]	AA,UR,TSP	100	40	7506	.206	15.47	1.48	111.5	63.6	14.6
8	N Knife	AA	50	0	6181	.203	12.47	1.08	66.8	61.0	12.9
9	N Knife	AA	100	0	6573	.194	12.72	1.44	94.5	61.7	13.8
10	NP Knife, NP2 DRILL[3]	AA,APP,UR,TSP	50	40	6053	.190	11.55	1.01	61.1	55.2	12.1
11	NP Knife, NP2 DRILL[3]	AA,APP,UR,TSP	100	40	6559	.204	13.10	1.44	97.4	58.2	13.2
Significance:					**	*	**	**	**	**	**
BLSD(.05):					743	.031	2.08	0.15	15.1	5.2	1.4
CV (%):					11.5	10.9	15.6	11.7	18.5	8.8	8.2

[1] AA = Anhydrous Ammonia (82-0-0), APP = Ammonium Polyphosphate (10-34-0), TSP = Triple Super-Phosphate (0-46-0), UR = Urea (46-0-0).

[2] NP1 DRILL = 10 N + 40 P_2O_5 at seeding with drill.

[3] NP2 DRILL = 10 N + 10 P_2O_5 at seeding with drill.

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

West Central Experiment Station - Morris

S. D. Evans 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 ten 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. In 1982 the plots were severely damaged by hail on August 31.

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 ten years and the averages are given in Table 1. Significant yield differences occurred in 1974, 1979, 1980, 1981, and 1982. 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, 1978 - 40 lb/A, and 1982 - 40 lb/A. The ten-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 ten-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 ten-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 ten-year average. Soil tests 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 ten 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, 1979, and 1982 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, 1976, and 1982, 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.

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

No.	Fertilizer Treatments	In addition to starter N[2]	P	Grain Yield 1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	10-year 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	57.9	82.1
2	"	0	0	116.3	70.7	104.5	20.1	100.6	117.4	75.0	67.9	78.8	52.5	80.4
3	"	40	0	122.1	81.7	104.7	24.2	101.4	128.2	107.9	95.8	104.0	74.8	94.5
4	"	80	0	129.8	94.0	110.9	24.4	103.3	129.3	112.2	104.0	111.4	74.3	99.4
5	"	120	0	128.2	91.2	112.5	21.2	102.5	126.7	111.0	103.6	113.2	75.2	98.5
6	"	120(SD)	0	126.5	90.4	119.8	19.6	103.1	126.4	116.3	112.0	111.2	79.6	100.5
7	"	160(SD)	0	128.9	91.9	110.7	25.6	99.3	125.7	105.8	103.2	107.6	71.8	97.0
8	"	80(F)	0	118.2	92.8	119.0	23.2	99.6	135.7	115.7	113.6	108.3	84.8	101.1
9	"	120(F)	0	128.9	90.2	125.7	21.2	103.4	128.6	115.8	106.1	112.7	77.2	101.0
10	"	80(ORG)	8	122.2	87.8	114.7	25.4	99.4	129.0	121.9	102.6	107.5	80.9	99.1
11	"	120(ORG)	12	127.7	96.9	119.2	22.0	101.0	130.7	113.1	109.6	100.2	76.2	99.7
12	"	80	30	123.6	91.8	108.9	24.7	104.2	127.8	123.5	105.4	109.2	80.0	99.9
Significance				NS	**	NS	NS	NS	NS	**	**	**	**	
BLSD(.05)				-	16.9	-	-	-	-	12.0	9.8	11.2	15.4	

[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.

No.	Fertilizer treatments	In addition to starter N[2]	P	N content of sixth leaves 1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	10-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	2.24	2.48
2	"	0	0	2.18	3.04	2.27	2.09	3.00	2.65	1.71	2.41	2.81	2.12	2.43
3	"	40	0	2.40	3.26	2.59	2.57	3.07	3.00	1.98	3.00	3.22	2.70	2.78
4	"	80	0	2.53	3.37	2.85	2.62	3.13	3.13	2.86	2.90	3.28	2.88	2.96
5	"	120	0	2.74	3.50	2.90	2.79	3.16	3.24	2.99	3.06	3.39	3.04	3.08
6	"	120(SD)	0	2.55	3.46	2.88	2.53	3.12	3.24	2.96	3.02	3.23	3.01	3.00
7	"	160(SD)	0	2.62	3.45	2.85	2.67	3.04	3.22	2.68	3.08	3.11	3.04	2.98
8	"	80(F)	0	2.50	3.32	2.82	2.64	3.14	3.12	2.86	2.72	3.19	2.93	2.92
9	"	120(F)	0	2.48	3.46	2.80	2.62	3.23	3.11	2.88	2.86	3.32	2.98	2.97
10	"	80(ORG)	8	2.52	3.42	2.84	2.54	3.23	3.16	3.00	2.95	3.29	2.89	2.98
11	"	120(ORG)	12	2.61	3.42	2.93	2.67	2.98	3.20	2.62	3.16	3.37	3.02	3.00
12	"	80	30	2.49	3.36	2.60	2.64	3.09	3.13	2.40	2.85	3.14	2.92	2.86
Significance				**	**	**	**	NS	**	**	**	**	**	
BLSD(.05)				.22	.19	.23	.16	-	.13	.59	.32	.29	.15	

[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.

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. 1982 Operations

In 1982 the variety was Trojan TXS99. Counter was applied at 1 lb/acre (active ingredient) at planting on April 29. Lasso @ 2.5 lbs/acre plus Bladex @ 2.2 lbs/acre were applied broadcast on April 30. AAtrex 9-0 @ 3/4 lb/acre + 1 qt oil/acre was applied on June 9. The plots were severely damaged by hail in August 31. Silage yields were taken on September 21 and grain yields on October 15.

III. Silage Yields - Dry matter; tons/acre

Treatment	1982 yield	1966-82 yield
Silage, low fertility	5.06	5.64
Silage, high fertility	5.87	6.07
Grain, low fertility	5.34	5.64
Grain, high fertility	5.65	5.90

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

	1982 yield	1966-82 yield
Grain, low fertility	60.02	89.64
Grain, high fertility	69.20	92.88

V. Check Yields

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

	1982 yield	1966-82 yield
Grain (0 + 0 + 0)	27.96	48.95
Silage (0 + 0 + 0)	3.07	3.73

VI. Discussion

A. In 1982 there were no significant differences in silage yields but the silage high fertility plots yielded slightly more than the low fertility plots.

B. The 17-year average yields show very little difference between silage and grain plots, but there is still a slight advantage for the higher fertility level.

EFFECT OF IRON ON THE CORRECTION OF SOYBEAN CHLOROSIS

West Central Experiment Station - Morris
S. D. Evans and H. L. Meredith

The primary objective of this study was to determine the effectiveness of a low pH iron containing urea-phosphate fertilizer on iron chlorosis in soybeans.

Experimental Procedures

Treatments used in this study are shown in Table 1. The urea phosphate (17-44-0) had a pH of 1.5. The same material was co-granulated with iron sulfate to give a material with an analysis of 15-39-0 also containing 4% iron. A foliar application of iron chelate applied at the 2nd trifoliate stage was also included in the study. Both studies were carried out on the Kermit Stahn farm in Section 11, Synnes Township, Stevens County. Two soybean varieties were included each year. One variety was Evans which is fairly tolerant of iron chlorosis. The other two varieties, II-74-15 and II-75-15, had many of the same characteristics as Evans but were fairly susceptible to iron chlorosis.

Results

The results for both years are shown in Table 2. In 1981 there was no chlorosis visible in the plot area. The only significant effect was a difference between Evans and II-74-15. There was no significant effect of any of the fertilizer treatments.

In 1982 chlorosis was quite evident. The chlorosis score shows a big difference between Evans and II-75-15. There was no significant effect of the urea phosphate + iron or iron chelate in correcting the visual symptoms. Yield figures for 1982 again show a variety difference but no effect of the fertilizer treatments. However, there seems to be some effect of the urea phosphate in increasing yields over the check in both varieties. The urea phosphate + iron also appeared to increase yields over the urea phosphate alone on the variety II-75-15.

Table 1. Plot information for 1981 and 1982.

Varieties	1981 Evans and II-74-15	1982 Evans and II-75-15
Planting date	May 14	May 24
Row spacing	30 inches	30 inches
Iron chelate	Fe 330	Fe 138
Date applied	June 24	June 29
Soil type	Hamerly clay loam	Nutley-Hattie clay

Table 2. Effect of urea phosphate + iron and iron chelate on soybean yield and chlorosis score, 1981-82.

Fertilizer Treatment	1981 Evans	1981 II-74-15	1981 Av.	1982 Evans	1982 II-75-15	1982 Av.	1982 Evans	1982 II-75-15	1982 Av.
	Bu/A			Bu/A			- Chlorosis Score[1] -		
Check	40.7	32.3	36.5	33.3	30.0	31.7	1.8	3.5	2.7
Urea phosphate 17-44-0 @ 100 lb/A	39.2	34.8	37.0	35.6	31.6	33.6	1.7	3.3	2.5
Urea phosphate + 4% iron sulfate @ 113 lb/A	35.5	32.0	33.7	35.7	33.6	34.7	1.7	4.0	2.8
Iron chelate to provide 0.15 Fe/A at 2nd trifoliate stage	38.7	32.8	35.8	36.0	30.1	33.1	1.3	2.8	2.1
Average	38.5	33.0		35.2	31.3		1.6	3.4	
Significance -									
Fertilizer Treatment:	NS			NS			NS		
Variety:	**			**			**		
Interaction:	NS			NS			NS		

[1] Chlorosis score, 1 = normal, 2 = slight chlorosis, 3 = 50% plants in row chlorotic, 4 = 75% plants in row chlorotic, 5 = most plants in row chlorotic.

SOIL TEST LAB COMPARISON

West Central Experiment Station - Morris

S. D. Evans and C. A. Schrader

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 and 1981 trials were summarized previously (Soil Series 109 and Misc. Publ. 2).

In the fall of 1981 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 alternate between wheat and corn. The plot size is 15 feet by 40 feet. Row spacing on the corn is 30 inches. A hail storm on August 31 caused severe lodging in the corn and lowered the yield potential.

Wheat

Copper and zinc treatments were dissolved in water and sprayed on the plots on November 3, 1981. The P, K, and S were applied by hand on November 4 and the N on November 10. The plots were then plowed. In the spring the plots were worked with a field cultivator and dragged. On April 23 the area was seeded to Era wheat @ 1 3/4 Bu/A. On May 24 the wheat area was sprayed with Hoelon @ 3 1/3 pts/A. The plots were sprayed again on June 3 with MPCA @ 1 pt/A. The upper two leaves were sampled prior to flowering on June 23 for nutrient analysis. On July 20 the soft dough stage whole plant samples were taken for nutrient analysis. The plots were harvested with a plot combine on August 9. Samples of grain were saved for protein analysis.

Corn

Copper and zinc were dissolved in water and sprayed on the plots on November 3, 1981. N, P, K, and S were hand spread on November 4. The area was plowed on November 5. On May 4 the plots were dug with a field cultivator, dragged and planted to Trojan TXS 99 @ 23,000 seeds/A. No starter fertilizer or insecticide was used. The herbicides Lasso (2.5 lb/A) and Bladex (2.2 lb/A) were applied on May 5. Early plant heights and samples were collected on June 23. Leaf samples at mid-silk were collected on July 28. The plots were hand harvested on September 28. 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 labs recommended sulfur and zinc and one copper. The N and K recommendations had wide variations.

Upper leaf nutrient concentration differences among the laboratories were found for Ca, Mg, Fe, Cu, and Mn. Lab B or C generally had the highest concentrations. Lab D usually had the lowest concentration. Soft dough nutrient concentration differences between laboratories were found for N, K, Ca, Mg, Fe, and B. There were significant differences in lodging, grain yield and grain moisture. Lab D had a significantly lower grain yield than all other labs.

Table 1. Soil test results and the suggested fertilizer program for wheat in 1982.

	Soil Test Results[1]				
Test	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	7.9	7.6	8.0	7.9	7.9
Phosphorus (Bray 1)		16-M		19-M	21
($NaHCO_3$)	22-M	48-H	18	- -	
Potassium	216-H	175-H	170	220-H	198
Organic Matter	3.4	2.9-M	3.1	M	M
Calcium	8800	2970-H	5169	3600-H	- -
Magnesium	920	420-VH	623	630-H	903
Sodium	45	- -	17	- -	- -
Sulfur	3-L	7-L	26	10-MH	5
Iron	15.3-VH	14-M	25.0	10-H	- -
Manganese	8.26-VH	11-M	11.0	5.5-H	- -
Zinc	1.50-H	1.5-M	1.8	1.6-M	1.4
Copper	.89-H	.8-L	.8	.6-H	.6
Boron	- -	1.0-M	.8	2.6-H	- -
ENR (lb/A)	- -	88	- -	- -	- -
Nitrate N (lb/A)	124	80	10	108	68
C.E.C. (meq/100 g)	26.2	18.8	31.5	- -	- -
Soluble salts	.29	- -	.30	- -	- -

	Suggested Fertilizer Program[2]				
Nutrient	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
Nitrogen	28	110	85	22	50
Phosphorus (P_2O_5)	45	45	45	41	30
Potassium (K_2O)	63	65	160[3]	100	60
Sulfur	- -	10	- -	20	- -
Zinc	- -	2	- -	6	- -
Manganese	- -	- -	- -	- -	- -
Copper	- -	.5	- -	- -	- -
Boron	- -	- -	- -	- -	- -

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

[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 in 1982.

	Soil Test Results[1]				
Test	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	7.9	7.6	7.7	7.9	7.6
Phosphorus (Bray 1)	- -	18-M	- -	23-M	25
($NaHCO_3$)	20-M	44-H	18	- -	- -
Potassium	202-H	202-H	228	261-H	222
Organic Matter	3.9	2.8-M	3.6	M	H
Calcium	7000	2790-H	4128	3600-M	- -
Magnesium	1050	521-VH	634	520-M	898
Sodium	43	- -	22	- -	- -
Sulfur	4-L	6-L	25	11-MH	5
Iron	16.5-VH	19-H	26.6	10-H	- -
Manganese	13.25-VH	16-H	17.6	11-H	- -
Zinc	1.62-H	1.8-M	2.7	1.9-M	1.7
Copper	.92-H	.9-M	1.1	1-H	.6
Boron	- -	1.1-M	.8	2.5-H	- -
ENR (lb/A)	- -	86	- -	- -	- -
Nitrate N (lb/A)	- -	- -	1	26	- -
C.E.C. (meq/100 g)	22.2	18.8	26.5	- -	- -
Soluble salts	.35	- -	.35	- -	- -

	Suggested Fertilizer Program[2]				
Nutrient	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
Nitrogen	132	150	135	111	90
Phosphorus (P_2O_5)	92	55	80	101	70
Potassium (K_2O)	68	65	95[3]	122	40
Sulfur	0	15	- -	20	- -
Zinc	0	1.5	- -	3	- -
Manganese	0	- -	- -	- -	- -
Copper	0	1	- -	- -	- -
Boron	- -	- -	- -	- -	- -

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

[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.

The fertilizer cost and economic returns are given in Table 8. The fertilizer cost differed by $18 between Lab C and Lab E. The return over fertilizer ranged from $232.40 (Lab E) to $162.83 (Lab D). The check had the lowest returns.

Results and Discussion of the Corn Trial

Soil tests varied widely, as shown in Table 2. Recommendations for N, P, and K were different, but the range was not as great as for the wheat. Two laboratories recommended both sulfur and zinc and one also recommended copper.

Small whole plant nutrient concentration differences among the laboratories were significant only for K and Cu.

Ear leaf nutrient concentration among laboratories was significant for N, P, K, Zn, and Cu. The copper level was highest in the two labs which have received Cu in the past three years.

Corn grain yields did not vary significantly between laboratories. None of the other plant measurements varied significantly. Variation in the plots was high due to the hail damage.

Fertilizer costs are given in Table 8. The costs ranged from $62.75 (Lab D) to $35.80 (Lab E). The economic return over fertilizer varied about $19/acre between labs.

Three-Year Summary

The combined data for 1980, 1981, and 1982 (Table 9) shows quite a range in the return over check. For wheat Labs C and D show the smallest return while Lab E shows the greatest return. For corn all results are negative because of reduced corn prices but Labs C and D show the most negative results while Lab D Shows the least negative results. The combined wheat and corn results averaged over years shows the same ranking of labs. After three years of testing, 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 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
	%				ppm				
A	.307	2.59	.533	.315	95	29.4	4.4	75	5.9
B	.304	2.73	.548	.310	96	35.7	5.9	82	7.2
C	.310	2.63	.536	.340	95	31.1	4.3	86	6.0
D	.310	2.48	.419	.269	82	26.1	3.2	62	7.6
E (UM)	.306	2.61	.479	.302	87	29.9	5.1	70	6.3
Check	.314	2.48	.331	.204	77	37.3	2.9	47	4.5
Significance	NS	NS	**	**	*	NS	**	**	NS
BLSD (.05)	- -	- -	.086	.057	10	- -	1.5	7	- -
CV (%)	3.8	6.5	12.2	12.9	9.9	31.1	21.8	7.2	42.4

[1] Upper 2 leaves prior to flowering.

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

Lab	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	Nutrient									
	%					ppm				
A	1.38	.213	1.11	.200	.179	57	22.8	1.2	46	1.9
B	1.42	.196	1.29	.245	.188	62	24.6	1.2	46	2.3
C	1.33	.193	1.31	.206	.184	62	21.2	1.4	46	2.1
D	1.08	.197	1.14	.159	.156	46	19.9	1.0	45	1.8
E (UM)	1.30	.205	1.13	.185	.169	53	22.7	1.0	45	1.7
Check	1.06	.201	0.98	.143	.129	53	22.9	0.9	40	1.4
Significance	*	NS	*	**	**	*	NS	NS	NS	**
BLSD (.05)	0.24	- -	.24	.048	.024	10	- -	- -	8	0.3
CV (%)	11.8	9.8	12.3	16.2	9.5	11.4	9.8	33.2	7.5	11.2

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

Lab	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	Nutrient								
	%				ppm				
A	.328	3.03	.563	.475	183	38.1	6.1	53.7	5.2
B	.319	3.42	.533	.427	197	38.5	6.3	47.9	5.1
C	.328	3.59	.504	.391	196	39.4	5.8	50.7	5.3
D	.315	3.30	.562	.419	195	40.0	6.4	53.2	5.2
E (UM)	.326	3.10	.544	.471	185	37.4	6.4	52.4	5.2
Check	.324	2.76	.574	.451	203	38.7	6.8	53.0	5.6
Significance	NS	*	NS	NS	NS	NS	+	NS	NS
BLSD (.05)	- -	0.57	- -	- -	- -	- -	- -	- -	- -
CV (%)	6.9	10.6	8.6	11.2	8.0	8.0	7.2	6.5	7.2

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

Lab	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	Nutrient									
	%					ppm				
A	2.95	.315	1.87	.554	.455	122	16.5	4.6	69	4.6
B	3.18	.322	1.93	.556	.421	130	18.7	5.6	66	4.9
C	3.08	.318	2.00	.580	.407	129	18.1	5.1	67	4.9
D	3.06	.314	1.98	.544	.307	126	18.3	5.3	65	4.7
E (UM)	3.01	.311	1.87	.541	.420	126	16.4	4.7	65	4.5
Check	2.67	.272	1.69	.550	.383	125	16.5	4.2	56	4.4
Significance	**	**	**	NS	NS	NS	**	**	NS	+
BLSD (.05)	0.15	.020	.15	- -	- -	- -	1.2	0.7	- -	- -
CV (%)	3.5	4.3	5.1	6.5	12.0	3.93	4.6	9.1	10.9	5.4

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

	Corn				Wheat				
Lab	Early Plant Height	Early Plants (10) Dry Weight	Corn Grain Yield	Grain Moisture	Plant Height at Harvest	Lodging at Harvest	Grain Yield	Grain Moisture	Grain Protein
	- in -	- grams -	-Bu/A-	- % -	- in -	Score[1]	-Bu/A-	- % -	- % -
A	21.2	38	107.3	34.0	27.0	1.8	57.3	14.6	13.8
B	20.9	44	108.3	34.0	29.0	1.8	62.8	14.5	14.3
C	20.4	38	105.3	34.9	28.5	2.0	66.7	14.4	14.0
D	31.3	41	106.0	35.0	28.2	1.2	49.0	14.6	12.4
E (UM)	20.9	42	106.6	34.2	29.5	2.0	64.4	14.6	13.5
Check	21.6	38	91.4	35.0	26.8	1.0	35.1	14.8	12.2
Significance	NS	NS	+	NS	+	**	**	**	*
BLSD (.05)	-	-	-	-	-	.5	9.30	0.2	1.4
CV (%)	6.2	19.5	7.3	4.3	5.1	21.2	11.6	.75	6.6

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

Table 8. Economic return over fertilizer costs - 1982.

	Wheat			Corn		
Lab	Value of Crop @ \$4/Bu	Fertilizer Cost*	Return over Fertilizer	Value of Crop @ \$2/Bu	Fertilizer Cost	Return over Fertilizer
	\$/A					
A	229.20	34.56	194.64	214.60	50.96	163.64
B	251.20	40.29	210.91	216.60	48.36	168.24
C	266.80	43.20	223.60	210.60	51.65	158.95
D	196.00	33.17	162.83	212.00	62.75	149.25
E (UM)	257.60	25.20	232.40	213.20	35.80	177.40
Check	140.40	0	140.40	182.80	0	182.80

* Values used (\$/lb) were as follows: N = \$0.15, P_2O_5 = \$0.25, K_2O = \$0.12, S = \$0.24, Zn = \$0.47, Cu = \$2.80.

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

	Wheat*				Corn**				
Lab	Total 3-year Yield	Total 3-year Fertilizer cost	Economic Return over Fertilizer	Return over Check	Total 3-year Yield	Total 3-year Fertilizer Cost	Economic Return over Fertilizer	Return over Check	Average Return per Year
	Bu/A	\$/A			Bu/A	\$/A			\$/A
A	166.5	71.73	594.27	+57.47	340.3	145.64	699.50	-31.64	+8.61
B	176.0	114.97	589.03	+52.23	348.1	166.22	695.98	-35.16	+5.59
C	175.8	152.65	550.55	+13.75	348.9	197.96	669.52	-61.62	-15.96
D	158.4	83.53	550.07	+13.27	342.5	179.50	671.32	-59.82	-15.52
E (UM)	170.9	62.11	621.49	+84.69	340.6	122.25	721.97	-9.17	+25.17
Check	134.2	-	536.80	-	292.9	-	731.14	-	-

* Wheat valued at \$4/Bu, 1980-82.

** Corn valued at \$3.00, \$2.40 and \$2.00/Bu in 1980, 1981 and 1982, respectively.

PROBLEMS WITH IRRIGATED CORN 1982

W. E. Fenster and C. J. Overdahl

County Agricultural Agents and irrigator farmers in recent years have reported corn production problems where corn yields appear to be on the decline. In 1979 two farmers in Morrison County complained that yields dropped by two-thirds from the year before. In 1980 and 1981 the Wadena County Agricultural Agent reported similar problems.

In 1982 field experiments were initiated at 2 irrigated sites, the CMIDRF at Staples and Roth farm northeast of Staples. Both areas had sandy textured soils.

The design of the experiment used at both sites is shown in table 1 along with 1982 corn yields.

Yield data from the Roth farm indicates a significant response to nitrogen, and a significant benefit from the use of the inhibitor "N-Serve". There appears to be no benefit from boron even though plant analysis of the corn leaf at silking time showed below sufficient levels of boron. There appears to be benefit from split applications of nitrogen at the 160 pound rate when N-Serve is not used.

Data from the Staples farm shows a significant response to nitrogen. There appeared to be no benefit from the inhibitor, the sulfur, the boron, or from split applications of nitrogen.

The efforts on this research project of Mike O'Leary, Greg Buzicky, Todd King, Gene Peters, Negussie Berihun and Mel Wiens are acknowledged.

Table 1. Nutrient treatments and various growth stages at Roth and Staples farms and corn yields. 1982

Trt	Total #N/A	Amount and Time of N Application: ppl[1]	8 leaf	12 leaf	Tassel	Sulfur[2]	Boron[3]	Yield Bu/A @ 15.5% moist.: Roth	Staples	Original Soil Test 0 - 6" Staples: Rep 1	Rep 2
1	0	-	-	-	-	+	+	72	100	pH 6.4	6.7
2	80		80+			+	+	156	155	P 44	29
3	160	160				+	+	128	160	K 210	204
4	160	160+				+	+	166	161	Mg 254	208
5	160		160+			+	+	168	153	S 3	3
6	160	80+	80			+	+	163	165	Zn 0.7	0.6
7	160		80	40	40	+	+	167	156	Roth	
8	160		80+	40	40	+	+	167	163	pH 5.6	6.0
9	200	200				+	+	151	166	P 105	140
10	200	200+				+	+	171	150	K 168	266
11	200		80	80	40	+	+	166	160	Mg 173	238
12	200		80+	80	40	+	+	165	160	S 2	3
13	200		80+	80	40	+[4]	+	168	163	Zn 1.5	3.0
14	200		80+	80	40	+	-	173	167		
15	200		80+	80	40	-	+	152	163		
16	200		80+	80	40	-	-	165	162		

Trts.	1-12	12-16	1-12	12-16
Signif.	**	**	**	ns
BLSD (.05)	14.3	5.3	13.4	-
C.V.	7.1	2.8	6.5	2.8

1/ Plus sign indicates use of N-Serve (½ lb/A a.i.) ppl = preplant

2/ Sulfur - 25 lbs/A (applied as starter)

3/ Boron - 2 lbs/A (Bdcst)

4/ Sulfur - 25# additional S at 12 leaf stage

Starter fertilizer results in additional 20 lbs N/A

Table 2. Plant analysis of corn at 2 stages of growth, Staples 1982.

Trt		% N	% P	% K	% S	% Mg	ppm B
			Whole plant 8-leaf stage (4 reps avg)				
1	Zero N, + S, + B	3.97	.46	4.76	.26	.26	36
9	ppl 200 #N, + S, + B	3.95	.44	4.62	.26	.24	48
15	ppl 200 #N, - S, + B	3.50	.35	3.92	.27	.23	50
16	ppl 200 #N, - S, - B	3.43	.35	4.17	.27	.21	9
	adequate levels	3.50	.40	3.00	-	.30	7
			6th leaf stage (2 reps avg)				
13	220 #N+, + S, + B	(See table 3)	.30	3.29	.25	.17	8
14	220 #N+, + S, - B		.31	3.24	.20	.18	4
15	220 #N+, - S, + B		.31	3.16	.22	.18	10
16	220 #N+, - S, - B		.31	3.29	.24	.17	4
	adequate levels	2.70	.25	1.75	.20	.16	6

Table 3. Plant analysis of corn at 2 stages of growth, Roth farm. 1982.

Trt		% N	% P	% K	% S	% Mg	ppm B
			Whole plant, 8 leaf stage (4 reps avg)				
1	Zero N, + S, + B	3.66	.46	4.73	.23	.24	32
9	200 #N, + S, + B	3.96	.46	4.81	.23	.24	45
15	200 #N, - S, + B	3.78	.44	4.63	.26	.25	48
16	200 #N, - S, - B	3.72	.40	4.54	.24	.24	9
	adequate levels	3.50	.40	3.00	-	-	6
			6th leaf stage (2 reps)				
13	220 #N, + S, + B		.24	3.04	.16	.16	7
14	220 #N, + S, - B		.29	3.26	.22	.20	4
15	220 #N, - S, + B		.31	3.20	.23	.18	8
16	220 #N, - S, - B		.31	3.17	.23	.22	4
	adequate levels		.25	1.75	.20	.16	6

		% N	
		Roth	Staples
1	0	2.31	2.08
2	80 N	2.84	2.48
3	160 N	2.80	2.93
5	160 (8th) N	3.26	2.97
6	80 + 80 N	2.96	3.29
7	80 + 40 + 40 N	2.98	3.03
10	200+ N	3.00	3.39
	adequate	2.70	2.70

CORN-BEAN ROTATION

Harvey Meredith, Melvin Wiens and Greg Buzicky

An experiment was initiated in 1981 at the Staples Station to evaluate corn yields under a regime of continuous corn versus corn following soybeans or edible beans.

The study contains two single cross maturity hybrids: Pioneer 3978 (85-day) and 3906 (95-day).

No significant differences in corn yields were noted in 1981 between the two maturity hybrids. The average yield was 151 bushels/A.

Purpose of Study: Yield of corn from a continuous corn monoculture has not met the expectation of many growers on the irrigated sand plain. Many factors have been advanced as probable cause-effect. The potential for consistently high yields rests with the best combination of weather and management. Perhaps the two most critical factors identified with top management focus around moisture and nitrogen. Excess moisture from rainfall or irrigation (or both) result in an extremely deleterious effect on the soil nitrogen regime.

This study represents an application of research coupled with the best known management. The study contains no fertility variable but nutrition requirements have been assured.

1982 Corn Yield Staples Station

Treatment	Bu/A	Shelling %	% Moisture
C-C 3978	168	90	36
C-C 3906	166	88	44
SB-C 3978	170	90	35
EB-C 3978	168	89	37

C-C: Continuous corn
SB-C: Corn following soybeans (Clay - ave. yield, 47 bu/A)
EB-C: Corn following edible beans (Seafarer - ave. yield, 1813 Lb/A)

Fertility: 210-60-210 plus 1 lb. B, 10 lb. Zn, and 12 lb. S. Nitrogen applied at three equal increments at 7th leaf stage, 12th leaf stage, and at silking. Starter fertilizer included 150 lb/A of 25-10-20.

Rainfall growing season - 14.6 in. plus 11 in. irrigation water. The suggested CB water use was 20.7 in.

SOUTHERN EXPERIMENT STATION - WASECA

WEATHER DATA - 1982

Month	Period	Precipitation 1982	Precipitation Normal	Avg. Air Temp. 1982	Avg. Air Temp. Normal	Growing Degree Days 1982	Growing Degree Days Normal
		-----inches------		--------°F--------			
January	1-31	2.38	.73	0.6	12.9		
February	1-28	0.57	.96	12.6	17.5		
March	1-31	1.86	1.94	27.7	28.5		
April	1-30	2.78	2.48	40.4	45.6		
May	1-10	1.58		57.4		100.5	
	11-20	2.44		63.6		135.5	
	21-31	2.43		58.7		102.0	
	Total	6.45	3.86	59.8	57.7	338.0	319
June	1-10	0.21		58.6		102.0	
	11-20	0.64		62.2		131.5	
	21-30	0.93		65.6		160.0	
	Total	1.78	4.75	62.2	67.1	393.5	519
July	1-10	0.93		71.4		203.0	
	11-20	0.45		72.4		223.5	
	21-31	0.08		73.0		252.0	
	Total	1.46	4.02	72.4	71.4	678.5	646
August	1-10	0.90		72.8		222.5	
	11-20	0.29		69.0		192.0	
	21-31	3.42		63.5		153.0	
	Total	4.61	3.60	68.2	69.7	567.5	604
September	1-30	4.27	3.45	58.8	60.3	242.0	337
October	1-31	3.72	1.89	49.3	50.3	0.0	35
November	1-30	2.82	1.25	30.0	32.9		
December	1-31	3.48	1.02	24.6	19.0		
Year	Jan-Dec	36.18	29.95	42.2	44.4	2220.0	2460
Growing Season	May-Sep	18.57	19.68	64.3	65.3	2220.0	2425

Notes:

1) Highest temp. on July 5 -- 96°
2) Highest 24-hour precipitation on November 10 -- 1.35"
3) Growing degree days were 10% below normal
4) Available soil moisture in 0-5' profile was below 30% of field capacity in August
5) Last spring frost -- April 22
6) Frost on September 21
7) Second driest June-July period in 67-year record

ROTATION NITROGEN STUDY

Waseca, 1982

G. W. Randall

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

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 1982, a C-C-Sb rotation was introduced to examine the N needs of second-year corn following soybeans.

In 1982, anhydrous ammonia was applied on April 27 to all corn plots. Wheat received 50 lb N/A as urea before planting. Broadcast P, K and Zn of 50 + 150 + 10 lb P_2O_5, K_2O, and Zn as $ZnSO_4$/A were applied in the fall of 1981 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 29900 ppA on April 29. Amaze was applied to all corn plots at 1 lb/A to control rootworms. Era wheat was planted on May 10. Corsoy-79 soybeans were planted on June 3.

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 grain N data were obtained on the harvested samples.

After the 1981 harvest, soil samples were taken in the fall to a 5' depth from the 0 and 160-lb N treatments which were applied to the corn grown in each crop sequence. For the continuous corn sequences (grain and silage) this means that samples were taken where the N was applied in 1981 whereas in the soybean and wheat sequences the N was applied to the corn in 1980. Two cores were taken/plot, divided into 1-foot increments, composited/rep, dried, crushed and analyzed for NO_3-N by the Soil Testing Laboratory.

RESULTS

Nitrate-N remaining in the soil profile after the 1981 crop, which was available to the 1982 corn, is shown in Table 1. When no fertilizer N was applied in 1981 (except the blanket 50-lb rate to wheat) very little difference in residual NO_3-N appeared among the four crop sequences. Highest residual NO_3-N followed soybeans while the lowest followed corn removed as silage. When 160 lb of N was applied some carryover of that N was found with continuous corn (both grain and silage). The 160-lb N rate applied to corn in 1980 did not appear to carryover following soybeans or wheat in 1981. In summary, these data indicate little difference in residual N among the crop sequences when no N was applied, but that residual NO_3-N following corn which received a standard 160-lb N rate was markedly higher than following soybeans which received no N or wheat which received 50 lb N/A.

Table 1. Effect of previous crop and N rate applied to corn in the crop sequence on residual NO_3-N remaining in the 0-5' profile at the end of the 1981 growing season.

Profile depth	Corn (grain)	Corn (silage)	Soybeans	Wheat
	Previous Crop			
feet	lb NO_3-N/foot			
	0 lb N/A			
0-1	37	29	39	34
1-2	25	21	32	25
2-3	24	20	27	24
3-4	24	22	23	20
4-5	23	20	27	17
Total (lb NO_3-N/5')	133	112	148	120
	160 lb N/A			
0-1	44	45	44	28
1-2	33	40	29	22
2-3	35	40	24	25
3-4	38	30	27	25
4-5	32	33	28	22
Total (lb NO_3-N/5')	182	188	152	122

Grain yield, leaf N and grain N responded to fertilizer N with both hybrids regardless of the previous crop (Table 2). The Pioneer 3732 hybrid yielded slightly more than the P3901 hybrid, especially at the higher N rates. Leaf N was also slightly higher with the 3732 hybrid but grain N was consistently lower compared to the 3901 hybrid.

When averaging the two hybrids together, corn grain yield response to the 200-lb N rate over the 0-lb N rate averaged 85.2, 68.8, 65.0, 58.6 and 104.5 bu/A for continuous corn (grain, continuous corn (silage), corn after soybeans, corn after wheat, and second year corn after soybeans, respectively (Table 2).

When no N was added, yields of second year corn following soybeans were lowest and were approximately 10 bu/A lower than for continuous corn. This was probably due to higher corn yields and greater stover production in the year following soybeans which resulted in a larger amount of corn residue being plowed under. This residue then could have immobilized more of the mineralized soil N than with the smaller amount of residue with the continuous corn system. This theory also holds if we compare the corn (silage) yields vs the corn (grain) yields. Again, with no residue plowed under the previous year, the corn (silage) yields averaged about 25 bu/A higher than where only the grain had been removed the previous year.

Highest corn yields were obtained following soybeans (Table 2). Yields were maximized at 160 lb N/A when the preceding crop was continuous corn (grain), soybeans, and corn following soybeans, at 120-160 lb N/A with continuous corn (silage), and at the 120-lb rate when the preceding crop was wheat. At the 200-lb N rate corn yields were 9, 12, 1 and 10 bu/A higher following corn (silage), soybeans, wheat, and corn after soybeans, respectively. These results were fairly consistent among hybrids although the 3732 did yield somewhat better than the 3901. The yield differences associated with the crop sequences were also fairly similar to the 1981 results but considerably different from the 1975-80 results. This was true even under growing conditions which provided substantially more stress than in 1981. Thus, one must suspect that the hybrids used in 1981 and 1982 are much more tolerant of dry, stress conditions than the hybrids used earlier.

When no N was added, leaf N was highest following soybeans and slightly lower following wheat (Table 2). Leaf N for second year corn following soybeans was lower than with corn (grain) which in turn was lower than corn (silage). This is closely related to the yield differences mentioned previously. Leaf N was highest when soybeans were the previous crop. Optimum leaf N associated with the optimum yield level was approximately 2.80-2.85% N regardless of the previous crop.

Table 2. Corn grain yield, leaf N and grain N as influenced by previous crop and N rate at Waseca in 1982.

Previous crop	Hybrid	N rate (lb/A) 0	40	80	120	160	200
		Yield (bu/A)					
Cont. corn (grain)	3901	82.0	119.1	152.1	158.5	171.6	165.7
	3732	84.3	117.5	143.9	165.8	172.7	171.2
Cont. corn (silage)	3901	107.8	134.1	155.4	168.5	166.5	173.6
	3732	108.6	146.1	165.9	177.9	173.1	180.4
Soybeans	3901	114.6	148.3	173.5	174.0	178.6	177.7
	3732	115.8	148.8	172.3	173.9	185.2	182.7
Wheat	3901	109.6	147.0	167.3	173.3	170.1	166.4
	3732	115.9	153.2	174.3	177.9	176.8	176.4
Corn after soybeans	3901	70.7	112.0	149.1	162.7	176.2	170.7
	3732	75.5	111.9	158.9	175.3	182.1	184.5
		Leaf N (%)					
Cont. corn (grain)	3901	1.77	2.23	2.45	2.58	2.72	2.81
	3732	1.83	2.08	2.49	2.74	2.95	2.93
Cont. corn (silage)	3901	1.89	2.30	2.69	2.73	2.76	2.81
	3732	1.94	2.27	2.71	2.83	2.78	2.93
Soybeans	3901	2.21	2.44	2.66	2.87	2.81	2.93
	3732	2.12	2.47	2.73	2.85	2.87	2.99
Wheat	3901	2.14	2.45	2.78	2.80	2.81	2.84
	3732	1.96	2.39	2.69	2.80	2.84	2.90
Corn after soybeans	3901	1.54	1.81	2.45	2.58	2.81	2.85
	3732	1.69	1.83	2.52	2.65	2.87	2.87
		Grain N (%)					
Cont. corn (grain)	3901	1.13	1.21	1.28	1.42	1.44	1.55
	3732	1.09	1.09	1.25	1.39	1.31	1.43
Cont. corn (silage)	3901	1.20	1.28	1.35	1.49	1.55	1.52
	3732	1.12	1.20	1.30	1.41	1.37	1.42
Soybeans	3901	1.21	1.32	1.44	1.53	1.53	1.55
	3732	1.10	1.22	1.35	1.38	1.46	1.42
Wheat	3901	1.24	1.33	1.42	1.54	1.55	1.52
	3732	1.13	1.18	1.31	1.44	1.44	1.47
Corn after soybeans	3901	1.15	1.19	1.33	1.49	1.56	1.59
	3732	1.10	1.12	1.30	1.40	1.41	1.45

Grain N data do not follow the yield and N data closely (Table 2). Grain N ranked according to previous crop as wheat > corn (silage) > soybeans > corn after soybeans > corn (grain) when N was not applied. This may have resulted from dilution due to differences in grain yield. Grain N at the 160-lb N rate was lower for the corn (grain) system than for the other systems even though yields were maximized at this N rate. When 200-lb N/A was applied, differences in grain N did not exist among the crop sequences. Protein levels at the optimum N rates averaged about 9.6 and 9.0% with the 3901 and 3732 hybrids, respectively.

The relationship between N rates needed for the optimum yields shown in Table 2 did not agree well with the residual NO_3-N values shown in Table 1. Highest residual N followed soybeans; yet the 160-lb N rate was necessary to optimize corn yield. On the other hand, lowest residual NO_3-N was found following corn (silage) and wheat; yet yields were optimized at only the 120-lb N rate.

NITROGEN LOSS TO TILE LINES AS AFFECTED BY TILLAGE

Waseca, 1982

G. W. Randall

Nitrogen losses to tile lines have been documented in a number of research studies including some conducted at Lamberton and Waseca, Minnesota. These studies primarily showed that N losses were a function of the N application rate and amount of precipitation. To some degree the time of application and crop grown have been shown to influence NO_3-N loss to tile lines. The purpose of this proposed long-term study is to determine if tillage has an effect on N utilization, accumulation of NO_3-N in the soil profile, and the subsequent loss of NO_3-N to tile lines.

Experimental Procedures

A study was initiated in 1975 on a Webster clay loam at Waseca to monitor the movement of N from 12 plots measuring 45' x 50' each enclosed with plastic sheeting to a 6' depth into a tile line installed in each plot. Annual N rates of 0, 100, 200, and 300 lb N/A were applied from 1975-1979. No N was applied for the 1980 and 1981 crops. During the last two years residual N was utilized by the corn which was planted over the 7-year period. Soil samples to 10' and tile water samples taken in late 1981 showed little remaining evidence of the previous treatments.

In the fall of 1981, the eight plots with the most uniform tile flow rates over the 1975-81 period were selected. Two tillage treatments (fall moldboard plow and no tillage) were replicated four times and randomized over the previous plot histories. A fertilizer application rate of 0 + 50 + 150 + 10 ($N+P_2O_5+K_2O+Zn$)/A was broadcast applied in October, 1981 before the moldboard plowing.

On April 28, 180 lb N/A as ammonium nitrate was broadcast applied to the surface of all plots. The moldboard treatment was then field cultivated. Corn (Pioneer 3732) was planted on May 3 at a population of 27700 plants/A with a John Deere Max-Emerge planter equipped with 2" fluted coulters. Starter fertilizer was not used because of the high soil tests. Counter was applied at 1 lb (ai)/A to control rootworms. Weeds were controlled with a preemergence application of Lasso (3½#) and atrazine (3#/A). Control was excellent.

The leaf opposite and below the ear was taken from 10 randomly selected plants per plot at silking and was analyzed for N. Silage and grain yields were taken at physiological maturity by hand harvesting 30 and 60' of row, respectively, from each plot.

Because the N was not applied until late April, tile line samples were not taken in May and June. Conditions were extremely dry during July and much of August so the tile lines did not begin to flow until October. Once flow commenced, flow rates were measured daily and samples taken on Monday, Wednesday and Friday for NO_3-N analysis. All analyses were done by the Research Analytical Lab.

Soil NO_3-N in the 0-5' profile was determined from two cores/plot taken in 1-foot increments in early November.

Results

Significant differences in final population, leaf N, silage yield, silage N uptake, grain yield, grain N and grain N removal were not found in this first year of the study (Table 1). A slight trend toward higher grain N and N uptake was observed with moldboard plow tillage, however.

Tile flow over the 3-month period (October-December) was slightly higher with the no tillage treatment (Table 2). Nitrate-N concentration in the tile water averaged 1.2 mg/L higher with no tillage--probably not a significant difference. Total NO_3-N loss was low from both treatments; however, slightly more was lost under no tillage.

Residual NO_3-N in the 0-5' profile after harvest was not affected significantly by the two tillage treatments (Table 3).

Table 1. Influence of tillage system on corn production and N utilization at Waseca in 1982.

Tillage system	Final popl'n.	Leaf N	Silage Yield	Silage N uptake	Grain Yield	Grain N	Grain N removal
	ppA x 10^{-3}	%	T DM/A	lb N/A	bu/A	%	lb N/A
Mb. Plow	24.6	2.52	6.76	115.3	146.1	1.16	81.0
No Tillage	25.7	2.47	6.69	109.7	143.6	1.11	75.7
Signif. Level(%):	77	19	14	39	17	66	42
CV (%) :	4.2	10.	7.7	13.	10.	6.1	16.

Table 2. Influence of tillage system on tile flow, NO_3-N concentration and NO_3-N loss at Waseca in 1982.

Tillage system	Tile[1/] flow	Nitrate-N Concentration	Nitrate-N Loss
	acre-inches	mg/L	lb NO_3-N/A
Mb. Plow	1.10	5.0	1.25
No Tillage	1.75	6.2	2.44

1/ October-December, 1982

Table 3. Influence of tillage system on residual NO_3-N in the soil profile in November, 1982.

Profile depth	Tillage System Mb. Plow	Tillage System No Tillage
feet	------NO_3-N (lb/A)-------	
0-1	19.4	19.7
1-2	17.4	12.2
2-3	12.6	14.2
3-4	13.7	16.6
4-5	14.7	18.8
Total (lb NO_3-N/A 0-5')	77.8	81.5

NITROGEN EFFICIENCY AS AFFECTED BY RIDGE - PLANTING

Waseca, 1982

G. W. Randall

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 plots in 1982 were planted on the same plots as in 1981. Thus, the treatments are continuous and will be continued in 1983. The previous crop of corn was ridged in July of 1981. 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 = 7.4, Bray P_1 = 41 lb/A (Very High) and exchangeable K = 325 lb/A (Very High). Response to additional fertilizer P and K would not be expected at these soil test levels; hence no P or K was applied for 1982.

Corn (Pioneer 3732) was planted with a Buffalo till-planter at 26000 plants/A with 1 lb Counter/A on May 10. No starter fertilizer was used. Weeds were chemically controlled with Lasso (3½ lb/A) + Bladex (3 lb/A) applied preemergence on May 20. All plots were cultivated and ridged on July 8.

One-third of the N treatments was applied preplant on May 10. The urea was broadcast on the surface by hand while the urea-ammonium nitrate (UAN) solution (28% N) was broadcast with a motorized bicycle sprayer. The planting operation which removes the top of the ridge and deposits the soil in the interrow 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 21). Application techniques were the same as at preplanting. The last one-third of the treatments was sidedress-applied at the 8-leaf stage (June 28). The urea and UAN materials were banded 4-6 inches to the side of each row and covered slightly with soil. This simulated N application with a cultivator.

The percent of the soil surface covered by corn residue from the 1981 crop was measured prior to planting and again at emergence by the line-intercept method.

Leaf samples were taken at silking from 10 random plants in the center two rows of each plot. Final population was determined from 120' 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 October 29.

Two separate analyses of variance statistical tests were conducted on the data. The first was a two-way ANOVA with all treatments including the check. A second analysis, with the check treatment omitted, was made to estimate the influence of each of the main factors (method-time, N source, and N rate) and the interactions among these factors.

RESULTS AND DISCUSSION:

Surface residue. Residue acccumulation measurements across both the ridge and inter-ridge areas of all treatments showed that 80% of the soil surface was covered by residue from the previous crop prior to planting (May 10). At the emergence stage (May 21) this had dropped to 19% as a result of residue incorporation by the planter.

Soil pH. Because high soil pH has been shown to increase the volatilization of NH_3 from surface-applied ammonical sources of N, soil pH measurements were taken from the 0-6" layer of each plot. Average soil pH values shown in Table 1 were relatively high but were not related to the N treatments. Factorial analyses also showed no marked relationship between pH and treatment (Table 2). These data indicate that there should have been no confounding of N response among treatments due to soil pH induced volatilization.

Plant height. Plant heights were measured at two stages: 16-17 leaf (July 20) and after tasseling (August 23). Prior to tasseling all N treatments increased the plant height above the check (Table 1). When averaged over N source and rate, the factorial analysis indicated the preplant (PP) application to have slightly taller plants than the emergence (EM) application with both the PP and EM plants being substantially taller than the sidedress (SD) plants (Table 2). Apparently the 22-day period between the 8-leaf sidedress application and July 20 was not long enough for the plants to utilize the N. Thus, the plants had not caught up in size and still were somewhat stunted. The UAN and urea treatments resulted in taller plants than the ammonia treatments when averaged over method-time and N rate. However, the highly significant method-time x source interaction (99% level) indicates only slight differences among sources when applied PP or SD but a large difference when applied at the EM stage. At this stage application of AA resulted in substantially smaller plants compared to UAN or urea treatments. This was primarily due to some of the physical problems associated with the sidedress application of ammonia (soil disturbance, covering of some plants, etc.) and was not felt to be due to unavailability of the N. Other interactions were not significant.

After tasseling (August 23) plant height was not significantly different (90% level) among all treatments (Table 1). The factorial analyses also showed no relationship between any of the factors and plant height (Table 2). These data indicate that plant height after tasseling may not be a good index for evaluating N efficiency and/or grain yield.

Table 1. Soil pH, plant height, final plant population, and leaf N as influenced method-time, source, and rate of N fertilizer applied to a ridge-plant system at Waseca in 1982.

Treatments							
Method[1/]	N		Soil	Plant Height		Final	Leaf
-Time	Source[2/]	Rate	pH	7/20	8/23	population	N
		lb N/A		------cm------		x 10^{-3}	%
PP	UAN	75	7.4	184	240	23.2	2.50
PP	"	150	7.5	186	240	24.1	2.90
PP	Urea	75	7.3	186	243	23.7	2.59
PP	"	150	7.3	187	241	23.2	2.86
PP	AA	75	7.6	176	236	23.7	2.75
PP	"	150	7.3	186	243	23.8	3.03
EM	UAN	75	7.4	185	242	24.1	2.39
EM	"	150	7.3	187	240	23.2	2.82
EM	Urea	75	7.6	186	240	24.6	2.53
EM	"	150	7.3	191	241	23.8	2.92
EM	AA	75	7.4	168	238	22.4	2.84
EM	"	150	7.5	167	239	20.9	2.88
SD	UAN	75	7.4	165	239	23.9	2.71
SD	"	150	7.4	164	236	23.7	2.72
SD	Urea	75	7.6	164	237	23.9	2.55
SD	"	150	7.6	166	238	24.4	2.66
SD	AA	75	7.6	164	238	25.3	2.75
SD	"	150	7.3	170	242	24.2	2.97
	Check	0	7.3	153	226	24.0	1.94
Significance Level(%):[3/]			89	99	87	99	99
BLSD (.05)		:		8		1.4	.18
CV (%)		:	3.1	4.0	2.5	4.5	5.9

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

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

3/ Probability level of significance.

Final population. Final population was influenced by the N treatments but none were higher and only a few lower than the check (Table 1). Factorial analysis showed somewhat higher plant populations with the SD time of application when averaged over source and rate (Table 2). However, the highly significant (99% level) interaction between method-time x source indicates that plant populations were significantly reduced by the application of AA at the EM stage. Population differences among N sources and between N rates were not significant (95% level). Other interactions among the main factors were also not significant.

Table 2. Factorial analyses of soil pH, plant height, plant population and leaf N as influenced by method-time, source and rate of N fertilizer applied to a ridge-plant system at Waseca in 1982.

		Soil pH	Plant Height 7/20	Plant Height 8/23	Final population	Leaf N
MAIN TREATMENTS			------cm------		x 10^{-3}	%
Method-Time						
PP		7.4	184	240	23.6	2.77
EM		7.4	181	240	23.2	2.73
SD		7.5	166	238	24.2	2.73
Signif. Level (%):		50	99	57	99	57
BLSD (.05) :			3		0.5	
N Source						
UAN		7.4	178	240	23.7	2.67
Urea		7.4	180	240	23.9	2.68
AA		7.5	172	239	23.4	2.87
Signif. Level (%):		48	99	18	87	99
BLSD (.05) :			3			.07
N Rate (lb/A)						
75		7.5	176	239	23.9	2.62
150		7.4	178	240	23.5	2.86
Signif. Level (%):		97	92	59	90	99
INTERACTIONS						
Meth-Time x Source						
PP	UAN	7.4	185	240	23.6	2.70
PP	Urea	7.3	187	242	23.5	2.72
PP	AA	7.4	181	239	23.7	2.89
EM	UAN	7.3	186	241	23.7	2.61
EM	Urea	7.4	188	241	24.2	2.72
EM	AA	7.5	168	238	21.6	2.86
SD	UAN	7.4	164	238	23.8	2.72
SD	Urea	7.6	165	238	24.1	2.61
SD	AA	7.4	167	240	24.7	2.86
Signif. Level (%):		83	99	54	99	81
			Significance Levels (%)			
Method-Time x Rate		1	21	14	90	98
Source x Rate		53	49	81	59	64
M-T x S x R		95	60	29	49	98

Leaf N. Nitrogen concentration in the earleaf at silking was increased significantly over the check by all of the N treatments (Table 1). Factorial analysis showed no effect of method-time on leaf N (Table 2). Leaf N was highest with the AA source compared to UAN or urea when averaged over method-time and N rate. Leaf N was also signficantly higher with the 150-lb N rate. The significant interaction (98% level) between method-time and N rate is illustrated by leaf N being increased from 2.61 at the 75-lb N rate to 2.93% N with the 150-lb rate applied at PP, from 2.59 to 2.87% N at the EM stage, but only from

2.67 to 2.79% N when applied at the 8-leaf stage. These were averaged over all three sources and again may indicate insufficient time between the 8-leaf application time and silking for much of the N to be taken up by the plants.

Grain yield. Grain yield was increased significantly (99% level) over the check by all of the N treatments (Table 3). Factorial analysis showed a slight yield improvement with N application at the PP stage but no difference among N sources when averaged over method-time and N rate (Table 4). However, the interaction between method-time and N source was highly significant. Close examination of these data indicates (1) little difference among sources when applied at the PP stage, (2) a marked yield reduction when ammonia was applied at the EM stage with little difference among UAN or urea, and (3) significant yield improvement with ammonia compared to UAN or urea when applied at the 8-leaf stage.

Table 3. Grain yield, moisture, protein, 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 1982.

Treatments			Grain				
Method-Time	N Source	N Rate	Yield	Moisture	Protein	N removal[1/]	N efficiency[2/]
		lb N/A	bu/A	%	%	lb N/A	%
PP	UAN	75	145.0	22.4	7.20	79.0	46
PP	"	150	162.4	21.9	7.89	97.1	35
PP	Urea	75	146.1	22.1	7.12	79.3	47
PP	"	150	166.8	21.9	7.97	100.9	38
PP	AA	75	146.3	23.3	7.00	78.0	45
PP	"	150	166.1	22.1	8.07	101.6	38
EM	UAN	75	140.0	22.6	6.92	73.5	39
EM	"	150	163.5	22.0	7.47	92.5	32
EM	Urea	75	145.9	22.6	6.82	75.8	42
EM	"	150	163.6	22.0	8.05	99.7	37
EM	AA	75	145.2	23.3	7.35	80.9	49
EM	"	150	142.1	23.7	7.77	83.9	26
SD	UAN	75	146.8	23.8	6.97	77.6	45
SD	"	150	155.0	23.1	7.26	85.4	27
SD	Urea	75	144.3	24.0	7.34	80.6	49
SD	"	150	148.4	23.6	7.49	84.1	27
SD	AA	75	154.2	23.4	6.96	81.7	50
SD	"	150	161.5	22.3	7.65	93.6	33
	Check	0	93.2	26.4	6.25	44.1	—
Significance Level (%):			99	99	99	99	
BLSD (.05) :			11.1	0.9	.38	8.2	
CV (%) :			6.4	3.3	4.4	8.5	

1/ Yield times grain N.

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

Reasons for the yield difference at the EM stage can be attributed to the stand reduction associated with the AA application and perhaps to some loss of fertilizer N. Ammonia vapors were seen smoking from the knife slit following this application. Sidedress application of AA at that stage is extremely tricky due to soil disturbance which can cover the emerging seedlings and because of the buried residue. Residue from the previous crop is buried between the rows by the planter as it shaves soil off from the ridge top and deposits it on the residue between the rows. The residue then begins to decompose. When coming back in 11 days later to inject ammonia, we found a very poor injection zone because the residue (1) was not cut well by the coulters and (2) did not seal well and trap the ammonia vapors. By the time of the 8-leaf SD application (7 weeks after planting) the residue had decomposed sufficiently and application proceeded smoothly. Yield data from the 1981 study indicated depressed yields with UAN when applied to the soil surface with 23% residue cover and not incorporated. In contrast, the 1982 yields when UAN and urea were applied to the soil surface with 19% residue coverage were not different and are essentially the same as when applied PP. This was probably due to 0.59 inches of rain falling within 4 hours after application and leaching the N into the soil (Table 5).

Table 4. Factorial analyses of grain yield, moisture, protein and N removal as influenced by method-time, source and rate of N fertilizer applied to a ridge-plant system at Waseca in 1982.

	Grain			
	Yield	Moisture	Protein	N removal
MAIN TREATMENTS	bu/A	%	%	lb N/A
Method-Time				
PP	155.4	22.3	7.54	89.3
EM	150.0	22.7	7.40	84.4
SD	151.7	23.4	7.28	83.8
Signif. Level (%) :	91	99	99	99
BLSD (.05) :		0.4	0.18	3.9
N Source				
UAN	152.1	22.6	7.29	84.2
Urea	152.5	22.7	7.47	86.7
AA	152.6	23.0	7.47	86.8
Signif. Level (%) :	2	90	95	69
BLSD (.05) :			.19	
N Rate (lb/A)				
75	146.0	23.1	7.08	78.5
150	158.8	22.5	7.74	93.2
Signif. Level (%) :	99	99	99	99
INTERACTIONS				
Meth-Time x Source				
PP UAN	153.7	22.1	7.54	88.1
PP Urea	156.4	22.0	7.55	90.1
PP AA	156.2	22.7	7.54	89.8
EM UAN	151.8	22.3	7.20	83.0
EM Urea	154.8	22.3	7.44	87.8
EM AA	143.7	23.5	7.56	82.4
SD UAN	150.9	23.4	7.12	81.5
SD Urea	146.4	23.8	7.41	82.4
SD AA	157.9	22.9	7.31	87.6
Signif. Level (%) :	99	99	64	75
		Significance Levels(%)		
Meth-Time x Rate	96	55	99	99
Source x Rate	78	20	69	35
M-T x S x R	90	75	97	98

Ammonia application at the 8-leaf stage went very smoothly and resulted in higher yields than with either UAN or urea. This was probably due to positional unavailability of the UAN and urea which were only incorporated about 1 in. deep. After application to very dry surface soils, rainfall totaled only 1.49" over the next 5 weeks. This did not allow for adequate movement of the N down into the soil where most of the root activity and nutrient uptake was occurring. On the other hand the AA was injected about 7" deep into moist soil where nitritification could take place, hence, greater N uptake.

Nitrogen applied prior to planting offered no problems. Apparently the UAN and urea were incorporated satisfactorily by the planter and the AA went on very easily. The residue was easily cut by the coulters and ammonia vapor losses were not observed.

Grain yields were improved by almost 13 bu/A with the 150-lb rate over the 75-lb rate. However, a method-time x rate interaction was signficiant (96% level). Examination of that interaction averaged over all three N sources indicated a 19.3 bu/A increase from 145.8 with the 75-lb rate to 165.1 bu/A with the 150-lb rate with the PP application, a 12.7 bu/A increase from 143.7 to 156.4 with the same rates at the EM stage and only a 6.6 bu/A increase from 148.4 to 155.0 with the SD application. This response again indicates the greater efficiency obtained with the PP treatments compared to the delayed N treatments under the dry conditions in 1982.

Grain moisture. Grain moisture was reduced significantly from the check by all of the N treatments (Table 3). Factorial analysis showed lower grain moistures to be associated with the earlier N application times and with the higher N rate (Table 4). Grain moisture was not significantly (95% level) affected by the source of N; however, the method-time x source interaction was highly significant. This is illustrated by the higher moisture level with AA compared to the UAN and urea treatments at the EM stage as contrasted to the lower moistures with AA and higher moisture with UAN and urea at the SD stage. No difference among sources was noticed at the PP stage. Reasons for this interaction are similar to those for grain yield which were discussed previously. In short, higher N efficiency and greater grain yields were closely associated with lower grain moisture at harvest.

Protein. Protein percentage of all treatments was generally low but was increased significantly over the check by all of the N treatments (Table 3). Factorial analysis indicated highest protein levels with the PP application and lowest with the SD application when averaged over N source and rate (Table 4). The UAN source resulted in lower protein levels than the urea or AA sources. Grain protein was increased significantly from 7.08% with the 75-lb rate to 7.74% with the 150-lb rate. However, the highly significant method-time x rate interaction indicated that protein was increased from 7.11% with the 75-lb rate to 7.98% with the 150-lb rate at the PP stage, from 7.03 to 7.77% with the same rates at the EM stage, and from 7.09 to only 7.47% with the SD application stage. This lower response to N rate at the later SD stage again indicates a lower N efficiency with delayed N application under dry conditions.

N removal. Grain N removal is the product of grain yield times grain N percentage and thus parallels the yield and protein responses very closely. All N treatments significantly improved N removal (uptake) over the check (Table 3). Averaged over N source and rate, N removal was significantly higher with the PP application time while no difference was observed at the EM and SD stages (Table 4). The highly significant method-time x rate interaction was similar to the yield and protein response in that N removal was increased most by the 150-lb rate at the PP stage, intermediate at the EM stage and least at the SD stage.

Nitrogen efficiency. The N efficiency, as calculated from grain N removal minus that of the check and then divided by the N application rate, showed the lowest values for 150-lb rate applied as ammonia at EM and as UAN and urea at SD (Table 3). The highest values were with ammonia and urea applied at the 75-lb rate at SD.

Weather conditions were not conducive to volatilization of the surface-applied UAN and urea following the EM application as shown in Table 5. Immediately after application, 0.59" of precipitation occurred and conditions throughout the following 10-day period were wet and cool.

Table 5. Air temperature and precipitation in the 10-day period following the emergence stage application of N in 1982.

Day	Air Temperature Max	Air Temperature Min	Precipitation
	^oF		inches
1 (N applied)	58	47	.59
2	57	45	.03
3	66	49	—
4	65	50	—
5	64	54	.10
6	60	55	.05
7	67	52	T
8	76	54	—
9	76	55	.01
10	77	54	1.05

SUMMARY

Application of N at PP regardless of N source resulted in the highest yields, protein level, and N removal, tallest plants at the 16-leaf stage, and the lowest grain moisture. Anhydrous ammonia applied at EM resulted in lower stands and yields, shorter plants and higher grain moisture. Volatilization of NH_3 from either the UAN or urea broadcast-applied to the 19% residue covered surface apparently did not occur because of significant rainfall immediately after application. Under the extremely dry conditions from June thru mid-August, the SD applications of urea and UAN at the 8-leaf stage did not improve yields as well as AA applied at this stage or any of the PP applications. Positional unavailability of the UAN and urea was thought to be the primary factor.

ACKNOWLEDGMENT

Sincere appreciation is given to Pioneer Hi-Bred International, Inc. for their financial assistance in this project.

SOIL TEST COMPARISON STUDY

Waseca, 1982

G. W. Randall and P. L. Kelly

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 and soybean 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.

In 1979, 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^{o}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 <u>initially</u> "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 and 1981 crops, 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 in the soil 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. For the 1982 crop the fertilizer was applied in early November, 1981 and plowed down.

The fertilizer recommendations were based on a yield goal of 60 bu/A of soybeans. Soybeans (Corsoy-79) were planted at the rate of 5 beans/foot in 15" rows on May 20. Chemical weed control consisted of 3½ qt Lasso and 5½ qt Amiben/A applied preemergence to all plots.

On July 27 (R1 stage) leaf samples were taken from each plot by sampling fifteen random, most recently mature trifoliate leaves. Seed yield was determined on soybeans harvested from the center eight rows of each plot with a modified JD 3300 plot combine. Seed yields were converted to 13.5% moisture.

In August, 1982, 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 1983 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. Phosphorus and potassium recommendations among the labs were substantially different. Nitrogen was recommended by two of the four private labs. Also recommended were various nutrients including sulfur, iron, manganese, zinc and boron.

Table 1. Soil test results and the recommended fertilizer programs on the very high testing site at Waseca in 1982.

Test	Lab A	Lab B	Soil Test Results[1/] Lab C	Lab D	Lab E (UM)
pH	6.1	6.2	6.5	5.2	5.5
pH (buffer)	6.7	6.7	---	6.7	6.1
Phosphorus	20 H	42 L	30	31 VH	24 VH
Potassium	151 M	156 D	125	136 M	112 MH
Organic matter (%)	3.9 H	4.1 A	M	2.4	H
Calcium	2130 M	3189 A	---	2770 M	---
Magnesium	390 VH	490 A	2+ A	339 M	---
Sulfur	7 L	12 L	18.3 A	15 H	2 LM
Iron	63 VH	98 E	8+ A	5.6 VH	---
Manganese	32 VH	18 E	2+ A	2.1 VH	---
Zinc	1.5 M	2.2 E	2+ A	1.5 M	.8 M
Copper	1.2 M	1.1 A	0.4+ A	---	---
Boron	1.3 H	.7 L	.88 S	---	---
ENR (lb/A)	108	---	---	45	---
C.E.C.(meq/100g)	16.6	24.5	---	21.3	---

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	12	20	0	0	0
Phosphorus (P_2O_5)	65	30	20	50	0
Potassium (K_2O)	105	205[3/]	60	130	60
Sulfur	15	18	---	---	---
Iron	---	---	---	.17[4/]	---
Manganese	---	---	---	.5[4/]	---
Zinc	3	---	---	.33[4/]	---
Copper	---	---	---	---	---
Boron	---	1	---	---	---
Lime (T/A)	2.7	1.5	---	3.8	4.5

2/ All values indicate pounds of nutrient recommended per acre for a yield goal of 60 bushels of soybeans per acre.

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

4/ As 6.7 qt/A of a material weighing 10 lb/gal and containing 2% Zn, 1% Fe and 3% Mn.

Seed yields were significantly affected by the fertilizer treatments (Table 2). All fertilizer recommendations resulted in higher yields than the unfertilized check. The only significant yield difference (P=.05 level) among the labs was that between lab D which had higher yields than those associated with lab A. No reason for this is apparent.

Leaf P, K, Ca and Fe concentrations among the five laboratories were not significantly different (P=.05 level) (Table 3). The low Mg concentration of lab B may have been due to the high application rate of K. Although lab D recommended Fe and Mn, the leaf analyses did not reveal any differences among the five labs. Slight but significant differences in leaf Zn were found among the five laboratories. Copper remained highest on the check treatment. The boron recommendation of lab B did not result in significantly increased leaf B. All leaf nutrient concentrations were adequate for optimum soybean yields.

Table 2. Effect of fertilizer recommendations on corn final population, grain yield and moisture on the very high testing site in 1982.

Lab	Fertilizer Recommendations	Grain Yield
	lb/A[1/]	bu/A
A	12N + 65P + 105K + S + Zn	54.9
B	20N + 30P + 205K + S + B	56.0
C	20P + 60K	56.6
D	50P + 130K + Fe + Mn + Zn	57.5
E(UM)	60K	55.9
Check		52.9
	Significance Level (%):[2/]	99
	BLSD (.05) :	1.7
	CV (%) :	2.6

1/ P and K expressed on oxide basis.

2/ Probability level of significance.

Table 3. Effect of fertilizer recommendations on soybean leaf nutrient concentrations on the very high testing site in 1982.

Lab	P	K	Ca	Mg	Nutrient Fe	Mn	Zn	Cu	B
	%				ppm				
A	.42	2.33	1.15	.41	141	62	46	9.4	50.3
B	.42	2.33	1.16	.39	129	62	45	8.9	51.2
C	.45	2.28	1.09	.42	122	59	46	8.8	47.5
D	.45	2.31	1.13	.42	124	64	48	8.6	48.0
E(UM)	.45	2.33	1.11	.42	124	60	44	9.0	48.0
Check	.42	2.36	1.06	.40	128	55	40	10.1	51.8
Signif(%):	66	41	35	99	71	98	99	99	93
BLSD(.05):				.01		6	2	.4	
CV(%) :	7.8	3.5	10	2.8	11.8	7.2	4.5	4.0	6.0

Medium-high testing site

The soil test results and the accompanying recommended fertilizer program of each laboratory are shown on Table 4 for the medium-high testing site. Phosphorus and potassium recommendations among the labs were substantially different. Nitrogen was recommended by two of the four private labs. Sulfur and the micronutrients Fe, Mn and Zn were recommended by three of the four private labs.

At this medium-high testing site the treatments that received fertilizer yielded significantly more than the check (Table 5). However, there were no significant yield differences among the fertilizer treatments (recommendations).

Table 4. Soil test results and the recommended fertilizer programs on the medium-high testing site at Waseca in 1982.

Test	Lab A	Lab B	Soil Test Results[1/] Lab C	Lab D	Lab E (UM)
pH	7.0	7.0	6.8	6.5	6.7
pH (buffer)	---	---	---	7.3	---
Phosphorus	10 L	43 L	20	26 MH	18 H
Potassium	158 M	189 L	130	162 MH	110 MH
Organic matter (%)	4.6 H	4.6 A	M	2.8	H
Calcium	3920 H	5386 E	---	5915 H	---
Magnesium	533 VH	699 A	---	1050 H	---
Sulfur	5 L	10 LD	37.5 A	18 H	.3 LM
Iron	37 VH	62 E	8+ A	5.6 VH	---
Manganese	24 H	17 E	2+ A	2.1 VH	---
Zinc	1.9 M	2.4 E	1.4 A	2.2 H	.8 M
Copper	1.3 H	1.3 A	.4+ A	---	---
Boron	1.6 H	1.1 AE	1.6 S	0	---
ENR (lb/A)	122	---	---	55	---
C.E.C.(meq/100g)	24.4	33.3	---	38.7	---

[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	10	15	0	0	0
Phosphorus (P_2O_5)	90	30	30	50	30
Potassium (K_2O)	115	177[3/]	48	80	60
Sulfur	16	21	---	---	---
Iron	---	---	---	.17[4/]	---
Manganese	---	---	---	.5[4/]	---
Zinc	2	---	---	.33[4/]	---
Copper	---	---	---	---	---
Boron	---	---	---	---	---
Lime (T/A)	---	---	---	---	---

[2/] All values indicate pounds of nutrient recommended per acre for a yield goal of 60 bushels of soybeans per acre.

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

[4/] As 6.7 qt/A of a material weighing 10 lb/gal and containing 2% Zn, 1% Fe and 3% Mn.

Table 5. Effect of fertilizer recommendations on soybean grain yield on the medium-high testing site in 1982.

Lab	Fertilizer Recommendations	Grain Yield
	lb/A[1/]	bu/A
A	10N + 90P + 115K + S + Zn	53.3
B	15N + 30P + 177K + S	53.0
C	30P + 48K	53.4
D	50P + 80K + Fe + Mn + Zn	53.4
E(UM)	30P + 60K	53.1
Check		47.7
	Significance Level (%):	99
	BLSD (.05) :	2.6
	CV (%) :	4.3

[1/] P and K expressed on oxide basis.

Leaf K, Mg and Cu were affected significantly by the fertilizer recommendations (Table 6). As fertilizer K rates increased, leaf K increased and leaf Mg decreased. All K recommendations resulted in higher leaf K levels than the check. Leaf Cu was reduced by the fertilizer applications. Leaf P, Ca, Fe, Mn, Zn and B were not affected significantly by the fertilizer treatments; even when Fe, Mn and Zn were recommended by lab D. All leaf nutrient concentrations were adequate for optimum yields.

Table 6. Effect of fertilizer recommendations on soybean leaf nutrient concentrations on the medium-high testing site in 1982.

	Nutrient								
Lab	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%				ppm				
A	.43	2.10	1.15	.46	115	57	44	8.9	50.7
B	.42	2.20	1.17	.45	115	59	42	8.6	49.0
C	.45	1.97	1.10	.48	115	56	42	8.9	48.5
D	.45	2.06	1.12	.47	120	56	43	8.7	48.2
E(UM)	.45	2.01	1.11	.49	115	56	43	8.9	48.8
Check	.40	1.76	1.16	.54	115	56	44	10.7	52.3
Signif(%):	91	99	31	99	19	21	15	99	90
BLSD(.05):		.10		.02				.5	
CV(%) :	8.3	4.6	7.9	4.1	6.1	7.7	7.6	4.9	5.5

SUMMARY - 1982

There were substantial differences among the laboratories' fertilizer recommendations for soybeans at both sites. Two of the five laboratories recommended N. Differences of over three-fold were shown among the labs for P and K. Three of the private laboratories recommended micronutrients while two recommended S. With the exception of K at the medium-high testing site, the fertilizer rates recommended and applied did not influence the leaf nutrient concentrations. Soybean yields were not influenced significantly by the large differences in fertilizer amounts applied but did respond over the check treatments where no fertilizer was applied for three years. This could have been due to a more favorable fertility-soil environment following the high corn yields and larger amounts of corn residue plowed down on the treatments which received fertilizer in the past. Also, carry-over of N from the previous N applications may have increased the soybean yields compared to the check treatment where no N had been applied.

Economic returns from the fertilizer recommendations for soybeans in 1982 are given in Table 7. On the very high testing site fertilizer costs ranged from $7 with lab E to $40/A with labs B and D. Positive economic return to the fertilization programs was only obtained with two of the labs (C and E). On the medium-high site fertilizer costs ranged from $13/A (lab C) to $42/A (lab A). Positive economic return to the laboratories' fertilizer recommendations was only obtained with two labs (C and E). Net return ranged from $19 to -$10/A.

Table 7. 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 1982.

	Very High Testing Site				Medium-High Testing Site			
Lab	Yield	Value @5.50/bu	Fert. cost[1/]	Return[2/]	Yield	Value @5.50/bu	Fert. cost[1/]	Return[2/]
	bu/A	$/A			bu/A	$/A		
A	54.9	302	35	-24	53.4	294	42	-10
B	56.0	308	40	-23	53.0	292	36	- 6
C	56.6	311	12	8	53.4	294	13	19
D	57.5	316	40	-15	53.4	294	34	- 2
E(UM)	55.9	307	7	9	53.1	292	15	15
Check	52.9	291	--	--	47.7	262	--	--

1/ Using May, 1982 prices for each nutrient expressed as dollars/lb as follows: N, .15; P_2O_5, .25; K_2O, .12; S, .24; B, .75; Zn, .47.

2/ Return yield value @5.50/bu - fertilizer cost - value of check trt.

Conclusions from the 1982 study can be summarized as follows:

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

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

THREE-YEAR SUMMARY

Economic returns from the very high testing site showed little benefit to fertilization (Table 8). Net return from 1980-82 period ranged from $15/A with lab E which had the lowest fertilizer cost to -$72/A with lab A. Recommendations from lab D showed the highest fertilizer cost. Part of the negative return on this site was due to fertilizer recommendations made for a yield goal of 180 bu/A in 1980 while the yields obtained barely exceeded 100 bu/A due to drought conditions.

On the medium-high site yield responses paid for the fertilizer recommendations by all five laboratories (Table 8). However, net return ranged from $0/A with lab B, whose recommendations resulted in the highest fertilizer cost, to $108/A with lab E which recommended the least amount of fertilizer.

Table 8. Effect of fertilizer recommendations on total yield, total fertilizer cost and the resulting economics on both the very high and medium-high testing site at Waseca from 1980-1982.

	Very High Testing Site 3-Year Total			Medium-High Testing Site 3-Year Total		
Lab	Crop Value[1/]	Fert. Cost.	Return[2/]	Crop Value[1/]	Fert. Cost	Return[2/]
	$/A			$/A		
A	1009	166	-72	1136	195	46
B	1028	175	-62	1108	213	0
C	1044	133	- 4	1124	148	81
D	1054	188	-49	1115	197	23
E(UM)	1029	99	15	1132	127	108
Check	915	0	--	897	0	---

1/ 3.00 & 2.40/bu used for corn in 1980 & 1981, respectively, and 5.50/bu for soybeans in 1982 for three-year total crop value.

2/ Return over 3-year period = crop value - fertilizer cost - value of check treatment.

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

Waseca, 1982

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 eight replications on a Nicollet clay loam soil (Aquic Hapludoll). Soil test of this site averaged: pH = 5.9, Bray 1 extractable P = 38 lb/A and exchangeable K = 225 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 April 27.

Corn (Pioneer 3901) was planted on May 10 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. Counter at a rate of 1 lb/A (active) was band-applied to control rootworms. Lasso (3½ qts/A) and Bladex (3 lb/A) were applied preemergence to control weeds.

Ten randomly selected plants from the outside 2 rows of these 4-row plots were sampled on June 21 for early plant growth measurements and for nutrient analysis. Plant heights were measured on July 7 (prior to tasseling) and on August 3 (shortly after tasseling). Leaf samples opposite and below the ear were taken at silking 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

Climatic conditions in the 3-week period after planting were much wetter and warmer than usual. June, however, was cool and dry. These conditions resulted in rather quick germination and emergence but slow growth during June. Early plant growth measurements taken six weeks after planting showed significant differences in plant weight (Table 1). All starter treatments showed larger plants than when no starter was applied. Slightly larger plants were found with the high rate of dry fertilizer than with the liquid materials. No difference in early plant growth was found between the two liquid materials or between the liquid products and the dry product applied at the same rate. These data indicate a primary effect related to rate of application and no effect related to placement (banded with the seed compared to 2 x 2).

Small plant P concentration was higher with the dry materials than with the liquids (Table 1). No difference in small plant P was seen between the two liquid materials. The higher plant P concentration associated with no starter treatment was probably due to less dilution because of the smaller plants. Small plant K was increased significantly over the no starter treatment by the 9-18-9 and 8-20-8 treatments. Small plant Mn was increased while Cu and B concentrations were decreased by the two dry materials.

Table 1. Influence of starter fertilizer on the nutrient concentration in the small whole corn plants at Waseca in 1982.

Treatment Material	Rate	Small plant weight	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		g DM/plt.	-----	-----%	-----	-----	-----	-----	ppm-----	-----	-----
No Starter		2.1	.43	4.99	.45	.28	227	74	44	7.6	6.2
9-18-9 (liq)	5 gal/A	3.0	.38	5.20	.46	.27	227	72	43	6.9	5.8
7-21-7 (liq)	5 gal/A	3.0	.39	5.03	.47	.26	240	80	44	6.8	5.9
5-12-5 (dry)	95 lb/A	3.2	.44	5.12	.46	.27	233	85	42	6.3	5.6
8-20-8 (dry)	140 lb/A	3.6	.46	5.14	.46	.27	220	88	40	6.2	5.6
P Level (%):[1/]		99	99	98	38	88	39	99	94	99	98
BLSD(.05) :		.6	.02	.14				9		.5	.4
CV(%) :		19.	4.0	2.5	4.1	3.8	11.	11.	6.7	7.1	6.5

[1/] Probability levels of significant difference among treatment means.

Nutrient uptake, the product of nutrient concentration times small plant weight (dry matter), was increased by the starter treatments over the no starter treatment primarily because of the larger plants associated with the starter treatments (Table 2). Highest nutrient uptake levels were associated with the 140-lb 8-20-8 treatment but these levels were not always statistically higher than the liquid and dry materials applied at lower rates. Uptake of P was significantly higher with the 5-12-5 dry material than with the 9-18-9. No significant difference in nutrient uptake was found between the two liquid materials.

Table 2. Influence of starter fertilizer on the nutrient uptake in the small whole corn plants at Waseca in 1982.

Treatment Material	Rate	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		-----	-----	-----	-----	mg/plant	-----	-----	-----	-----
No Starter		9.0	105	9.5	5.8	.47	.16	.09	.016	.013
9-18-9 (liq)	5 gal/A	11.6	158	13.9	8.1	.68	.22	.13	.021	.017
7-21-7 (liq)	5 gal/A	11.9	152	14.2	8.0	.72	.24	.13	.021	.018
5-12-5 (dry)	95 lb/A	14.0	163	14.8	8.6	.74	.27	.13	.020	.018
8-20-8 (dry)	140 lb/A	16.4	183	16.3	9.7	.77	.31	.15	.022	.020
P Level (%):		99	99	99	99	99	99	99	94	99
BLSD(.05) :		2.3	27	2.8	1.6	.11	.06	.03		.004
CV(%) :		19.	18.	20.	20.	17.	25.	23.	21.	20.

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

Table 3. Influence of starter fertilizer on the nutrient concentrations in the corn ear leaf at Waseca in 1982.

Treatment Material	Rate	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		-----	-----	%	-----	-----	-----	-----	ppm	-----	-----
No Starter		2.5	.28	2.18	.41	.25	150	56	28	3.6	6.4
9-18-9 (liq)	5 gal/A	2.5	.28	2.10	.43	.26	146	60	28	3.6	6.8
7-21-7 (liq)	5 gal/A	2.7	.28	2.17	.42	.26	144	57	28	3.6	6.3
5-12-5 (dry)	95 lb/A	2.5	.26	2.10	.42	.26	146	61	27	3.5	6.8
8-20-8 (dry)	140 lb/A	2.6	.29	2.11	.42	.27	145	60	28	3.6	6.4
P Level (%):		88	80	30	23	22	17	22	25	0.2	92
CV (%) :		5.4	7.5	6.2	6.9	7.4	6.3	13.	6.2	10.	5.6

Plant height at approximately the 13 to 14-leaf stage was significantly improved by the starter fertilizers and reflected the differences shown in early plant growth in mid-June (Table 4). However, differences in height did not exist among the treatments once tasseling occurred.

Reductions in final plant population have been reported when applying liquid fertilizers with the seed. The data shown in Table 4 indicate no deleterious effect of any of the starter treatments on plant population. No reason can be given for the higher population with 7-21-7.

Although a trend exists toward higher grain yields with some of the starter fertilizer treatments, grain yields were not increased significantly by the starters (Table 4). In addition, an economical return to the starter fertilizer per se would not have been realized with some of the treatments and return would have been marginal with the others. Grain moisture at harvest was reduced by the dry starter fertilizer treatments.

Table 4. Influence of starter fertilizer on plant height, final population, grain yield and grain moisture at Waseca in 1982.

Treatment		Plant Height		Final	Grain	
Material	Rate	7/7	8/3	population	Yield	Moisture
		-----cm-----		x 10^{-3}	bu/A	%
No Starter		131	249	28.0	154.6	24.0
9-18-9 (liq)	5 gal/A	141	248	28.8	155.5	24.2
7-21-7 (liq)	5 gal/A	144	250	29.6	158.6	23.6
5-12-5 (dry)	95 lb/A	148	249	28.5	160.1	23.0
8-20-8 (dry)	140 lb/A	147	250	28.5	160.2	23.2
P Level (%):		99	40	98	54	98
BLSD (.05) :		6		1.0		0.8
CV (%) :		4.1	1.0	3.1	4.2	2.8

SUMMARY

Under these soil test P (high) and K (medium-high) conditions early plant growth was enhanced by all starter fertilizer treatments. Differences were not seen among the liquid materials. Early growth appeared to be a function of application rate rather than fertilizer placement. These differences continued to be found up until tasseling when all treatments showed the same height. Nutrient concentrations in the small plants were only affected slightly. The greatest influence was on P with the dry materials. However, nutrient concentrations among the treatments at silking were not different. Grain yields were not improved significantly by the starter fertilizer treatments, whereas, grain moisture was reduced by the dry materials.

USE OF DWELL 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 (N-Serve-Dow Chemical, U.S.A. and Dwell-Olin Corporation) were evaluated under field conditions at the Southern Experiment Station at Waseca, MN in 1982. The objectives of the trial 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 relication, was arranged in a randomized complete block design and established at the Southern Experiment Station. Twelve treatments were applied on November 2, 1981 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 April 30 1982 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 21. 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 treatments: Urea was broadcast and the respective nitrification inhibitor treatments were 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 and Dwell were however, injected into the anhydrous ammonia at a position after the nitrolater and before the manifold utilizing a separate pumping system.

Spring treatments: Urea, anhydrous ammonia, and the nitrification inhibitors N-serve and Dwell were applied in a manner similar to the fall treatments.

Applications of 28% solution were sprayed onto the plots with a separate spray application for the nitrificiation 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 # ai/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; they were dried and Kjeldahl nitrogen was 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

Corn grain yields were excellent in 1982 in spite of the very dry conditions experienced in June and July. The relatively wet spring coupled with the very dry mid-season created conditions which lead to a number of interactions especially with N utilization characteristics which made the main effects more difficult to interpret.

N-Rate - In general grain yields were increased up through the 150 # N/A application. The significant N-rate x inhibitor interaction suggested that both inhibitors tended to give positive responses (5 bu/A) at the 150 # N/A rate while at the 75 # N/A rate, no influences in yields (Dwell) and a possible yield depression (N-Serve) were observed when compared to the no inhibitor treatment. Total N removal was increased by increasing the N rate, but anhydrous ammonia was better than urea, spring was better than fall, and the inhibitor tended to depress N uptake when applied in the spring.

N-form - Grain yields were significantly better with anhydrous ammonia than for urea (10 bu/A). Although 28% N solution was not applied in the fall, application of 28% in the spring resulted in yields intermediate between anhydrous ammonia and urea treatments at the 75 # N/A rate, and equal to urea at the 150 # N/A rate of application.

Nitrification inhibitor - in general nitrification inhibitors had relatively little influence on grain yield and total N removal. The significant N-rate by inhibitor interaction did, however, suggest a small positive yield advantage (5 bu/A) when used with 150 # N/A. Significant yield increase and N removal were obtained when N-Serve was applied as a spring application with 28% solution.

Time of N application - Grain yields were signficantly higher with spring N applications than for fall applications. This trend was also seen with total N removal, but a significant inhibitor x time interaction suggested reduced N uptake when the nitrification inhibitor was applied with spring N applications. There was no yield advantage or nitrogen uptake advantage associated with a sidedressed application of anhydrous ammonia at the 8-leaf growth stage.

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 - Waseca, MN - 1982.

Treatments						Dry Matter Production			N-Conc.		N-Removal		
N Rate	N Form	Time§	Inh.	Leaf N	Grain Yield	Grain	Stover	Total	Grain	Stover	Grain	Stover	Total
#/A				%	Bu/A	- - - - -T/A- - - -			- - - % - - -		- - - - -lbs/A- - - -		
Check	-	-	-	1.88	83.5	2.31	2.46	4.77	1.06	0.40	49.1	19.8	68.9
75	Urea	F	-	2.33	125.8	3.51	3.34	6.85	1.14	0.43	79.9	28.7	108.6
75	Urea	F	N-S	2.35	118.4	3.10	3.24	6.35	1.09	0.44	66.7	28.4	95.1
75	Urea	F	Dwell	2.42	123.8	3.54	3.54	7.09	1.12	0.46	79.3	32.3	111.6
75	AA	F	-	2.59	134.9	3.34	3.44	6.77	1.16	0.49	77.4	33.7	111.1
75	AA	F	N-S	2.46	125.8	3.57	3.53	7.11	1.16	0.49	82.6	34.9	117.5
75	AA	F	Dwell	2.47	126.8	3.48	3.45	6.93	1.12	0.39	78.4	27.1	105.5
150	Urea	F	-	2.61	141.2	4.02	3.78	7.81	1.23	0.49	98.8	37.1	136.0
150	Urea	F	N-S	2.74	147.2	3.90	3.72	7.62	1.28	0.48	100.0	35.5	135.5
150	Urea	F	Dwell	2.73	146.6	4.07	4.13	8.20	1.25	0.52	101.6	42.4	144.0
150	AA	F	-	2.93	152.2	4.25	4.01	8.26	1.33	0.55	112.9	43.9	156.8
150	AA	F	N-S	2.93	160.1	4.48	3.95	8.44	1.44	0.55	129.4	43.6	173.0
150	AA	F	Dwell	3.02	159.3	4.16	3.88	8.04	1.39	0.67	115.5	52.0	167.5
75	Urea	S	-	3.12	122.1	3.23	3.41	6.64	1.15	0.51	73.9	35.4	109.3
75	Urea	S	N-S	2.37	117.8	4.15	3.49	6.64	1.09	0.43	69.2	30.2	99.4
75	Urea	S	Dwell	2.22	123.4	3.17	3.18	6.35	1.12	0.44	71.1	28.1	99.3
75	AA	S	-	2.72	145.0	3.95	3.52	7.47	1.28	0.53	100.8	37.2	138.0
75	AA	S	N-S	2.48	125.9	3.62	3.54	7.17	1.14	0.43	82.7	30.0	112.7
75	AA	S	Dwell	2.53	138.5	3.77	3.60	7.37	1.21	0.50	90.9	35.4	126.3
75	28%	S	-	2.54	136.7	3.76	3.69	7.45	1.16	0.44	86.9	32.4	119.4
75	28%	S	N-S	2.58	142.0	3.79	3.51	7.30	1.21	0.55	91.3	38.2	129.4
75	28%	S	Dwell	2.67	140.6	3.90	3.69	7.60	1.19	0.47	93.2	34.8	128.0
150	Urea	S	-	2.87	153.8	4.41	3.90	8.32	1.34	0.62	118.1	48.2	166.4
150	Urea	S	N-S	2.82	152.9	4.17	3.66	7.83	1.32	0.58	110.3	42.5	152.8
150	Urea	S	Dwell	2.86	157.7	4.29	4.00	8.28	1.33	0.61	114.4	47.9	162.3
150	AA	S	-	3.01	158.7	4.51	4.22	8.74	1.42	0.69	128.3	57.7	186.0
150	AA	S	N-S	2.94	165.3	4.63	4.13	8.76	1.37	0.68	127.5	55.5	183.0
150	AA	S	Dwell	2.92	158.4	4.43	4.09	8.52	1.38	0.70	122.5	57.0	179.5
150	28%	S	-	2.89	152.1	4.52	4.20	8.71	1.27	0.67	114.8	57.1	171.9
150	28%	S	N-S	2.80	172.7	4.68	4.26	8.94	1.42	0.71	131.9	60.2	192.1
150	28%	S	Dwell	2.98	162.7	4.33	3.97	8.30	1.45	0.67	125.4	53.5	178.9
75	AA	8-L	-	2.90	146.1	4.10	3.33	7.43	1.26	0.67	103.6	44.6	148.3
75	AA	8-L	N-S	2.88	131.4	3.88	3.33	7.21	1.17	0.63	90.3	42.3	132.6
75	AA	8-L	Dwell	2.84	138.5	3.78	3.17	6.95	1.20	0.66	90.2	41.6	131.8
150	AA	8-L	-	3.19	155.4	4.24	3.22	7.47	1.37	0.79	116.6	51.0	167.6
Significance				**	**	**	**	**	**	**	**	**	**
BLSD (.05)				0.17	14.3	0.30	0.42	0.62	0.10	0.11	11.0	9.5	15.8

Table 1 continued on next 2 pages § F=Fall; S=Spring; 8-L=8-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- - - - -			- - -%- - - -		- - - - - -#/A- - - - -		
Factorial Arrangement (Nitrogen Rate X Nitrogen Form X Inhibitors X Time)										
N-Rate #/A										
75	2.42	127.3	3.45	3.44	6.89	1.15	0.46	79.4	31.8	111.2
150	2.86	154.5	4.28	3.95	8.23	1.34	0.59	114.9	46.9	161.9
Significnace				**	**					
N-Form										
Urea	2.54	135.9	3.71	3.62	7.33	1.20	0.50	90.3	36.4	126.7
Anhydrous Ammonia	2.75	145.9	4.02	3.78	7.80	1.28	0.56	104.1	42.3	146.4
Significance		*		*						
Inhibitor										
None	2.64	141.7	3.90	3.70	7.60	1.25	0.54	98.8	40.2	139.0
N-Serve	2.64	139.2	3.83	3.66	7.49	1.24	0.51	96.0	37.6	133.6
Dwell	2.65	141.8	3.86	3.73	7.60	1.24	0.53	96.7	40.3	137.0
Significance				NS	NS		NS		NS	
Time										
Fall	2.63	138.5	3.79	3.67	7.45	1.22	0.50	93.5	36.6	130.1
Spring	2.65	143.3	3.94	3.73	7.67	1.26	0.56	100.8	42.1	142.9
Significance		*		NS	*					
N-Rate X N-form	NS	NS	NS	NS	NS	NS	*	NS	*	*
N-Rate X Inhibitor	NS	*	NS	NS	NS	*	NS	*	NS	NS
N-Rate X Time	*	NS	*	NS	NS	NS	NS	+	NS	NS
N-form X Inhibitor	*	NS	*	NS	NS	NS	NS	+	NS	NS
N-Form X Time	NS	NS	*	NS	+	NS	NS	NS	NS	NS
Inhibitor X Time	NS	NS	NS	NS	NS	*	NS	*	NS	*
Rate X Form X Inh.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rate X Inh. X Time	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rate X Form X Time	**	NS	**	NS	NS	*	NS	**	NS	*
Form X Inh. X Time	NS	NS	NS	NS	NS	NS	NS	*	NS	NS
Rate X Form X Inh. X Time	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 1 continued on next page

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- - - - -			- - -%- - - -		- - - - -#/A- - - - -		
Factorial Arrangement (Anhydrous Ammonia 75#N/A X Time X Inhibitor)										
Inhibitor										
None	2.74	142.0	3.79	3.43	7.22	1.23	0.56	93.9	38.5	132.5
N-Serve	2.61	127.7	3.69	3.47	7.16	1.15	0.52	85.2	35.7	120.9
Dwell	2.61	134.6	3.67	3.41	7.08	1.17	0.52	86.5	34.7	121.2
Significance	NS	NS	NS	NS	NS	*	NS		NS	
Time										
Fall	2.50	129.1	3.46	3.47	6.94	1.14	0.46	79.4	31.9	111.4
Spring	2.58	136.4	3.78	3.55	7.33	1.21	0.48	91.5	34.2	125.7
8-leaf	2.87	138.7	3.92	3.28	7.20	1.21	0.65	94.7	42.8	137.6
Significance	**	NS	**	NS	NS	NS	**		**	
Inhibitor X Time										
Significance	NS	NS	NS	NS	NS	NS	NS	+	NS	+
Factorial Arrangement (Anhydrous Ammonia X N-Rate X Time)										
N-Rate #/A										
75	3.74	142.0	3.79	3.43	7.22	1.23	0.56	93.9	38.5	132.4
150	3.04	155.4	4.33	3.82	8.15	1.37	0.68	119.3	50.9	170.1
Significance	**	**				**	**		**	
Time										
Fall	2.76	143.5	3.79	3.72	7.52	1.24	0.52	95.1	38.8	134.0
Spring	2.87	151.9	4.23	3.87	8.10	1.35	0.61	114.4	47.4	162.0
8-leaf	3.05	150.8	4.17	3.28	7.45	1.32	0.73	110.0	47.8	158.0
Significance	**	NS				*	**		NS	
N-Rate #/A X Time										
Significance	NS	NS	*	*	*	NS	NS	+	NS	+

CONSERVATION TILLAGE STUDY

Waseca, 1982

G.W. Randall, J.B. Swan, and W.S. Cranshaw

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. In 1982, 12 gallons of 7-21-7 was used as the starter fertilizer material. 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 4 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 26,000 ppA on May 10. 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 not applied for the 1982 crop because of very high soil tests. Nitrogen (200 lb N/A as ammonium nitrate) was broadcast on May 4. Counter (1 lb/A) was applied to all plots at planting. One row in each plot was left without insecticide to allow for entomological measurements. Chemical weed control consisted of 3 1/2 lb Lasso and 3 lb Bladex/A applied preemergence. Treatments 2, 3, 4, and 5 were cultivated on July 1. 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 39 days after planting. Yields were taken by combine harvesting the center two rows from each plot.

On July 19 after the ridges had been built, soil samples were taken to a 12" depth from the no tillage, moldboard plow, chisel plow and till plant (ridge) plots which had starter fertilizer for the last eight years. The till-plant plots were sampled in two places: directly down thru the center of the ridge and midway between the ridges (center of the valley). Before compositing the 6 cores/plot they were separated into 0-2", 2-4", 4-6", 6-9" and 9-12" increments. After drying at 100° F they were submitted to the University of Minnesota Soil Testing Lab for pH, Bray 1 extractable P and exchangeable K analyses. After harvest two cores/plot from reps 1 and 2 were taken from the 0-5' depth, separated into 1-foot increments, composited, dried, and analyzed for NO_3-N. Conditions were too wet to allow sampling reps 3 and 4.

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 ($\geq$ 90% level) in early plant growth, grain moisture, protein, N removal in the grain, and grain yield were found among the tillage treatments (Table 1). Six weeks after planting the till plant (ridge) (TP-R) treatment had the largest plants and they were significantly larger than those from the chisel plow (CP), till plant (flat) (TP-F), and no tillage (NT) treatments. Early plant weight from the moldboard plow (MP), CP, TP-F and NT treatments averaged 90, 79, 69 and 54% of the weight from the TP-R treatment. Starter fertilizer averaged over tillage treatments did not affect early plant growth significantly probably because of the high variability and the trend reversal shown with the TP-F treatment. This reversal resulted in a tillage x starter fertilizer interaction which was significant at the 88% level, but at present is not explainable. The correlation between EPG and grain yield was barely significant with starter fertilizer (+.475*) and was not significant with no starter (+.438^{NS}). The best relationship for each was linear rather than curvilinear.

Grain moisture at harvest, an indication of maturity, was reduced below that of the NT system by all of the other tillage treatments with no difference among the four. Starter fertilizer did not affect grain moisture.

Grain protein was affected only slightly (90% level) with the MP and TP-R treatments showing slightly less protein. Starter fertilizer had no overall effect, but did not improve protein with the TP-R and TP-F treatments compared to the NT, MP and CP treatments. Hence, the significant (97% level) tillage x starter fertilizer interaction.

Nitrogen removal in the grain (product of grain N times grain yield) was significantly increased over the NT system by the MP, CP, TP-F and TP-R systems with no difference among them. Starter fertilizer had no effect on grain N removal.

Table 1. Influence of tillage methods and starter fertilizer on continuous corn production at Waseca in 1982.

Treatment		Early plant growth	Grain			
Tillage	Starter[1] fert.		Moist	Protein	N Removal	Yield
		g/plant	%	%	lb/A	bu/A
No tillage	S	1.82	23.1	8.25	87.1	139.4
No tillage	NS	1.50	23.1	8.31	88.3	140.1
Fall plow,f.cult.	S	2.95	22.3	8.09	107.2	174.8
Fall plow,f.cult.	NS	2.60	22.0	8.20	107.1	172.4
Fall chisel,d.,f.cult.	S	2.58	22.2	8.19	101.7	164.1
Fall chisel,d.,f.cult.	NS	2.32	21.8	8.42	104.3	163.5
Till plant (Ridge)	S	3.38	21.7	8.30	104.5	166.4
Till plant (Ridge)	NS	2.80	22.2	8.03	99.3	163.4
Till plant (Flat)	S	1.82	22.0	8.43	102.1	159.7
Till plant (Flat)	NS	2.42	21.6	8.23	103.5	165.9
Individual Factors						
Tillage						
No tillage		1.66	23.1	8.28	87.7	139.7
Fall plow		2.77	22.2	8.15	107.2	173.6
Fall chisel		2.45	22.0	8.30	103.0	163.8
Till plant (Ridge)		3.09	21.9	8.16	101.9	164.9
Till plant (Flat)		2.12	21.8	8.34	102.8	162.8
Signif. Level(%):[2]		99	93	90	99	99
BLSD (.05) :		.61			10.4	12.1
Starter fertilizer						
Starter		2.51	22.2	8.25	100.5	160.9
No starter		2.33	22.1	8.24	100.5	161.0
Signif. Level(%):[2]		79	45	20	2	10
Till x SF IA						
Signif. Level(%):[2]		88	50	97	80	79
CV (%) :		18.	2.7	1.9	3.3	2.5

[1] S = starter fertilizer used: NS = no starter fertilizer

[2] Probability level of significance.

Grain yields were highest with the MP treatment and slightly but not significantly less than the TP-R, CP and TP-F treatments. The yields from no tillage were approximately 25-30 bu/A less. Starter fertilizer had no influence on grain yield with any of the tillage systems. This was in contrast to previous years when a response to starter fertilizer had been obtained with the CP, TP-R and NT systems. Reasons for no starter response in 1982 were probably due to the warm conditions during May and the high soil test values.

Surface residue measured just after planting showed the highest amounts with the NT (4.67 T DM/A) and TP-F (3.09 T DM/A) systems (Table 2). Much less but equal amounts of residue were associated with the CP (1.06) and TP-R (1.01) treatments. Fall plow had somewhat less residue (0.44 T DM/A). These levels were somewhat more than in 1981 and were associated with the large 1981 crop. Percent surface residue measurements agreed quite closely to weight measurements.

Final population among the five treatments was slightly different (91% level) primarily because of the lower population with the TP-F treatment (Table 2).

Planting depth averaged significantly deeper with the MP and CP systems than the NT system which in turn was significantly deeper than either of the TP systems (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 NT system. Seed placement ranged between 1.7" and 3.0" with the MP system and between 0.4 and 2.2" 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, plant population, and seeding depth at Waseca in 1982.

Treatment	Surface Residue		Final popl'n.	Planting Depth		
				Average	S	Range
	T DM/A	%	$x10^{-3}$	mm		
No tillage	4.67	92	24.9	46	9.5	20-69
Fall plow	.44	12	25.5	59	5.9	43-75
Fall chisel	1.06	34	24.6	54	6.8	33-69
Till plant (Ridge)	1.01	20	23.5	34	7.2	10-55
Till plant (Flat)	3.09	63	21.7	32	6.6	15-46
Signif. Level (%):	99	99	91	99		
BLSD (.05) :	.84	10		8		
CV (%) :	29.	17.	7.6	13.		

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 12-day period prior to planting were essentially identical for the MP (49.1°F) and TP-R ridges (48.7°F) (Table 3). The valleys, however, averaged 3°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 1982.

Treatment-Position	Day 4/20	4/21	4/22	4/23	4/26	4/27	4/28	4/29	4/30	5/1	Avg.
	°F[1]										
Fall plow	40.1	40.9	44.7	48.3	51.5	52.9	50.3	50.6	53.0	59.0	49.1
T-P (Ridge) Top	42.4	40.4	44.7	47.4	53.1	51.4	49.1	49.5	52.2	57.0	48.7
T-P (Ridge) Valley	39.4	38.2	41.6	44.3	49.3	48.0	46.1	46.5	49.8	54.1	45.7

[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 9th to the 18th day following planting. Emergence, as a percent of final stand, shown in Table 4 indicates the most rapid germination and growth with the TP-R treatment and followed closely (1 day) by the MP, CP treatments and 2 days by the TP-F treatment. Slowest emergence occurred with the NT system.

Table 4. Influence of tillage methods on the emergence progress of continuous corn at Waseca in 1982.

Treatment	9	10	11	12	13	14	17	18
	Days Post Planting							
	% emerged							
No tillage	1	22	38	63	87	93	98	100
Fall plow	4	76	88	94	98	99	100	100
Fall chisel	4	69	82	89	97	98	99	100
T-P (Ridge)	50	87	90	90	96	99	99	100
T-P (Flat)	16	60	74	82	94	97	98	100

The small whole plants taken from early plant growth measurements (EPG) were chemically analyzed (Table 5). Nutrient analyses indicated significant effects (90% level) of the tillage treatments on small plant K, Ca, Mg, Fe, Cu and B. Plant K was significantly higher with the MP and CP systems compared to the TP-R and TP-F systems. Plant Ca and Mg were inversely related to plant K levels.

Table 5. Influence of tillage methods and starter fertilizer for continuous corn on small whole plant nutrient concentrations at Waseca in 1982.

Treatment: Tillage	Starter fert.	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		Nutrient								
		%				ppm				
No tillage	S	.48	4.46	.46	.26	147	51	31	9.0	5.2
No tillage	NS	.44	4.15	.46	.28	137	52	33	9.9	5.0
Fall plow	S	.44	5.14	.46	.26	179	66	34	8.7	5.5
Fall plow	NS	.43	4.83	.45	.26	186	70	39	9.6	5.5
Fall chisel	S	.48	4.83	.45	.26	169	61	29	9.9	5.2
Fall chisel	NS	.43	4.63	.44	.28	160	54	33	9.4	5.1
Till plant (Ridge)	S	.46	4.08	.48	.33	177	52	35	10.7	5.8
Till plant (Ridge)	NS	.45	3.73	.48	.39	197	52	42	10.8	5.2
Till plant (Flat)	S	.45	3.94	.52	.31	177	60	36	10.6	5.1
Till plant (Flat)	NS	.41	3.56	.52	.37	165	50	37	10.6	5.0
Individual Factors										
Tillage										
No tillage		.46	4.30	.46	.27	142	52	32	9.5	5.1
Fall plow		.44	4.98	.46	.26	183	68	36	9.2	5.5
Fall chisel		.46	4.73	.44	.27	165	57	31	9.7	5.2
Till plant (Ridge)		.46	3.90	.48	.36	187	52	39	10.8	5.5
Till plant (Flat)		.43	3.75	.52	.34	171	55	36	10.6	5.0
Signif. Level (%):		66	99	95	97	90	56	82	90	95
BLSD (.05)			.52	.06	.08					.4
Starter fertilizer										
S		.46	4.49	.47	.28	170	58	33	9.8	5.4
NS		.43	4.18	.47	.32	169	55	37	10.1	5.2
Signif. Level (%):		99	99	29	99	17	88	99	83	93
Till x SF IA										
Signif. Level (%):		71	14	6	90	91	93	72	81	46
CV (%) :		4.8	4.0	6.6	8.8	7.5	8.7	7.1	6.7	6.4

Plant Fe was higher with the MP and TP-R systems which indicated that some soil may have splashed onto the plants and contamination resulted. Plant Cu was lowest with the MP and highest with the TP systems. The addition of starter fertilizer increased small plant P, K, and B concentrations but decreased Mg and Zn concentrations. The tillage x starter fertilizer interactions for Mg, Fe and Mn were significant, but large consistent trends were not shown. All plant concentrations appeared to be sufficient for optimum yields.

Nutrient uptake by the small plants was calculated by multiplying the nutrient concentrations (Table 5) by the EPG found in Table 1. Nutrient uptake differences among the treatments are closely associated with the respective EPG values (Table 6). Uptake of all elements was significantly affected by the tillage treatments. Generally, uptake was greatest with the TP-R and MP systems, intermediate with the CP and TP-F systems and lowest with no tillage. Starter fertilizer resulted in significantly higher uptake of P, K, Mn and B.

Table 6. Influence of tillage methods and starter fertilizer for continuous corn on small whole plant nutrient uptake at Waseca in 1982.

Treatment		Nutrient								
Tillage	Starter fert.	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		mg/plant				mg/10 plants				
No tillage	S	9	82	8	5	2.7	.93	.56	.16	.09
No tillage	NS	7	63	7	4	2.1	.76	.50	.15	.08
Fall plow	S	13	153	14	8	5.4	1.96	1.03	.26	.16
Fall plow	NS	11	126	11	7	4.9	1.83	1.04	.25	.14
Fall chisel	S	12	125	11	7	4.4	1.54	.76	.25	.14
Fall chisel	NS	10	110	10	6	3.7	1.32	.76	.21	.12
Till plant (Ridge)	S	16	138	16	11	6.0	1.74	1.19	.36	.19
Till plant (Ridge)	NS	13	103	14	11	5.5	1.48	1.19	.30	.14
Till plant (Flat)	S	8	70	10	6	3.2	1.15	.64	.19	.09
Till plant (Flat)	NS	10	87	12	9	4.1	1.17	.90	.25	.12
Individual Factors										
Tillage										
No tillage		8	72	8	4	2.4	.85	.53	.16	.08
Fall plow		12	140	12	7	5.2	1.89	1.04	.25	.15
Fall chisel		11	117	11	7	4.0	1.43	.76	.23	.13
Till plant (Ridge)		14	121	15	11	5.8	1.61	1.19	.33	.17
Till plant (Flat)		9	78	11	8	3.6	1.16	.77	.22	.11
Signif. Level (%):		99	99	99	99	99	98	99	99	95
BLSD (.05) :		3	38	2	3	1.6	.62	.27	.04	.39
Starter fertilizer										
S		12	114	12	7	4.3	1.47	.84	.24	.14
NS		10	98	11	8	4.0	1.31	.88	.23	.12
Signif. Level (%):		97	97	77	49	70	98	60	66	93
Till x SF IA										
Signif. Level (%):		80	80	86	95	63	35	73	92	46
CV (%) :		18	20	19	19	20	14	17	16	6

Leaf samples were taken from the leaf opposite and below the ear at silking. With the exception of K, Ca, Mg, and Cu, nutrient concentrations were not affected significantly (90% level) by the tillage systems (Table 7). The MP system showed significantly higher leaf K concentrations and lower leaf Ca and Mg concentrations than the two TP systems. Leaf Cu was lowest with the MP system and highest with NT. Starter fertilizer showed slightly lower N, P, and Zn concentrations and slightly higher K concentrations. All nutrient concentrations in the leaf were considered adequate for optimum yields.

Soil pH, P and K levels in the top 12" of the profile were significantly affected by the eight years of continuous tillage (Table 8). The major effect on soil pH can be observed with no tillage where the 0-2" layer was acidified and ranged between 0.6 to 1.0 pH units lower than the other treatments. This was probably due to nitrification of the surface-applied ammonium nitrate over the 8-year period.

Table 7. Influence of tillage methods and starter fertilizer for continuous corn on the nutrient concentration in the earleaf at Waseca in 1982.

Treatment		Nutrient									
Tillage	Starter fert.	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%					ppm				
No tillage	S	2.89	.27	1.94	.48	.35	129	37	18	6.2	7.5
No tillage	NS	2.95	.29	1.75	.48	.37	131	36	22	6.2	8.2
Fall plow	S	2.84	.27	2.01	.47	.31	122	37	20	5.0	7.8
Fall plow	NS	2.86	.28	1.96	.47	.30	119	47	21	5.1	7.5
Fall chisel	S	2.81	.26	1.72	.53	.42	123	40	21	5.3	8.0
Fall chisel	NS	2.96	.28	1.72	.52	.40	125	40	21	5.0	7.5
Till plant (Ridge)	S	2.90	.28	1.72	.52	.45	129	39	22	5.8	7.9
Till plant (Ridge)	NS	2.92	.27	1.66	.51	.42	122	36	22	5.5	7.5
Till plant (Flat)	S	3.00	.26	1.66	.52	.43	125	40	23	5.6	7.6
Till plant (Flat)	NS	2.99	.28	1.65	.50	.42	121	41	23	5.9	7.8
Individual Factors											
Tillage											
No tillage		2.92	.28	1.84	.48	.36	130	37	20	6.2	7.9
Fall plow		2.85	.28	1.99	.47	.31	121	42	21	5.1	7.7
Fall chisel		2.88	.27	1.72	.52	.41	124	40	21	5.2	7.8
Till plant (Ridge)		2.91	.27	1.69	.52	.44	126	38	22	5.6	7.7
Till plant (Flat)		2.99	.27	1.65	.51	.42	123	41	23	5.7	7.7
Signif. Level (%):		82	14	99	93	99	28	6	43	96	01
BLSD (.05) :				.18		.06				.8	
Starter fertilizer											
S		2.89	.27	1.81	.50	.39	126	39	21	5.6	7.8
NS		2.94	.28	1.75	.50	.38	124	40	22	5.5	7.7
Signif. Level (%):		98	99	97	54	55	74	75	94	28	25
Till x SF IA											
Signif. Level (%):		86	79	77	21	35	57	92	49	60	8.4
CV (%) :		2.0	4.4	4.7	4.2	7.8	4.6	11.	9.0	6.3	6.4

Soil P and K levels were very high and were quite well distributed throughout the 0-9" profile with the MP system (Table 8). This was accomplished with an average plowing depth of 8-9 inches. Even though a 4" wide twisted chisel shovel (Glencoe Soil Saver) was used, the P and K were not distributed much below 4" with the CP system. Samples were taken after ridging; hence, we must remember that about 2-3" of the soil surface from between the rows was scraped off to build the ridges. Analyses of the area between the ridges (rows) showed accumulations of P and K in the remaining top 2" with levels declining rather sharply below that. Within the ridges extremely high levels of P and K were found in the top 2" with very high levels in the 2-4" layer. Below 4" the P and K values in the ridge were less than in the comparable depths with the MP system but about equal to NT. No tillage also showed substantial stratification of the nutrients with very high P and K levels in the 0-2" zone, similar P and K levels to the MP system in the 2-4" zone and declining of P and K below 4".

Because the soil NO_3-N data shown in Table 9 are from only two replications, we cannot place too much emphasis on the results. However, the data obtained do show a substantial amount of NO_3-N remaining in the 0-5' soil profile with the MP system compared to the other reduced tillage systems. Total NO_3-N remaining after harvest was quite high with all systems, however.

Weed counts (grass and broadleaf) were taken from five randomly placed 1 ft^2 sections/plot in July. Weed populations averaged over all replications show excellent control of all broadleaves with all tillage systems (Table 10). Grasses were also controlled extremely well with the MP, TP-R and CP systems. A slight grass problem was noted with the TP-F system. Grass control was totally inadequate in the NT system probably because of the thick surface residue accumulation which prevented the preemergence herbicides from fully contacting the soil.

Table 8. Soil pH, P, and K as influenced by eight years of continuous corn tillage at Waseca.

Profile depth	Tillage System: Plow	Chisel	Ridge-Plant[1] Between	Ridge-Plant[1] Within	No tillage
inches	SOIL pH				
0-2	6.6	6.4	6.6	6.2	5.6
2-4	6.8	6.9	7.1	6.6	6.6
4-6	6.8	7.1	7.1	6.8	6.8
6-9	6.9	7.2	7.1	7.0	6.9
9-12	7.2	7.3	7.2	7.0	7.0
	SOIL P (lb/A)				
0-2	62	72	66	136	92
2-4	58	42	37	84	59
4-6	55	22	25	39	39
6-9	41	10	14	24	30
9-12	14	5	8	15	10
	SOIL K (lb/A)				
0-2	465	580	480	590	585
2-4	430	385	315	430	460
4-6	440	285	250	310	335
6-9	340	245	230	235	305
9-12	240	235	215	215	265

[1] Between rows and within rows after ridging.

Table 9. Soil NO_3-N as influenced by eight years of continuous tillage for corn at Waseca.[1]

Depth	Tillage System: No till	Plow	Chisel	Till-Plant: Ridge	Till-Plant: Flat
ft.	ppm NO_3-N				
0-1	11.7	17.7	10.5	13.6	8.7
1-2	7.2	14.0	7.5	6.4	8.3
2-3	7.3	18.0	10.0	10.8	13.7
3-4	7.0	21.5	9.2	12.0	13.5
4-5	10.1	7.2	9.5	10.4	11.0
Total	43.3	78.4	46.7	53.2	55.2
lb NO_3-N/5' =	173	314	187	213	221

[1] From two replications only.

Table 10. Weed populations after cultivation as affected by eight years of continuous corn tillage at Waseca.

Treatment	Grasses	Broadleaves
	number per 5 ft^2 [1]	
No tillage	346	0
Fall plow	0	1
Fall chisel	4	2
Till plant (Ridge)	0	0
Till plant (Ridge)	11	0

[1] Average over 4 replications.

Entomological data were intensively obtained on the non-insecticide treated rows in each plot throughout 1982. Emergence traps were placed adjacent to these corn rows. A variety of small flies were the predominant insects captured in the survey. Most flies were either in the family Anthomyiidae (primarily seed corn maggot) or the suborder Nemocera (Table 11). Although there were some significant differences in capture of anthomyiids and nemocerans on both sampling dates, no great differences were present when total captures were combined. Total anthomyiid capture was greatest on the CP plots and most nemocerans emerged from the TP-R plots.

Table 11. Effect of tillage systems on the capture of Anthomyiidae and Nemocera in emergence traps at Waseca in 1982.

Tillage system	Anthomyiidae 6/3	Anthomyiidae 6/16	Anthomyiidae Total	Nemocera 6/3	Nemocera 6/16	Nemocera Total
	no. in 8 traps[1]					
No tillage	15 a	24 a	39	13 ab	5 a	18
Fall plow	6 a	37 ab	43	28 b	7 a	28
Fall chisel	10 a	53 b	63	13 ab	3 a	16
Till plant (Ridge)	8 a	36 ab	44	19 ab	16 b	35
Till plant (Flat)	10 a	25 a	35	6 a	4 a	10

[1] Two traps/replication. Numbers within each column followed by the same letter are not significant (95% level) by DMRT.

Leaf chewing injury, apparently due primarily to armyworm activity, was observed by mid-June. In addition, a "shothole" type of feeding of undetermined origin, was also noted. Armyworm leaf chewing was significantly higher on NT than on TP-R or MP tillage systems (Table 12). "Shothole" incidence was also higher on the NT and TP-F systems (higher surface residue accumulation also) than on the MP system.

Table 12. Effect of tillage systems on the number of plants showing leaf chewing and shothole injury at Waseca.

Tillage system	Leaf chewing injury	Leaf shothole injury
	no. plants/250' of row[1]	
No tillage	28 b	23 b
Fall plow	8 a	6 a
Fall chisel	17 ab	14 ab
Till plant (Ridge)	11 a	15 ab
Till plant (Flat)	21 ab	24 b

[1] June 16. Numbers within each column followed by the same letter are not significant (95% level) by DMRT.

Corn rootworm populations were sampled July 13 by pulling five plants from the center row of each plot and counting all larvae and pupae in the root zone. Signficantly higher numbers of rootworms were present in the CP than the MP system (Table 13). No tillage and TP-R systems had intermediate populations. Corn root injury was rated July 22 and no significant differences were observed among treatments.

Table 13. Corn rootworm activity and subsequent root damage rating as influenced by different tillage practices at Waseca.

Tillage system	Corn Rootworm Larvae	Corn Rootworm Pupae	Corn Rootworm Total	Root damage rating[1]
	no. found in 15 root systems			
No tillage	18	4	22 ab	2.45 a
Fall plow	8	3	11 a	2.38 a
Fall chisel	27	8	35 b	2.40 a
Till plant (Ridge)	13	5	18 ab	2.48 a

[1] 20 plants rated on Iowa 1-6 injury rating scale.

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 grown on a Webster clay loam. Beginning in 1979 all plots were split to evaluate the effect of starter fertilizer with these tillage treatments. The most rapid emergence and early plant growth were observed for the till plant (ridge) and moldboard plow systems. Small plant and leaf K concentrations were less with the till plant systems. Grain yields among the moldboard plow, chisel plow and till plant systems were not significantly different but were all significantly higher than with no tillage which was heavily infested with weeds. Starter fertilizer did not improve yields with any of the tillage systems. Eight years of continuous tillage showed a marked influence on soil pH with no tillage and the stratification of soil P and K with the reduced tillage systems. However, these long-term tillage systems had little effect on various entomological measurements.

EIGHT-YEAR YIELD SUMMARY

Grain yields have been obtained from the five tillage systems where starter fertilizer was used from 1975-1982 (Table 14). The 8-year average yield shows a 5.3 bu/A yield advantage for the moldboard plow over the till-plant (ridge) system. Some of this difference can 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.

Four-year data indicate some advantage for the use of starter fertilizer with the chisel plow (6 bu/A), till-plant (ridge) (5 bu/A) and no tillage systems (5 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 14. Influence of tillage methods and starter fertilizer on continuous corn yields at Waseca.

Treatment		Avg. Grain Yield	
Tillage	Starter fert.	1979-82	1975-82
		bu/A	
No tillage	S	140.6	129.2
No tillage	NS	136.0	
Fall plow	S	170.9	154.5
Fall plow	NS	170.8	
Fall chisel	S	161.8	144.4
Fall chisel	NS	155.5	
Till plant (Ridge)	S	161.5	149.2
Till plant (Ridge)	NS	156.4	
Till plant (Flat)	S	154.8	144.9
Till plant (Flat)	NS	157.4	

SOYBEAN ROW WIDTH IN A RIDGE-PLANT TILLAGE SYSTEM

Waseca, 1982

G. W. Randall

One of the tillage systems that is rapidly gaining popularity is the ridge-plant system (sometimes referred to as till planting). With this system no primary tillage is done. Ridges are built sometime the previous year and the crop is merely planted on the ridge. Since most Corn Belt farmers are growing corn in 30" rows prior to soybeans in the crop sequence, ridges are built in a 30" row-width. Most recent studies, however, have indicated soybean yield responses of 0-20% by using 15" and narrower rows compared to 30" rows. Thus, the objective of this study was to evaluate 30" soybean rows planted on ridges compared to 30" and 10" rows planted on previously ridged areas that had been tilled lightly before planting.

Experimental Procedures

An area of Webster clay loam which was planted to corn in 30" rows and ridged in June, 1981, was the site of this study. A split-plot design consisting of three row width-ridge treatments (30" row-on ridges, 30" row-with ridge disked, and 10" row-with ridge disked) and split into two varieties (Corsoy 79 and Hodgson 78) was used. A light 20" diameter blade tandem disk was used to disk the tops off of the ridges immediately prior to planting of the last two treatments. Each individual plot measured 60' long by 10' wide and was replicated six times. A Buffalo till planter was used to plant the 30"-ridge treatment, a John Deere 7000 Max-Emerge planted the 30"-disked ridge treatment, and an ALAMCO experimental planter was used for the 10" rows. Soybeans were planted on June 3 (because of the wet spring) at a rate of about 160,000 seeds/A. Starter fertilizer was not used because of high soil tests. Weeds were controlled chemically with Lasso + Amiben.

Emergence rates were taken from June 10 thru June 30 by counting plants in either two 30-inch rows or four 10-inch rows per plot. Surface residue accumulation was measured with the line-transect method. All yields were determined by combine harvesting the center rows of each plot.

Results

Emergence rate of the soybeans was greatly affected by the row width-ridge treatments but was not affected by soybean variety (Table 1). Planting in 30" rows directly into the ridges with the till-planter resulted in soybean emergence 7 days after planting with 95% of the beans emerged by 11 days after planting. Disking the tops off of the ridges and planting in 30" rows with the Max-Emerge planter delayed initial emergence by 1 day. Over 95% of the beans had emerged 14 days after planting with this treatment. Rate of emergence was slowest with the soybeans planted in 10" rows on the disked ridges. The first beans emerged 9 days after planting, but emergence continued to drag on for the next 2½ weeks. Over 95% of the plants did not emerge until about 23 days after planting. The reason for this delayed emergence can be attributed to (1) disking which tends to dry the surface soil especially when rainfall was limited in the 3-week period following planting and (2) this planter did not place the seed as deep in 10" rows as when planted in 30" rows. Consequently, emergence was delayed significantly by the combination of drier surface soil and shallower planting.

Table 1. Influence of row width-ridge treatment and soybean variety on soybean rate of emergence.

Treatment		Days after planting										
Row width-ridge	Variety	7	8	9	11	12	13	15	18	20	25	27
		% emerged										
30", ridge	Corsoy 79	23	68	87	95	96	96	99	100	100	100	100
"	Hodgson 78	11	61	81	95	96	97	99	100	100	100	100
30", flat	Corsoy 79	0	3	25	86	92	94	99	100	100	100	100
"	Hodgson 78	0	1	19	87	92	93	99	100	100	100	100
10", flat	Corsoy 79	0	0	2	48	68	75	87	88	91	98	100
"	Hodgson 78	0	0	4	52	65	72	86	88	92	98	100

Date of canopy closure estimated subjectively showed a large difference between row width but essentially no difference between ridge treatment or soybean varieties. The date of closure was July 13 with the 10" rows while the 30" rows did not close until August 4.

Surface residue measurements taken prior to disking of the ridges indicated that 80% of the soil surface was covered by residue from the previous corn crop. After planting surface residues with the ridges that had been disked lightly covered approximately 50% of the soil surface compared to 39% after planting with the till-planter (Table 2). As expected no difference in residues was observed between the varieties.

Soybean yields were also affected significantly by the treatments (Table 2). Even though emergence was delayed significantly, yields from the 10" rows averaged about 9 bu/A better than from the 30" rows. No significant difference occurred between the ridge-planted and flat-planted treatments in 30" rows. The Hodgson 78 variety yielded 2.8 bu/A better than the Corsoy 79 variety. There was no interaction between variety and row width-ridge treatment.

Table 2. Influence of row width-ridge treatment and soybean variety on surface residues and soybean yield.

Treatment: Row width-ridge	Treatment: Variety	Surface residue after planting	Seed yield
		%	bu/A
30", ridge	Corsoy 79	40	42.0
"	Hodgson 78	37	46.4
30", flat	Corsoy 79	46	41.6
"	Hodgson 78	53	44.6
10", flat	Corsoy 79	54	52.0
"	Hodgson 78	50	53.0
Individual Factors			
Row width-ridge			
30", ridge		39	44.2
30", flat		50	43.1
10", flat		52	52.6
Signif. Level(%):1/		99	99
BLSD(.05) :		4	1.9
Variety			
Corsoy 79		47	45.2
Hodgson 78		47	48.0
Signif. Level(%):1/		1	99
Row width-ridge x Variety interaction			
Signif. Level(%):1/		87	89
CV (%) :		15.	4.

1/ Probability of a significant difference among the treatment means.

SUMMARY

Data from this one-year study indicated that a light disking of ridges could be performed easily and satisfactorily to enable narrow row planting of soybeans in a ridge-plant corn-soybean sequence. This, of course, necessitates building the ridges for corn (if one desired to do so) after the soybean crop is harvested.

ACKNOWLEDGMENT

Sincere appreciation is given to Pioneer Hi-Bred International, Inc. for their financial assistance in this project.

EFFECT OF TIME OF RIDGING SOYBEANS ON SOYBEAN PRODUCTION IN A RIDGE-PLANT SYSTEM

Waseca, 1982

G. W. Randall

The ridges in a ridge-plant system are usually considered one of the keys in making the system work. This is especially important in wet, poorly-drained soils planted to corn, which is sensitive to cold soil temperatures. The ridge warms up and dries more quickly; thus allowing earlier planting.

Construction of the ridges in soybeans for corn the next year poses some potential problems. If the ridging is done during the growing season, are the soybeans damaged to the point of yield reduction? Is pod height lowered so as to increase harvest losses? On the other hand, if narrow-row soybeans are planted, is it possible to build the ridges post-harvest? What are the effects of this late ridging treatment on surface residue cover?

The purpose of this study was to evaluate three times of ridging soybeans for corn on soybean production.

Experimental Procedures

The experimental site (Webster clay loam) was planted to corn in 30" rows and ridged in 1981. Two varieties of soybeans (Corsoy 79 and Hodgson 78) were planted with a Buffalo till planter in 30" rows on June 3 at a rate of 160,000 seeds/A. No starter fertilizer was used. Weeds were controlled chemically with Lasso + Amiben. The ridging treatments were superimposed over varieties at three stages of soybean growth (early bloom (R1), mid-bloom (R2.5), and post harvest). A Buffalo rolling disk-hiller cultivator was used to build the ridges. This split-plot design with ridge treatments as the main plot was replicated six times.

Plant height at maturity and the height of the lowest pod above the soil surface were measured from 10 randomly selected plants/plot just prior to harvest. All yields were determined by harvesting each plot with a modified JD3300 plot combine.

Results and Discussion

The ridging operation at the R1 stage (July 22) presented some problems in that some plants were knocked over by the slabs of soil from the cultivation. Speed and depth of the cultivation had to be carefully watched. At the mid-bloom stage (R2.5) on August 6, the plants were bigger and did not appear to be quite as sensitive to speed. Ridge height at the end of the July and August treatments was estimated to be about 5" (amplitude). Conditions were quite dry during each of these operations.

Plant height at maturity from either the ridge top (July and August treatments) or flat soil surface (post-harvest) was not significantly affected by the treatments (Table 1). Corsoy 79 soybeans were significantly taller than the Hodgson 78 variety. A variety x time of ridging interaction for plant height was not found.

The height of the lowest pod above the soil surface was significantly affected by ridging (Table 1). The ridging operations during the summer reduced the pod height to about 4.5 cm from the soil surface compared to 8.1 cm with the post-harvest ridging. The lower pod heights on the ridges did present some harvest problems such as very slow speed and constant header adjustment. Although the pod height of the Group I variety (Hodgson 78) was expected to be lower than the Group II variety (Corsoy 79), difference between the two were not found.

Seed moisture at harvest was influenced by the variety but not by the time of ridging (Table 1).

Soybean yields were significantly reduced almost 2.5 bu/A by ridging at the R2.5 stage (August 6) compared to earlier ridging (R1 stage) on July 22 or no ridging (Table 1). This may have been due to the low pod height and possible harvest losses although the latter was not measured. Another factor could have been some possible root pruning or physical damage to the pods which were setting at this later date. Corsoy 79 significantly (94% level) out-yielded Hodgson 78. There was no interaction between time of ridging and soybean variety.

Table 1. Influence of time of ridging on soybean plant height, pod height, seed moisture, and seed yield.

Treatment: Ridging time[1/]	Treatment: Variety	Plant height at maturity	Height of lowest pod	Seed: Moisture	Seed: Yield
		inches	cm	%	bu/A
July 22	Corsoy 79	35	4.4	13.9	45.9
" "	Hodgson 78	26	4.1	13.2	44.5
August 6	Corsoy 79	34	4.9	13.8	43.8
" "	Hodgson 78	26	4.5	13.2	42.0
Post-harvest	Corsoy 79	36	8.3	13.8	45.6
" "	Hodgson 78	27	7.9	13.4	45.1
Individual Factors					
Ridging time					
July 22		30	4.2	13.6	45.2
August 6		30	4.7	13.6	42.9
Post-harvest		31	8.1	13.6	45.4
Signif. Level(%):[2/]		75	99	1	99
BLSD (.05) :			1.0		1.3
Variety					
Corsoy 79		35	5.8	13.8	45.1
Hodgson 78		26	5.5	13.3	43.8
Signif. Level(%):[2/]		99	66	99	94
Ridge time x Variety interaction					
Signif. Level(%):[2/]		9	3	62	36
CV (%) :		6.	19.	2.	4.

1/ Corresponds to R1 (July 22) and R2.5 (August 6) stages.

2/ Probability of a significant difference among treatment means.

SUMMARY

These one-year data indicate that ridging of soybeans for corn should either be done at the R1 stage or after harvest. The latter date would present less harvest problems.

ACKNOWLEDGMENT

Since appreciation is given to Pioneer Hi-Bred International, Inc. for their financial assistance in this project.

MAXIMUM YIELD DEMONSTRATION

University of Minnesota
Southern Experiment Station
Waseca, MN
1982

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 yields could be maximized in a demonstration approach with two replications.

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. Four main plot sites were used. Two plots (reps) followed soybeans and two were third year corn. Each main plot measured 20' x 65', the subplots (row width) 20' x 32', and the sub-subplots (hybrid) 10' x 32'. Because only two replications were used and because the treatments were fixed (not possible to randomize due to the previous crop history of the plots) no statistical analyses of the data were performed.

After rototilling the soil twice, the corn was planted by hand at a population of 40000 plants/A on April 23. Two hybrids (Agway 849X and Pioneer 3732) were planted at two row widths (15" and twin row, 23" and 7"). All plant measurements were taken on the center four 15" rows of each 8-row plot and the center two twin rows of each four-row plot. Trickle irrigation using Chapin Watermatic Drip Hose 12 mil, 12" outlet tubing was installed at 30" spacings. Flow meters measured application rates. Water was applied from July 6 thru August 26. Additional experimental procedures are outlined in Table 1.

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.

RESULTS

Growing conditions during 1982 were less than optimum for maximum corn production. The spring was not especially early; hence, a planting date of April 23. Throughout May temperatures were slightly above normal, but conditions were very wet (Table 1). Temperatures during June averaged 5°F below normal while August and September were also below normal. Growing degree days totaled 10% below normal for the 1982 growing season. In the 12-week period between May 30 and August 22, a total of only 4.43" of rain fell. This was the second driest June-July period in the 68-years of weather recording at the Southern Experiment Station.

To supplement the sparse rainfall during the summer, a total of about 17 acre-inches of water was applied to both cropping systems (Table 1). Applications were made weekly from early July to August 26 with little damage to the tubing due to birds. At no time did the corn show any drought symptoms.

Nutrient concentrations in the diagnostic tissues shown in Table 3 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, somewhat less K, and slightly more Ca and Zn than did Pioneer 3732. The K and Mg relationships were similar to 1981. 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. Differences in nutrient concentrations between the two row widths were not apparent.

Table 1. Experimental procedures used in "non-limiting" environment demonstration at Waseca in 1982.

Parameter	Crop System: Cont. Corn	Crop System: Corn after Soybeans
Tillage:	F. Chisel Spr. rototill (2x)	F. Chisel Spr. rototill (2x)
Fertilizer:	400 lb N/A -200 as urea (4/19) PPI -200 as urea (6/1) topdressed No P or K	350 lb N/A -200 as urea (4/19) PPI -150 as urea (6/1) topdressed No P or K
Hybrid-Variety:	Agway 849X Pioneer 3732	Agway 849X Pioneer 3732
Planting date:	4/23	4/23
Planting rate:	40000 ppA	40000 ppA
Row width:	15" and twin-row (23 & 7")	15" and twin-row (23 & 7")
Herbicide:	Lasso + Bladex	Lasso + Bladex
Insecticide:	Counter (3 lb/A)	Counter (3 lb/A)
Rainfall	May 6.45" June 1.78" July 1.46" August 4.61"	
Irrigation:	Jul 7.7" Aug 9.6"	7.8" 9.2"
Harvest date:	9/17 & 10/4	9/17 & 10/4
Harvest method:	Hand	Hand

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

Depth	Crop System: 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)

Table 3. Nutrient concentrations in the leaf[1] from the "non-limiting" environment demonstration at Waseca in 1982.

Crop system	Hybrid	Row width	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
			%					ppm				
CC	849X	15"	2.93	.35	2.38	.46	.14	118	37	30	4	9
"	"	TR	2.93	.37	2.34	.46	.15	120	35	23	4	8
"	3732	15"	2.86	.35	2.50	.38	.20	116	30	19	5	11
"	"	TR	2.74	.32	2.50	.36	.19	110	36	17	5	9
C-Sb	849X	15"	2.86	.40	2.38	.48	.12	121	30	23	4	8
"	"	TR	2.76	.40	2.48	.43	.14	126	32	22	4	8
"	3732	15"	2.80	.38	2.62	.39	.18	133	34	17	5	10
"	"	TR	2.97	.36	2.60	.39	.19	136	44	21	5	9

[1]Leaf opposite and below ear at silking.

Corn yields from this demonstration again fell below our goal of 250 bu/A (Table 4). Highest yield of 233.2 bu/A was obtained with the Agway 849X variety planted in 15" rows and following corn. No yields were less than 207 bu/A. Averaged over row width the yields with Pioneer 3732 were almost identical for the continuous corn and corn/soybean systems (218.0 vs 217.2). However, yields of Agway 849X were substantially higher following corn (225.2) compared to following soybeans (208.6). When yields were averaged over previous crop and row width, Pioneer 3732 (217.6 bu/A) and Agway 849X (216.9) were identical. Yields from the 15" rows averaged 9.3 bu/A better than the twin rows (221.0 vs. 211.7 bu/A).

Table 4. Corn production in a "non-limiting" environment at Waseca in 1982.

Crop system	Hybrid	Row width[1]	Grain Yield	Grain Protein	Final Population
			bu/A	%	x 10^{-3}
Cont. Corn	A 849X	15"	233.2	8.7	37.9
" "	"	TR	217.2	8.8	35.9
" "	P 3732	15"	223.0	8.4	37.2
" "	"	TR	213.0	8.3	35.5
Corn/Soybean	A 849X	15"	210.1	9.1	37.4
" "	"	TR	207.1	8.8	36.8
" "	P 3732	15"	217.8	8.5	35.7
" "	"	TR	216.6	8.7	37.9

[1] TR = twin-row (23 & 7")

Grain protein ranged from 8.3 to 9.1% (Table 4) and averaged consistently higher with the Agway hybrid. No differences in protein were found between the continuous corn and corn/soybean systems or between the 15" and twin rows.

Final plant population ranged from 35500 to 37900 plants per acre (Table 4) and should have been sufficient to maximize yields. Even with this high population the number of barren stalks and lodged corn was so small that counts were not taken.

Rows outside of the harvest areas were harvested to measure the border effects and to determine the yield potential of those plants which receive more light on the edges. Yields shown in Table 5 indicate approximately a 100 bu/A increase with the outside row (15" width) over the inside harvest areas (rows 3-6). This dropped to a 50 bu/A advantage with the second row compared to rows 3-6. Differences among rows 3, 4, 5 and 6 were not consistent (data not shown). The outside twin row averaged about 60 bu/A better than twin rows 2 and 3.

Table 5. Corn yield of outside (border) rows in 1982.

Row location	Hybrid Agway 849X	Hybrid Pioneer 3732
	bu/A	bu/A
15" - outside	335.4	303.6
15" - 2nd from outside	267.1	277.4
TR - outside pair	276.4	273.4

Total above ground plant material was weighed, separated into grain and fodder, dried and weighed to calculate dry matter production. The Agway hybrid produced more total dry matter than did the Pioneer hybrid, especially in the continuous corn system (Table 6). However, the Pioneer hybrid consistently showed a higher grain:stover ratio as indicated by harvest index values of .50 and .51 regardless of crop system or row spacing. Fodder N was consistently higher with the Agway hybrid but did not vary much between crop systems or row spacing. Fodder yield with both crop systems was consistently higher with the Agway hybrid planted in twin rows. Row spacing had no influence on the Pioneer hybrid. Total N uptake (grain + fodder) was highest for the Agway 849X hybrid over both cropping systems and was well below the 350 and 400 lb N/A application rates. Total N uptake as a percent of N application ranged from 49 to 68% 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 1982.

Crop system	Hybrid	Row width	Total Dry Matter	Harvest Index	Fodder N	Fodder Yield	Total N Uptake
			T/A		%	T DM/A	lb/A
CC	A 849X	15"	11.941	.46	.83	5.630	246
"	"	TR	11.952	.43	.82	5.985	242
"	P3732	15"	10.581	.50	.76	4.696	213
"	"	TR	9.962	.51	.70	4.314	195
C/Sb	A 849X	15"	10.967	.45	.87	5.318	237
"	"	TR	11.758	.42	.82	6.100	239
"	P3732	15"	10.288	.50	.74	4.540	207
"	"	TR	10.066	.51	.76	4.334	207

Soil samples were taken in one-foot increments to a depth of 5' from the corn plots following harvest. Nitrate-N analyses show substantial carryover of residual NO_3-N with both the continuous corn and corn-soybean sequence (Table 7). These values also indicate the N application rate of 350 lb/A following soybeans and 400 lb/A following corn was in excess of demand.

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	54	38
1-2	106	47
2-3	57	43
3-4	26	32
4-5	24	23
Total	267	183

DISCUSSION

Problems encountered in the conduct of the 1982 study were reduced from previous years. Even under some adverse conditions, irrigation did not pose any problems. Much of this was due to the use of the 12-mil Drip Hose which performed extremely well. Birds and squirrels were still a problem but corrective measures consisted of (1) feeding them water, sweet corn and 1981 corn twice weekly at a site in the trees approximately 50 yards away from the plots and (2) placing a netting over the plots following tasseling and running it under a 3' high wire fence which surrounded the plots.

Stalk and root lodging were almost non-existent in 1982 even though final populations were about 37000 per acre. This could have been due to less wind and a more precise irrigation program.

Weather conditions during 1982 provided a good test for the irrigation system. A 12-week period from Memorial Day to August 22 only showed 4.4" of rain. Yet with the irrigation no drought symptoms were noticed. Also we did not begin to irrigate until July which should have allowed the roots to penetrate deeply into the soil before supplemental water was applied. This could have been the major reason for the lack of root lodging.

Growing degree day accumulation in 1982 was 10% below normal and may have been a disadvantage to the Agway 849X hybrid. This late relative maturity corn (120-day) was beginning to black layer at harvest (October 4) and would have been susceptible to a fall frost (normal occurrence is September 29—30-year avg.) even though it was planted very early.

If a farmer is planning to use his corn for silage and is willing to risk either a cool growing season or early frost, the data from this study indicate that the Agway hybrid would be preferred because of higher total dry matter yields. Also the N content of both the grain and fodder was higher with Agway 849X than with Pioneer 3732.

The slight yield advantage for the continuous corn system is in contrast to most research and personal experiences. Perhaps the generous use of irrigation water in this rather limited test (two replications) may explain this result. Yields from the twin-row system were quite comparable to those in 15" rows. Considering that standard 30"-row equipment can be used to harvest the 23-7" twin rows, it would seem that this type of row spacing would merit further investigation and application in practice if yields can be increased over conventional 30" rows.

In summary, yields in this study were more than likely limited by the cool growing season, especially June and August, and by the unusually high number of cloudy days.

ACKNOWLEDGMENT

Sincere appreciation is extended to the Potash and Phosphate Institute for their financial assistance to this project.

RELATING SOIL SURVEY DATA TO CROP RESPONSE AND LAND MANAGEMENT

Nancy Gire and Terence H. Cooper

INTRODUCTION

The Accelerated Soil Survey Program in Minnesota is rapidly increasing the amount of basic information on our soil resources. The primary objective of the survey is to describe and map the soils so that predictions can be made about their behavior for various uses and responses to defined management. To date, however, few studies have been conducted in Minnesota that will assist farm managers and others in using the soil survey data in making land management decisions. It is necessary to provide information for the users so they can interpret and use the soil survey data to aid in management decisions.

OBJECTIVES

The objectives of this study are to identifiy both qualitatively three soil mapping units and to determine the relationships of crop response, management practices, and economic factors to those mapping units. The ultimate objective is to develop interactive and conventional soil information delivery systems for the growers so they can interpret and use soil survey data to aid in their management decisions.

METHODS

The study involves collecting crop response and soil characterization data over a period of two years on three soil mapping units occurring in the same field. The experimental sites are in Traverse County on six cooperators' fields.

Three plots corresponding to the three soil mapping units or the treatments were set up in each cooperator's field. For the 1982 growing season, three cooperators produced wheat and the others produced soybeans. Plot sizes for wheat were 600 ft^2 and 1200 ft^2 for soybeans. Eight replications were taken to determine differences. Data were analyzed to determine if differences in crop responses could be attributed to the differences between mapping units.

The three major soils of the catena under study are the Aazdahl series, a fine-loamy, mixed Aquic Haploborall; the Hamerly series, a fine-loamy, frigid Aeric Calciaquoll; and the Lindaas series, a fine, montmorillonitic, frigid Typic Argiaquoll. The Aazdahl series is a moderately well-drained soil on slightly convex slopes with gradients of 0 to 1 percent. The Hamerly series is a poorly or moderately well-drained soil on convex slopes with gradients of 1 percent. The Lindaas series is a poorly drained soil in shallow depressions, with slopes less than 1%.

GENERAL RESULTS

Results are shown in Tables 1 and 2. Significant differences in soybean yields and percent protein were found among the treatments.

The mean separation test (HSD) indicates that yields obtained on Lindaas were significantly different from Aazdahl and Hamerly. The soybean yields were greatest on Lindaas in two out of the three sites. This may be due to the topographic position Lindaas occupies on the landscape. Lindaas is in depressional areas where moisture is less likely to be deficient than positions up slope. Wheat harvested from Aazdahl produced grain with the highest percent protein; Hamerly, the second highest percentage; and Lindaas, the lowest percentage at all three sites. The poorer drainage conditions associated with Lindaas decreases the amount of available nitrogen when compared to soils in the better drained positions.

Table 3 contains some of the managment practices inventoried from the cooperators. No attempt is made at this time to evaluate the practices for the 1982 growing season.

Selected morphological and chemical data averaged over sampled pedons are shown in Table 4. It is proposed differences in crop responses may be related to the distribution of calcium carbonate, percent clay in the solum, and the drainage characteristics of the three soils. More information on these soils must be collected before statistical analysis can be performed.

FUTURE

In the 1983, crops response data will be collected from the same sites. The data collected in 1982 and various other crop responses to management and soil will be monitored. Soil transects will be conducted to gain a better understanding of each mapping unit. After this study, the determination of the relationships of crops response, management practices, and economic factors to those mapping units will be evaluated to provide information to growers to aid in their management decisions.

ACKNOWLEDGEMENTS

Sincere appreciation goes out to the Soil Survey crew in Traverse County for all their assistance in and out of the field.

Table 1. Wheat yields, test weights and percent protein on three soil series in Traverse County.

	Grain bu/A	Test Wt.	% Protein
		Site 1W	
Aazdahl	25.68	50.57	17.49
Hamerly	36.56	56.36	16.64
Lindaas	23.90	52.46	15.40
Significance	NS	NS	NS
P Values	.0683	>.1	.0685
		Site 2W	
Aazdahl	28.07	53.76	17.51
Hamerly	29.61	57.17	17.37
Lindaas	36.41	60.17	15.26
Significance	NS	NS	NS*
P values	.1928	.0800	.0007
		Site 3W	
Aazdahl	30.70	57.04	17.69
Hamerly	26.85	54.44	17.50
Lindaas	26.92	53.10	16.20
Significance	NS	NS	NS*
P values	.7100	.3591	.0358

Table 2. Soybeans on Three Soil Series in Traverse County.

	Yield bu/A
	Site 1S
Aazdahl	15.71
Hamerly	14.64
Lindaas	21.06
Significance	*
P Values	.1E-06
HSD	5.62
	Site 2S
Aazdahl	11.95
Hamerly	11.76
Lindaas	11.16
Significance	NS
P values	.8757
HSD	--
	Site 3S
Aazdahl	15.35
Hamerly	16.21
Lindaas	27.91
Significance	*
P Values	.5E-09
HSD	8.43

Table 3. Management Inventory Data

	Variety	Row Spacing	Seeding Rate	Fertilizer AMT	Planting Date
Site 1W	Era	6"	2 bu/A	200 lbs/A 30-25-10	2nd week April
Site 2W	Olaf	6"	2 bu/A	100 lbs/A 40-30-10	--
Site 3W	Era & Waldren	6"	2 bu/A	80 lbs/A 82-0-0	April 24
Site 1S	--	12"	--	--	--
Site 2S	Evans	12"	--	50 lbs/A 8-22-22	June 1
Site 3S	Jacques	30" rows	70 lbs	(no fert.)	May 8

Table 4. Selected Morphological and Chemical Data averaged over sampled pedons.

Horizon	Depth"	% Clay	% CCE	pH H_2O	pH $CaCl_2$	Depth and Color of Mottles
Aazdahl						
Ap	0-9	30.4	0.0	7.1	6.8	matrix color 2.5 Y 5/4
Bw	9-20	28.9	5.0	7.5	7.2	mottles at 26"
Ck	20-33	33.3	28.0	8.2	8.0	10 YR 5/8
C	42-60	27.8	20.0	8.0	7.9	
Hamerly						
Ap	0-9	31.5	10.0	7.9	7.6	matrix color 10 YR 5/4
Ck	9-22	31.0	32.0	8.0	7.8	Mottles at 27"
C	41-60	19.8	18.0	7.8	7.6	2.5 Y 6/4
Lindaas						
Ap	0-8	33.8	0.0	6.9	6.7	matrix color 5 YR 5/6
Bt1	8-22	45.2	0.0	6.7	6.5	mottles at 26"
Ck	32-42	29.5	16.0	7.7	7.5	5 YR 5/6
Cg	42-60	28.0	16.0	7.8	7.5	

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 by the public 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 more erodible 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, were 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 were made of the core increments:

chemical: organic carbon, available phosphorus, exchangeable potassium, available zinc, and pH

physical: particle size and available water-holding capacity

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 data have not been statistically analyzed yet.

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. 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".

Extractable phosphorus in parts per million for three horizons as plot averages and averages for depth increments 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 on the 1981 fields was mostly in the lower medium range as shown in Table 5. Heavy applications of zinc on the Walker field for 1982 caused an abnormally high average for the 1982 fields.

Available moisture capacities of the horizons in the erosion classes are listed in Table 6. They are quite uniform within years.

Soil acidities as pH are given in Table 7. The pH of the Ap horizons reflects the liming history of the fields. Limy till lies a little below 5 feet from the surface. Several 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. 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 to slope steepness as it affects soil formation.

Particle size data are in Table 9. The figures are the averages of the three fields for each depth increment 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 capacity 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.

Yield data only will be obtained from the 1983 fields. The Mt. Carroll soils seem to be quite uniform and predictable so soil data on more fields is probably not needed. Funds are not available to finance analyses, anyway.

Table 1. Corn stands and yields - 1981 3-field averages, 1982 fields.

Erosion Class	1981 3-field averages	1982 Dodge	1982 Heyn	1982 Ohm	1982 Walker	1982 4-field averages	1981-82 7-field averages
				plants per acre			
slight	20,700	23,700	24,100	25,200	21,800	23,700	22,350
moderate	22,050	23,700	23,100	24,500	22,800	23,525	22,893
severe	21,067	22,300	23,600	25,700	22,700	23,575	22,500
				bushels per acre			
slight	142	112	187	152	122	143	143
moderate	139	106	181	131	116	136	136
severe	138	110	166	162	132	142	141

Table 2. Horizon Lower Boundary - average depth (inches). 1982 plots, 1981-82 averages.

Erosion Class	Horizon	1982 3-core averages Dodge	Heyn	Walker	1982 3-plot averages	1981 3-plot averages	1981-82 6-plot averages
slight	Ap	7.3	10.0	8.3	8.5	8.8	8.6
	B2	36.7	32.0	38.3	35.7	33.0	34.3
	B3	47.3	38.7	49.0	45.0	43.9	44.4
moderate	Ap	6.3	8.3	7.0	7.2	7.9	7.6
	B2	29.3	27.3	27.7	28.1	25.8	27.0
	B3	39.3	37.7	41.3	39.4	35.4	37.4
severe	Ap	5.0	8.7	7.3	7.0	6.6	6.8
	B2	14.0	15.7	19.7	16.5	18.7	17.6
	B3	21.3	24.3	31.0	25.3	30.8	28.0
	C1	42.7	35.7	48.7	42.4	47.2	44.8

Table 3. Extractable phosphorus - 1981 3-plot averages, 1982 plots (parts per million).

Erosion Class	Depth (inches)	1982 3-core averages Dodge	Heyn	Walker	1982 3-plot averages	1981 plots horizon	3-plot averages
slight	Ap	40	18	40	33	Ap	22
	Ap-20	24	5	8	12	B21	17
	20-30	26	18	20	21		
	30-40	35	23	25	28		
	40-50	33	16	24	24		
	50-60	31	07	22	20	C1	22
moderate	Ap	26	16	48	30	Ap	18
	Ap-20	13	08	14	12	B21	17
	20-30	28	18	20	22		
	30-40	31	19	19	23		
	40-50	28	15	19	21	C1	22
	50-60	25	13	19	19		
severe	Ap	22	16	34	24	Ap	25
	Ap-20	15	09	16	13	B21	16
	20-30	18	08	25	17		
	30-40	18	07	25	17	C1	16
	40-50	10	06	24	13		
	50-60	05	06	21	11		

Table 4. Exchangeable potassium - 1981 plot averages, 1982 plots (parts per million).

Erosion Class	Depth (inches)	1982 3-core averages Dodge	Heyn	Walker	1982 3-plot averages	1981 plots horizon	3-plot averages
slight	Ap	167	106	135	136	Ap	127
	Ap-20	91	75	77	81	B21	89
	20-30	116	88	96	100		
	30-40	119	80	97	99		
	40-50	106	72	97	92		
	50-60	107	60	98	88	C1	79
moderate	Ap	210	107	105	141	Ap	114
	Ap-20	112	72	82	89	B21	90
	20-30	104	77	89	90		
	30-40	104	72	81	86		
	40-50	97	63	77	79	C1	75
	50-60	89	59	77	75		
severe	Ap	191	99	95	128	Ap	112
	Ap-20	92	64	76	77	B21	85
	20-30	71	54	80	68		
	30-40	78	53	77	69	C1	60
	40-50	71	58	76	68		
	50-60	73	50	73	65		

Table 5. Available zinc in the Ap horizon - 1981 plot averages, 1982 plots (parts per million).

Erosion Class	1982 3-core averages Dodge	Heyn	Walker	1982 3-plot averages	1981 3-plot averages	1981-82 plots 6-plot averages
slight	0.8	0.8	4.2	1.9	0.7	1.3
moderate	0.6	1.2	3.0	1.6	0.5	1.0
severe	0.4	0.3	2.8	1.2	0.5	0.8

Table 6. Available moisture capacity - 1981 plot averages, 1982 plots.

Erosion Class	1982 Depth (inches)	difference between 1/3 bar and 15 bar, percent of oven dry weight — 1982 plots Dodge	Heyn	Walker	1982 averages	1981 horizons	1981 averages
slight	Ap	23.4	22.3	21.9	22.5	Ap	15.6
	Ap-20	22.0	23.6	21.6	22.4	B21	18.2
	20-30	21.8	21.8	22.2	19.5	B22	18.7
	30-40	22.8	22.2	19.8	21.6		
	40-50	22.9	20.9	19.7	21.2		
	50-60	22.6	20.3	18.1	20.3	C1	18.2
moderate	Ap	22.0	19.5	20.7	20.7	Ap	14.7
	Ap-20	21.8	22.2	21.5	21.8	B21	17.1
	20-30	21.5	20.9	18.3	20.2	B22	18.5
	30-40	22.5	21.1	18.0	20.5		
	40-50	23.0	20.4	18.2	20.5	C1	17.4
	50-60	22.0	19.7	17.7	19.8		
severe	Ap	20.3	20.5	20.2	20.3	Ap	14.0
	Ap-20	20.9	19.9	21.1	20.6	B21	16.8
	20-30	20.9	20.1	19.5	20.2	B22	16.6
	30-40	22.3	19.5	19.1	20.3	C1	17.9
	40-50	19.8	18.6	20.4	19.6		
	50-60	20.4	18.6	20.3	19.8		

Table 7. pH (water) - 1981 plot averages, 1982 plots.

Erosion Class	Depth (inches)	1982 3-core averages Dodge	Heyn	Walker	1982 3-plot averages	1981 horizons	1981 averages
slight	Ap	6.1	6.2	5.8	6.0	Ap	6.4
	Ap-20	6.5	6.0	6.0	6.2	B21	6.4
	20-30	6.4	5.9	5.9	6.1	B22	6.0
	30-40	5.9	6.1	6.0	6.0		
	40-50	5.7	6.8	5.9	6.1		
	50-60	6.1	7.7	5.9	6.6	C1	6.0
moderate	Ap	6.4	5.8	5.9	6.0	Ap	6.7
	Ap-20	6.5	6.3	6.0	6.3	B21	6.3
	20-30	5.9	6.3	6.0	6.1	B22	5.8
	30-40	5.8	6.2	6.1	6.0		
	40-50	5.8	6.5	6.0	6.1	C1	5.8
	50-60	5.9	7.0	6.5	6.5		
severe	Ap	6.6	6.6	6.2	6.5	Ap	6.8
	Ap-20	6.8	7.2	5.9	6.6	B21	6.5
	20-30	7.1	7.7	6.1	7.0	B22	6.2
	30-40	7.1	7.7	6.0	6.9	C1	6.6
	40-50	7.7	8.0	6.2	7.3		
	50-60	8.2	8.1	6.5	7.6		

Table 8. Percent organic carbon in the Ap horizon - 1981 3-plot averages, 1982 plots.

Erosion Class	1982 3-core averages Dodge	Heyn	Walker	1982 3-plot averages	1981 3-plot averages	1981-82 plots 6-plot averages
slight	1.7	1.9	2.0	1.9	1.7	1.8
moderate	1.6	1.9	1.5	1.7	1.4	1.6
severe	1.3	1.2	1.6	1.4	1.2	1.3

Table 9. Particle size data - 1982 fields (average percent).

Erosion Class	Depth (inches)	Sand		Silt		Clay
		v.f. sand	total	fine	total	
slight	Ap	5.1	5.9	32.9	72.0	22.1
	Ap-20	5.0	5.3	32.0	70.0	24.7
	20-30	8.5	9.1	24.4	65.5	25.4
	30-40	11.1	11.9	21.3	67.0	21.2
	40-50	11.4	12.4	21.2	68.8	18.8
	50-60	12.2	13.3	19.2	69.0	17.6
moderate	Ap	5.5	9.9	30.0	67.3	22.8
	Ap-20	7.3	7.7	25.0	65.7	26.6
	20-30	10.3	11.4	22.9	65.5	23.1
	30-40	11.0	11.8	22.0	67.9	20.2
	40-50	11.5	13.8	21.2	68.0	18.2
	50-60	13.7	14.8	20.8	67.8	17.3
severe	Ap	6.3	7.1	27.5	68.7	24.2
	Ap-20	9.6	10.2	24.5	67.4	22.4
	20-30	11.1	12.3	21.5	69.8	17.9
	30-40	11.5	13.2	22.3	69.7	17.1
	40-50	11.3	12.4	21.4	73.3	14.4
	50-60	9.1	10.1	22.3	75.1	14.8

COMPARISON OF THREE PHOSPHORUS SOIL TEST PROCEDURES TO WHEAT, CORN AND SOYBEAN YIELDS

W.E. Fenster, J. Grava, S.D. Evans, G.E. Varvel, M. O'Leary, and G. Buzicky

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 6 sites and soybeans on the other. There were 3 additional sites in 1982, 6 in wheat, 2 in corn and 1 in soybeans. One additional plot from 1981 was lost due to flooding in 1982.

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 independent of pH. At 3 of the locations starter and no starter comparisons were made in addition to the four broadcast P treatments.

Table 2a gives wheat yields, initial soil tests, table 2b gives plant analysis for 1982 and 1981 soil test in fall after first crop was grown. Soils were not sampled in the fall of 1982. The tables 3a and 3b give similar results for corn and soybeans.

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 no yield increases resulted from P treatments.

Correlation with yield is not relevant since no yield increases were obtained. This study will be continued.

Table 1. Soil type, county, and rates of starter fertilizer where used.

	Heinecke	Klassen	Morris Sta.	Mehrkens W	Mehrkens S	Dahl	Klenz	Crookston Sta.	
County	Swift	Swift	Stevens	Pennington	Pennington	Norman	Martin	W. Polk	H. Polk
Soil type	Colvin	Colvin	Doland	Clearwater	Glyndon	Vallers	Webster	Wheatville	Hegne
Texture	SiCL	SiCL	SiL	Loam	Loam	SiL	CL	SiL	SiC
Starter Fertilizer[1/]									
N	-	-	0	15	15	-	-	-	-
P_2O_5	-	-	30	30	30	-	-	-	-
K_2O	-	-	0	30	30	-	-	-	-

[1/] Adequate N and K applied across all plots.

Table 2a. Wheat yields at 13% moisture 1982 from 4 phosphate levels broadcast plus starter and no starter at 6 locations and corresponding check plot P soil test using 3 methods[1/].

Lbs. P_2O_5/A Broadcast	Crookston Sta. W	Crookston Sta. H	Morris Sta.	Mehrkens W.	Mehrkens S.	Dahl
	bu/acre					
0	53	51	61	46	52	58
30	55	46	65	50	51	62
60	57	48	68	48	49	61
90	55	46	69	52	51	59
significance	ns	ns	*	*	ns	ns
starter	-	-	68	50	49	-
no starter	-	-	64	48	53	-
significance	-	-	*	ns	ns	-
P test lbs/acre						
Bray 1:10	16	54	10	17	2	23
Bray 1:50	60	84	12	24	8	57
Olsen's	15	20	6	9	16	17
K test lbs/acre						
pH	8.2	8.0	7.8	7.9	8.0	8.3

Table 2b. Plant analysis of entire wheat plant at boot stage and relationship to P treatment and soil test[1/].

Lbs. P_2O_5/A Broadcast	Crookston Sta. W	Crookston Sta. H	Morris Sta.	Mehrkens W.	Mehrkens S.	Dahl
	% P 1982					
0	.28	.30	.22	.27	.35	.27
30	.26	.30	.26	.32	.36	.28
60	.28	.30	.29	.37	.35	.29
90	.28	.31	.31	.39	.38	.29
significance	+	ns	**	**	ns	ns
			Bray's 1:10 lbs/A P			
0	16	54	10	17	2	23
30	-	-	18	21	2	-
60	-	-	23	23	2	-
90	-	-	33	21	4	-
			Bray's 1:50 lbs/A P			
0	60	84	12	24	8	57
30	-	-	23	25	5	-
60	-	-	25	28	9	-
90	-	-	33	25	11	-
			Olsen's lbs/A P			
0	15	20	6	9	16	17
30	-	-	13	11	17	-
60	-	-	15	12	21	-
90	-	-	23	13	24	-

[1/] Crookston & Dahl farms sampled spring of 1982 prior to treatment, others sampled fall 1981.

Table 3a. Corn or soybean yields 1982 from 4 phosphate levels broadcast at 3 locations and corresponding check plot P soil test (fall 1981) using 3 methods.

Lbs P_2O_5/A Broadcast	Heineke S.B.	Klassen Corn	Klenz Corn
	bu/acre		
0	42	164	162
30	43	160	172
60	45	165	172
90	44	173	167
significance	ns	ns	ns
P test lbs/acre			
Bray 1:10	5	6	13
Bray 1:50	15	15	33
Olsen's	9	6	10
pH	7.8	8.0	7.7

Table 3b. Plant analysis of ear leaf on corn and upper mature triofoliate leaves at initial flowering of soybeans and relationship to P treatment and 1981 fall soil test.

Lbs P_2O_5/A Broadcast	% P 1982		
0	.35	.27	.26
30	.38	.27	.29
60	.38	.29	.30
90	.39	.30	.30
significance	ns	-	**
	Bray's 1:10 lbs/A P		
0	5	6	13
30	7	4	18
60	9	7	21
90	7	5	27
	Bray's 1:50 lbs/A P		
0	15	15	33
30	20	14	36
60	33	15	39
90	35	15	46
	Olsen's lbs/A P		
0	9	16	10
30	8	17	12
60	17	17	14
90	22	18	19

Table 4. Plant analyses of wheat at boot stage Wheatville and Hegne soils at Crookston and Dahl farms, 1982.

Lbs P_2O_5/A Broadcast	Bu/A @ 13% M	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%				ppm				
Wheatville										
0	53	.28	2.69	.28	.24	81	47	31	3	5
30	55	.26	2.60	.27	.24	82	48	30	2	4
60	57	.28	2.47	.24	.24	75	50	24	2	6
90	55	.28	2.45	.27	.24	70	46	24	2	6
significance	ns	+	ns	ns	ns	ns	ns	*	ns	*
C.V.	7	4.0	10.6	22.7	19.7	40.9	14.1	14.6	47.9	14.8
Hegne										
0	51	.30	2.92	.34	.30	64	44	20	2	5
30	46	.30	3.06	.36	.31	64	43	20	2	5
60	48	.30	2.94	.34	.29	63	41	18	2	4
90	46	.31	2.95	.36	.31	58	42	18	2	4
significance	+	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.	6.0	3.1	6.3	8.9	10.0	8.5	6.3	8.9	26.7	24.4
Dahl										
0	58	.27	2.89	.31	.29	60	49	29	4	3
30	62	.28	2.89	.27	.43	42	35	40	6	4
60	61	.29	2.76	.28	.30	51	45	27	5	3
90	59	.29	2.80	.33	.30	62	42	25	4	3
significance	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.	18	5.1	3.1	31.0	49.6	32.1	30	36.4	25.2	16.0

Table 5. Plant analysis of wheat at boot stage at Morris and Mehrkens farms, 1982.

Morris Station

Broadcast P_2O_5/A	Starter	Bu/A @ 13% M	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
			---------- %			-----------	-------------- ppm				-------------
0	-	60	.20	2.82	.32	.22	77	68	19	2	3
0	+	67	.24	2.80	.35	.26	101	84	16	2	3
30	-	64	.26	2.64	.34	.24	91	77	17	2	3
30	+	67	.27	2.66	.34	.24	80	84	16	2	3
60	-	68	.28	2.61	.34	.24	78	81	16	2	3
60	+	69	.30	2.82	.36	.26	76	88	15	2	3
90	-	69	.30	2.70	.35	.24	68	84	16	2	3
90	+	68	.32	2.68	.36	.26	78	94	16	2	4
significance		*	*	ns	ns	*	ns	ns	ns	ns	ns
C.V.		5.7	3.2	4.8	7.4	4.5	26.8	7.4	10.8	16.7	13.6

Mehrkens (S)

Broadcast P_2O_5/A	Starter	Bu/A @ 13% M	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
0	-	53	.36	3.61	.38	.35	81	40	34	3	5
0	+	51	.35	3.78	.39	.33	82	42	34	3	5
30	-	53	.37	3.18	.37	.34	72	41	28	2	5
30	+	49	.36	3.57	.35	.31	68	43	25	2	5
60	-	51	.38	3.60	.40	.35	71	41	24	2	5
60	+	48	.33	3.26	.38	.31	70	38	22	2	5
90	-	54	.38	3.60	.40	.33	68	39	21	2	4
90	+	48	.37	3.49	.42	.30	70	46	21	1	5
significance		ns	ns	*	ns	ns	ns	ns	ns	ns	ns
C.V.		7.5	10.5	5.8	11.7	11.2	8.9	12.0	7.3	21.5	24.1

Mehrkens (W)

Broadcast P_2O_5/A	Starter	Bu/A @ 13% M	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
0	-	41	.26	3.36	.29	.22	68	32	24	3	5
0	+	50	.29	3.47	.26	.23	65	33	21	2	6
30	-	51	.31	3.32	.27	.24	66	36	19	2	5
30	+	50	.32	3.61	.29	.26	64	38	21	2	5
60	-	49	.36	3.42	.35	.27	68	40	20	2	6
60	+	48	.38	3.68	.32	.24	64	36	18	2	5
90	-	50	.38	3.25	.30	.27	62	42	17	2	5
90	+	54	.41	3.66	.34	.31	75	42	19	2	6
significance		*	ns	ns	ns	ns	ns	ns	*	ns	ns
C.V.		7.0	5.6	6.2	14.0	11.3	14.0	13.3	8.1	27.7	17.4

Table 6. Plant analysis of soybeans and corn at Heinecke, Klassen and Klenz farms, 1982.

	Lbs P_2O_5/A	Bu/A @ 13% M	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
			%				ppm				
Heinecke											
Soybeans initial flowering											
	0	42	.35	2.62	1.22	.61	142	115	46	11	50
	30	43	.38	2.67	1.24	.60	132	102	50	12	48
	60	45	.38	2.63	1.26	.56	171	85	45	11	50
	90	43	.39	2.62	1.21	.59	132	100	46	11	50
significance		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.		4.9	9.6	4.9	5.0	9.4	33.6	30.6	20.0	9.3	3.8
Klassen											
Corn, 8 leaf stage											
	0	164	.17	2.41	2.52	.78	4300	184	52	9	6
	30	160	.19	2.76	2.32	.74	4000	174	46	8	6
	60	165	.19	2.46	2.65	.80	4125	180	48	9	6
	90	173	.22	2.80	2.30	.72	3625	168	48	9	6
significance		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.		4.4	11.6	11.6	19.6	13.0	10.5	7.2	5.8	10.0	11.6
Klassen											
Corn ear leaf											
	0		.28	2.41	.34	.43	95	86	24	7	8
	30		.28	2.32	.32	.41	91	85	23	7	8
	60		.29	2.11	.34	.46	95	89	24	6	8
	90		.30	2.18	.33	.43	94	83	22	7	8
significance			ns	+	ns	ns	ns	ns	ns	ns	ns
C.V.			4.5	7.0	9.3	11.8	3.0	6.6	5.9	13.8	7.4
Klenz											
Corn, 8 leaf stage											
	0	161	.34	2.15	.90	.47	1800	123	30	10	4
	30	172	.36	2.27	.95	.45	2125	141	29	10	4
	60	172	.36	2.14	.94	.43	2275	142	26	9	3
	90	167	.35	2.30	.96	.45	1975	142	26	10	4
significance		ns	ns	ns	ns	ns	ns	ns	*	ns	ns
C.V.		4.2	7.2	25.6	8.3	15.6	24.6	8.9	4.5	13.0	22.0
Klenz											
Corn ear leaf											
	0		.26	1.18	.56	.63	88	92	21	6	5
	30		.29	1.21	.61	.63	90	104	20	6	5
	60		.30	1.12	.64	.68	91	109	17	5	5
	90		.30	1.28	.60	.63	90	106	18	6	5
significance			**	ns	ns	ns	ns	ns	*	ns	ns
C.V.			2.9	17.2	9.1	11.7	6.6	12.5	8.0	8.2	4.9

MICRONUTRIENTS AND RELATIONSHIP TO MICRONUTRIENT SOIL TESTS

W. E. Fenster and C. J. Overdahl

The micronutrient study was initiated in 1981 at 6 locations, all plots were with corn. Three locations were discontinued for various reasons in 1982 and the three that were continued were planted to soybeans.

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. Sulfur and magnesium, even though not micronutrients, were included as a variable.

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

Tables 1 through 5 show the 1982 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 Testing

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. The trials will continue for 3 more years.

Acknowledgments

The efforts of Mike O'Leary and Greg Buzicky in arranging details of securing, weighing and packaging materials is gratefully acknowledged. Also Todd King, Gene Peters, and Negussie Berihun helped make the results shown here possible. Also thanks go to Brian Schreiber, Bob Olson, and Floyd Bellin for their efforts with farm cooperators.

Funding of the micronutrient research project was made possible by the Cenex Foundation and the boron special study was funded in part by U.S. Borax and Chemical Corporation, to these companies the authors are indeed grateful. To the three laboratories making the many tests goes a special thanks.

Table 1. Corn and soybean yields, plant boron, and soil test boron from four levels of boron applications. 1981 & 1982.

lbs B/A	yield bu/A[1]		ppm B[1] leaf		soil test - ppm[1] hot H_2O	
	1981	1982	1981	1982	1981	1982
	Corn	Soybeans	Corn	Soybeans		
Jokela Farm - Goodhue Co. non-irrigated Mt. Carroll silt loam						
0	170	49	4.3	38	0.60	0.79
1	178	42	4.6	44		1.10
2	175	47	4.6	51		1.53
4	174	42	6.8	61		2.54
significance	ns	+	ns			
BLSD (.10)		5				
C.V.	3.7	7.2	9.8			
Kingston Farm - Dakota Co. - irrigated loamy sand						
0	155	36	7.0	43	0.25	0.19
1	159	34	8.1	52		0.25
2	147	32	11.8	67		0.47
4	160	27	18.2	112		0.86
significance	ns	**	**			
BLSD (.05)		4	3.5			
C.V.	5.0	82	21.9			
Geiger Farm - Morrison Co. - irrigated loamy sand						
0	92		4.1		0.09	
1	87		6.7			
2	90		10.9			
4	90		13.7			
significance	ns		**			
BLSD (.05)			3.4			
C.V.	11.7		24.8			

[1] average of 4 replications, soil test U. of MN.

Table 2. Soybean yields[1/] in three counties comparing complete treatments of micronutrients plus Magnesium to plots using missing element techniques. 1982.

Treatment [2/] omitted (-) added (+)	Martin Yield	Goodhue Yield	Dakota [3/] Yield
none	56	47	33
-Mg	51	43	35
-Zn	52	45	33
-Fe	53	44	34
-Mn	54	43	34
-B	52	44	34
-Cu	52	45	33
+ complete includes S	54	47	33
significance	ns	ns	ns

[1/] average of 4 repplications

[2/] pounds per acre of nutrient added Mg=50, Zn=10, Fe=10, Mn=10, B=1, Cu=5.

[3/] irrigated sandy loam, other two counties fine textured non-irrigated soils.

Table 3. Plant analysis [1/] from micronutrient and magnesium treatments in trials at three counties. 1982.

Treatment omitted (-) added (+)	Martin		Goodhue		Dakota	
	------- (ppm except Mg which is %) --------					
	-	+	-	+	-	+
Mg	.48	.52	.46	.43	.43	.49
Zn	42	48	42	46	45	47
Fe	113	131	104	99	84	92
Mn	61	97	44	44	63	58
B	50	50	41	44	39	54
Cu	10	11	10	10	10	10

[1/] average of 4 replications from leaf opposite and below ear at silking time.

Table 4. Soybean yields,[1/] plant sulfur and soil test sulfur with and without sulfur treatments in three counties. 1982.

Sulfur Treatment	Yield bu/A	Ear Leaf % S	U of M Soil Test PPM S
-----Martin-----			
None	54	.31	1
50#/A	53	.31	-
Significance	ns		
-----Goodhue-----			
None	44	.32	10
50#/A	43	.35	19
Significance	ns		
-----Dakota[2/]-----			
None	33	.28	1
50#/A	34	.30	2
Significance	ns		

1/ average of 4 replications

2/ irrigated sandy loam soil, other two counties are fine textured non-irrigated soils

Table 5. Soil test means for micronutrients. U. of M. Lab. 1981 & 1982.

County	#/A Mg	ppm Zn	ppm Mn	ppm Cu	ppm B	ppm Fe
1981 Tests*						
Goodhue	579	2.0	31	0.75	.60	55
Dakota	312	1.0	21	0.48	.25	41
Martin	881	1.0	41	1.28	1.20	21

1982 Tests**

Treatment omitted (-) added (+) 1981	Martin -	Martin +	Goodhue -	Goodhue +	Dakota -	Dakota +
	(ppm except Mg which is lbs/A)					
Mg	990	970	495	595	295	364
Zn	1.2	2.3	4.8	8.0	1.4	4.2
Fe	42	26	76	90	78	80
Mn	40	40	30	30	19	18
B	2.1	1.8	1.0	3.2	2.2	2.4
Cu	1.8	2.5	1.5	4.0	0.6	3.1

* before 1981 treatments

** from treated plots in 1981

TILLAGE-SOIL FERTILITY STUDIES ON A TYPIC EUTROCHREPT IN GOODHUE CO.

J. B. Swan, J. F. Moncrief, and B. P. Schreiber

This research includes two separate studies:

1) Determining the effect of tillage on the response of corn to potassium at two levels of nitrogen (N-K Study).

2) Evaluation of tillage system performance and nitrogen release from injected manure (Manure study).

NEED FOR STUDY

Since soil erosion by water is of major concern in much of southeastern Minnesota, conservation tillage systems which retain crop residue on the soil surface are of great importance in the region. Water conservation due to conservation tillage can increase corn yield even though the region has the states greatest average growing season rainfall. Increased yields from surface residue are most likely to occur in years when moldboard plowed fields experience water stress due to extended periods between rainfall events, due to high runoff from the bare soil surface which seals readily under raindrop impact, or due to the low water holding capacity of shallow soils. Time saving during periods of peak labor demand is another potential benefit of conservation tillage.

Tillage can affect fertilizer considerations and may require change in fertilizer use and application methods. Reduction in the availability of soil potassium and modification of the nitrogen response were reported for tillage systems which leave large amounts of crop residue on the soil surface and cause little soil disturbance compared to moldboard or chisel plowing (Moncrief 1981).

Because of the large number of livestock enterprises in southeastern Minnesota, animal manure is an important source of plant nutrients as well as a potential source of pollution if improperly handled. Ideally the manure is applied in the cropping sequence so as to maximize crop use of the nutrients in the manure without significantly delaying or otherwise adversely modifying production practices. Method of application, weather and time pressures can prevent the achievement of this goal.

The extent to which different tillage systems and methods of manure application benefit or interfere with each other is not well documented. Manure injection accomplishes some tillage but restricts the spacial distribution of nutrients unless redistributed by additional tillage. The rate of release of nitrogen from manure may also be affected by the soil conditions created by the tillage operation. The type of tillage may also affect the time of manure application, while the date of manure injection may delay subsequent tillage or planting operations.

OBJECTIVES

1) To assess the effect of tillage on the availability of nitrogen and potassium to corn.

2) To evaluate nitrogen release from manure under two tillage systems.

3) To compare changes in potassium soil test level with the amount applied in manure and as Kcl.

4) To evaluate tillage systems for corn where manure is injected.

METHODS AND MATERIALS

Site: The experimental plots are located on four acres of land on the farm of Dale Flueger in Sec. 15 of Hay Creek Twp. of Goodhue Co. The soil is a Timula silt loam (Typic Eutrochrept) with an organic matter level of about 2.5 percent, pH of 6.5 ± 0.5, initial range in K (ammonium acetate extraction) of 90 to 280, P (Bray 1) of 32 to 85. The site has been in corn for at least two years. 3-Ton/A of limestone were applied in 1980 and approximately 9000 gal/A of dairy manure was injected in the fall of 1979. Corn silage was removed from the site in 1981 leaving the surface essentially bare.

Experimental Procedure: Tillage comprises the main plots of a RCB design (3 replicates) with fertility and manure subplots. The treatments and associated practices for the studies are:

Tillage/Planting	N - K Study	Manure Study
Chisel plow, field cultivate, plant	5/20	5/20
No-till plant		
Fertility		
Nitrogen 0, 200 lbs N/A Bdcst. as ammonium nitrate	5/20	-
Potassium 0, 200, 400 lbs/A K_2O B Bdcst. as potassium chloride	5/4	-
Manure: 12,700 gallons/A dairy manure Injected: (375 lbs/A total N of which 190 lbs/A was in ammonium form, 234 lbs/A K_2O; 141 lbs/A P_2O_5	-	5/4
Starter: 111 lbs/A of 0-46-0 at planting on all plots area	At planting	At planting
Insecticide: 7 lbs/A counter	At planting	At planting
Herbicide: 2 lbs (active ingredient) each of Atrazine and Lasso as post at 4-5 leaf stage		6/8
2 qts/A Round up on No-till only for quack	5/28	5/28
Weed control was excellent over entire area		
Hybrid: Pioneer 3732 (105 day) Planting rate of 29,000 plants/A		

Equipment

Chisel (Soil saver)
Field cultivator (Bushog soil finisher)
Planter (John Deere 7000 Max emerge with light duty coulters for trash - 38 inch row width

RESULTS AND DISCUSSION

1) Soil Tests

N-K study-soil test K was sampled for the 0 to 6 inch depth on each plot on 7/15. A great range in soil test K occurred for each K application level (table 1). The averagesoil test K value of the 0 and 224 kg/ha applications of K_2O were within one standard deviation of the 224 and 448 kg/ha applications, respectively.

SOIL TEST K

K_2O Applied	Plot range	Plot Average	Std. Dev.
Kg/ha		Kg/ha	
0	92 to 213	149	36
224	112 to 264	195	48
448	152 to 394	271	76

Soil nitrates were measured on 6/25, one measurement per replicate. In the upper 60 cm 112, 103 and 76 kg/ha nitrate were measured for replications 1, 2 and 3 respectively. For the 150 cm depth the respective values were 211, 134 and 161 kg/ha soil nitrates. Soil nitrate levels also showed considerable variation. Plots with levels similar to those measured in replications 1 and 3 would be expected to have reduced yield response to nitrogen application.

EARLY GROWTH

(Was measured on 7/13/82; table 3)

A. Dry matter

Significant differences were measured between the individual nitrogen and potassium (N-K) treatment levels on no-till plots but differences were not significant between individual N-K levels on chisel plots. For no-till, greatest early growth occurred on the 448 kg/ha K_2O, 224 kg/ha N treatment which was significantly greater than the 0 K_2O treatment with N and all levels of K_2O without N. The no-till 0 N,0 K_2O treatment had the least early growth which was significantly less than all the N treatments and the 224 kg/ha K_2O treatment without N. The early growth on the other four no-till treatments was not significantly different. The effect of applied K was largely masked by the wide range in soil test K at each treatment level of K_2O.
When the data were analyzed as a 2x3 factorial, effect of nitrogen on early growth was highly significant for no-till and significant for chisel tillage.

Soil test K: The effect of soil test K on early growth was described by the following sets of equations:

No-till	EG gms/plant	R^2
N = 0	$= 19.74 - 3.48 \times 10^{30} K^{-15}$	0.47
N = 224 kg/ha	$= e^{0.125935} K^{0.59428}$	0.46
Chisel		
N = 0	*$= e^{-28.986} K^{11.711-1.0660 \ln K}$	0.61
N = 224 kg/ha	= 28.5 (avg. value)	-

*gms/10 plants

Regression lines of early growth on soil test K converged at soil test K of 120 kg/ha for no-till treatments with and without N. For soil test K >120 kg/ha early growth increased as soil test K increased with N but remained nearly constant without N. Regression relationships explained slightly less than one half the variation in early growth.

For the chisel treatment without N, early growth increased as soil test K increased reaching an apparent maximum at soil test K values greater than 200 kg/ha. Within the range measured, soil test K had no detectable effect on early growth when 224 kg/ha N was added. In general soil test K level was more closely related to early growth than was applied K.

B. Total K uptake

For the no-till plots, total K uptake for the different N and K treatments was significantly different. The 224 kg/ha N, 448 kg/ha K_2O plots had significantly greater K uptake than any other treatment. All other treatments were not significantly different. K uptake was significantly greater with N compared to without N. The effect of K applications on K uptake was highly significant but the NxK interaction term was not significant.

With the chisel treatment there were no significant differences detected in K uptake due to treatments or due to N, K level or NxK interaction. The effect of applied K on K uptake was significant at the 10% level. Again the wide range in soil test K at each K treatment level tended to mask the effect of applied K.

The following relationships between soil test K and total K uptake were determined by regression:

No-till	gms K uptake/plant	R^2
N = 0	$= 61.67 - 530.74\ K^{-\frac{1}{2}}$	0.66
N = 224 kg/ha	$= -23.6 + 0.2683\ K$	0.51
Chisel		
N = 0	$= e^{-5.772675} K^{1.7183799}$	0.57
N = 224 kg/ha	$= 36.38 - 6.13 \times 10^{32} K^{-15}$	0.41
Both N rates	$= e^{-2.70} K^{1.14}$	0.41

For no-till treatments without N, K uptake increased rapidly up to K soil test values of about 150 kg/ha, but increased more slowly at greater values of soil test K. The equation explained about 2/3 of the variation in K uptake. When N was applied, K uptake increased approximately linearly with K soil test ($R^2 = 0.51$) and no indication of a maximum value of K uptake was detected.

For the chisel treatments the results appeared similar to those of the no-till with N in that K uptake increased nearly linearly with K soil test and that the effect of N was not discernable.

C. Ear moisture

Ear moisture was significantly different between N-K treatments for no-till but not for chisel; the effect of N was highly significant for the no-till.

No-till treatments receiving both N and K had significantly lower ear moisture than the 0 and 224 kg/ha K treatments without N. Again the variation in soil test K within each level of applied K tended to mask the differences due to level of applied K.

For no-till, ear moisture was highly correlated with soil test K ($R^2 = 0.80$) when no N was applied. The correlation between ear moisture and soil test K was $R^2 = 0.64$ when 224 kg/ha of N was applied. At soil test K levels below 200 kg/ha, ear moisture increased markedly. N application reduced ear moisture about 2 percent over most of the soil test range.

The effect of N on ear moisture was not detectable with the chisel treatment; nor was the effect of soil test K when all chisel data were considered together. However, for each level of applied K, ear moisture decreased as soil test K increased.

D. Corn yields

When analyzed as a 3x2x2 factorial the effect of blocks was significant and the effect of N and of N-K tillage treatments were significant at the 1 percent level. All other main effects, factors and interaction terms were not significant.

When chisel and no-till were analyzed separately the effect of blocks and N-K treatments were significant for the no-till but not the chisel; however, the effect of N on yield was highly significant for both no-till and chisel. The variation of soil test K again masked the effect of applied K.

Soil test K was closely correlated with corn yield ($R^2 = 0.83$) (Figure 1) for the no-till; yield decreased markedly with decreasing soil test K levels below about 200 kg/ha soil test K when N was applied. Within both 0 and 224 kg/ha levels of applied K_2O, corn yield increased as soil test K increased; however, for 448 kg/ha of K_2O, increased soil test K had no effect on yield. Without N the effect of soil test K on yield was not discernable except possibly at the 448 kg/ha level where yield appeared to increase as K level increased.

For the chisel treatment without N, at each level of applied K, the corn yield generally tended to increase with increased soil test K as indicated by a positive slope (Δ yield/Δ soil test K). When 224 kg/ha N was applied, there was no discernable yield response to soil test K except possibly at soil test K values below 150 kg/ha; thus, yield was poorly correlated with soil test K ($R^2 = 0.31$). The regressions between yield and soil test K indicate that at soil test K values below about 170 kg/ha chisel treatments generally outyielded no-till and over 200 kg/ha the reverse was true. For K soil tests greater than 225 kg/ha, no-till outyielded chisel sufficiently for the yield differences to be significant at the 10 percent level.

Comparing the yield responses of no-till and chisel, without N the no-till yields for 0 and 224 kg/ha K_2O were depressed to a greater extent than the chisel treatments as was the 0 K treatment with 224 kg/ha N. Apparently both K and N uptake were depressed more with no-till at these N and K levels than with chisel. These conclusions agree with the previous research results of Moncrief 1981.

E. Yield and early growth

Since both corn yield and early growth for no-till were affected by N and soil test K levels, it would be expected that yield and early growth would be related and they are ($R^2 = 0.45$). The data points cluster into two groups, with and without N. For early growth values over 24 gms/plant, yield appears unrelated to early growth. The relationship appears even more well defined for chisel. Without N, yield increases as early growth increases ($R^2 = 0.64$) until yields essentially equal those with N. With N, yield appears unaffected by early growth. Thus for both no-till and chisel when 224 kg/ha N was applied, early growth and yield were not well correlated; however, when both levels of N were considered the relationship of yield to early growth improved considerably.

MANURE STUDY

The results of the manure study are briefly summarized in table 5. The chisel and no-till treatments with manure both significantly outyielded their counterparts without manure. The chisel without manure outyielded the no-till without manure by 31 bu/acre. No-till with manure averaged 7 bu/acre less than chisel with manure. The difference is largely due to positional unavailability of manure for the no-till treatment caused by unequal spacing of injectors and lack of distribution from the point of injection on the no-till treatment.

REFERENCE

Moncrief, J. F. 1981. The effect of tillage on soil physical properties and the availability of nitrogen, phosphorus, and potassium to corn. Ph.D. Thesis, University of Wisconsin - Madison, WI.

Table 1. Soil test K (N-K Study)

Tillage	Fertilizer application N	K$_2$O	Kg/Ha Replicate 1	2	3	Avg
	kg/ha					
No-till	0	0	163	139	92	131.3
		224	235	137	112	161.3
		448	246	374	204	274.7
	224	0	148	190	132	156.7
		224	246	211	208	221.7
		448	197	347	242	262.0
Rep. Avg. No-till			206	233	165	201.3
Chisel	0	0	213	155	101	156.3
		224	246	150	166	187.3
		448	336	152	233	240.3
	224	0	190	125	141	152
		224	264	172	195	177
		448	394	246	276	305.3
Rep. Avg. Chisel			274	167	185	203.0
Rep. Avg. No-till & Chisel			240	200	175	202

Table 2. Corn yield - grain (N-K Study)

Tillage	Fertilizer Application N (kg/ha)	K_2O (kg/ha)	Bu/A Replicate 1	2	3	Avg	Mg/ha Replicate 1	2	3	Avg
No-till	0	0	98.3	136.1	91.1	108.5	6.17	8.54	5.71	6.81
		224	70.4	128.6	88.0	95.7	4.42	8.07	5.52	6.00
		448	123.1	158.1	95.8	125.7	7.72	9.92	6.01	7.88
	224	0	126.7	170.9	117.7	138.4	7.95	10.72	7.38	8.68
		224	178.8	154.3	146.6	159.9	11.21	9.68	9.19	10.03
		448	163.2	165.0	161.9	163.4	10.23	10.34	10.15	10.25
	0	Avg				109.9				6.90
	224	Avg				153.9				9.65
Chisel	0	0	145.8	140.9	113.2	133.3	9.14	8.84	7.10	8.36
		224	161.0	118.4	118.3	132.6	10.10	7.43	7.42	8.32
		448	127.4	108.8	131.9	122.7	7.99	6.82	8.27	7.70
	224	0	167.3	151.8	132.5	150.5	10.49	9.52	8.31	9.44
		224	153.7	155.3	152.9	154.0	9.64	9.74	9.59	9.66
		448	149.5	155.6	159.6	154.9	9.37	9.76	10.01	9.72
	0	Avg				129.5				8.12
	224	Avg				153.1				9.60

Table 3. Early growth (N-K Study), sampled 7/13/82

Tillage	Fertilizer Application N	Fertilizer Application K_2O	Replicate gms/10 plants 1	2	3	Avg	
No-till	0	0	159	182	76	139.0	a
		224	205	250	188	214.3	b
		448	248	224	116	196.0	ab
		Avg	204	218.7	126.7	183.1	
	224	0	232	292	187	237.0	b
		224	233	312	260	268.3	bc
		448	217	341	415	324.3	c
		Avg	227.3	315	287.3	276.5	
Chisel	0	0	313	198	114	208.3	ns
		224	276	226	144	215.3	
		448	192	153	235	193.3	
		Avg	260	192.3	164.3	205.6	
	224	0	381	219	330	310.0	ns
		224	272	279	256	269.0	
		448	296	262	267	275.0	
		Avg	316.3	253.3	284.3	284.7	
Rep Avg No-till & Chisel			251.9	244.8	215.7	237.5	

Table 4. Percent ear moisture (N-K Study), cob and grain

Tillage	Fertilizer Application N (kg/ha)	K_2O (kg/ha)	Percent H_2O Replicate I	2	3	Avg	
No-till	0	0	43.0	41.3	46.1	43.5	a
		224	41.4	43.3	45.3	43.2	a
		448	41.0	41.8	40.9	41.2	ab
		Avg	41.8	42.1	44.1	42.7	
	224	0	41.4	38.9	41.4	40.6	ab
		224	38.3	40.0	40.1	39.5	b
		448	40.5	39.1	38.1	39.2	b
		Avg	40.1	39.3	39.9	39.8	sig. at 5% level
Chisel	0	0	38.4	41.3	39.8	39.8	
		224	38.8	44.3	41.3	41.4	
		448	41.2	44.9	41.4	42.5	
		Avg	39.4	43.5	40.8	41.2	
	224	0	38.3	40.9	40.2	39.8	
		224	38.3	41.4	44.0	41.2	
		448	39.7	42.3	39.8	40.6	
		Avg	38.8	41.5	41.3	40.5	
Rep Avg No-till & Chisel			40.0	41.6	41.5	41.1	

<u>Table 5</u>. Tillage-manure study with continuous corn

	Corn yield bu/A			
	Rep 1	Rep 2	Rep 3	Avg
Chisel manure	163	165	163	164
No-till manure	150	163	158	157
Chisel none	147	130	118	132
No-till none	80	132	90	101

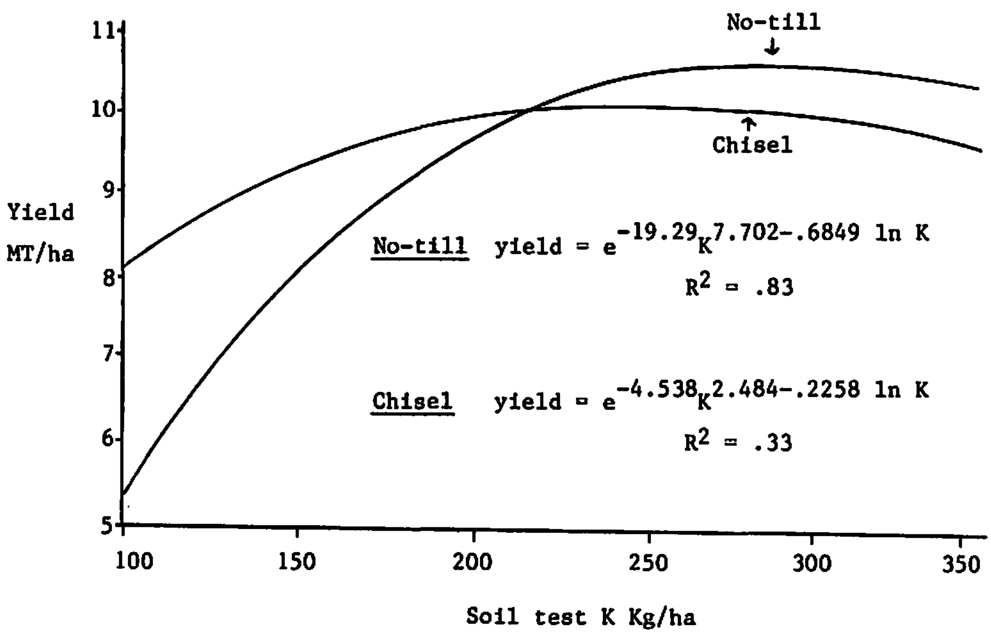
Manure application

375 lbs/A N (total)

234 lbs/A K_2O

141 lbs/A P_2O_5

<u>Figure 1</u>. The effect of tillage on potassium response , Goodhue Co., MN, 1982



THE EFFECT OF TILLAGE, N RATE, AND NITRAPYRIN ON CORN GROWTH, GOODHUE COUNTY, MN., 1982

J. F. Moncrief, G. L. Malzer, J. B. Swan, M. J. O'Leary, and T. J. Graff

INTRODUCTION

Conservation tillage systems for corn production are imperative in parts of Minnesota where water erosion is of paramount importance. Growers as well as researchers have found reductions in N availability to be associated with systems which leave large amounts of crop residue on the soil surface and result in very little soil disturbance. The purpose of this study is to explore several management scenarios which may improve the availability of N.

OBJECTIVES

1. To assess the effect of tillage on the availability of nitrogen to corn.
2. To evaluate the potential for increased N availability with nitrification inhibitors.

METHODS AND MATERIALS

The experimental plots are located in Goodhue County, Minnesota on a Typic Hapludalf, fine-silty, mixed, mesic and Mollic Hapludalf, fine-silty,mixed, mesic (Seaton, silt loam and Mt. Carroll silt loam respectively). Tillage was done April 30 (chisel plow followed by a light disc). Both the no-till and till plant systems were planted with a Hiniker planter in the till plant configuration. Consequently during the establishment year these two systems are similar (until cultivation of the till plant system). Planting in the chiseled area was done with the fluted coulter and trash sweeps lifted. Residue cover was measured by the line transect method.

This site has been in continuous corn for the past ten years. The two years prior to this study were cropped with till plant tillage. Corn was planted (Pioneer 3732 single cross 105 day) on May 20, 1982 in 97 cm rows at a population of 70,000 plants/ha. Anhydrous ammonia was applied on May 11 at 0, 85, 170 and 340 Kg/ha. Plots were split with a .56 Kg/ha application of nitrapyrin. Weeds were controlled with a pre-emergence application of Atrazine (1.3 Kg/ha) and Alachlor (4.2 l/ha). A post-emergence application of 2,4-D amine (.56 Kg/ha) was needed to control Atrazine resistant Lambs Quarter. Grain and stover yields were measured at physiological maturity and tissue samples analyzed for N.

RESULTS AND DISCUSSION

A final stand of 68,000 plants/ha was obtained and not influenced by tillage. The effect of tillage on residue distribution is shown in table 1. There is no difference in cover in the row due to tillage. There is more cover between the rows with the no-till and till plant systems. These two systems had significant differences in and between the row. Chisel tillage resulted in similar cover regardless of position relative to the row.

Table 1. The effect of tillage on residue distribution (June 17, 1982)+.

	Position Retalive to Row++	
Tillage	In	Between
No-till	24 a	46 a
Till plant	18 a	49 a
Chisel	25 a	35 b

+ Means within the same column followed by different letters are significantly different at $\alpha = .10$, N = 48.

++ "In" is defined as the 20 cm area centered over the row and "Between" is the remainder. The no-till and till plant treatments are similar at this point in time.

The effect of tillage on nitrapyrin response is shown in table 1. There was no grain response beyond the first rate of applied N at this site. This makes it very dubious that there is a grain response to inhibitor at the higher rates. Corn grown under the chisel system had lower stover yields and N uptake at the 85 Kg/ha N rate. This may have caused the positive change in N index. Although May was very wet and conducive to N losses the anhydrous ammonia probably did not have a change to nitrify and therefore was less likely to be denitrified. June and July were very dry at this site. The inhibitor responses are spotty and show no obvious trend.

Least squares estimates for yields and N uptake are shown in table 2. Curves described by these equations are shown in figure 1. There are differences due to tillage of grain yield and N uptake with no N applied. The chisel system resulted in higher grain and stover yields as well as N uptake. Total N uptake appears to be higher over all levels of applied N for this system. There was little difference due to tillage in yields and grain N uptake beyond the first rate of applied N. The stover N uptake response over all rates of applied N are due to luxury consumption of N. Since there was very little N response at this location it is not possible to draw many conclusions. The differences in yield and N uptake (with no N applied) due to tillage suggest future differences with higher yield levels.

Table 1. The effect of tillage, N rate, and nitrapyrin on yield and N uptake at Goodhue County, MN, 1982+.

		Grain		Stover		Total Dry Matter		Index**	
	N rate Kg/ha	Yld Mg/ha	N upt Kg/ha	Yld Mg/ha	N upt Kg/ha	Yld Mg/ha	N upt Kg/ha	Harvest	N
No Till	85								
	170						*(11.6)		
	340		*(9.5)						
Till Plant	85								
	170								*(.016)
	340	*(.76)				*(1.0)		*(.017)	
Chisel	85			*(-.81)	*(-11.0)	*(-.58)			*(.046)
	170	*(.64)	*(12.7)				*(12.9)		
	340								

+ Values in parenthesis are mean differences.

* Means are significantly different at α = .10 with N = 4 as the result of a paired t test.

** Index is defined as: harvest = grain yield/total dry matter, and N = grain N uptake/total N uptake. Cob mass is included in stover estimates. It is assumed that cobs have the same N concentration as stover.

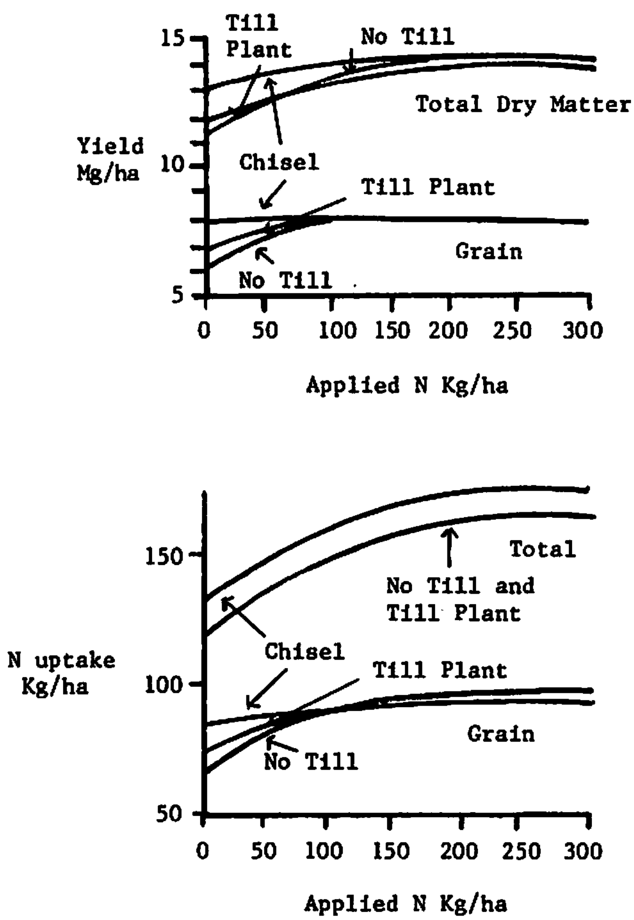
Appreciation is expressed for partial funding of this project to the Minnesota Plant Food and Chemical Association.

Table 2. Least squares estimates of corn yields and N uptake at Goodhue County, MN., 1982.[+]

No Till		
Grain	$= e^{-7.6285} N^{3.4053-.29664 \ln N}$	$R^2 = .57$
Total Dry Matter	$= e^{-4.2761} N^{2.3747-.20303 \ln N}$	$R^2 = .58$
Grain N uptake	$= e^{-10.758} N^{5.3245-.46177 \ln N}$	$R^2 = .59$
Total N uptake	$= e^{-4.9228} N^{3.3755-.28315 \ln N}$	$R^2 = .64$
Till Plant		
Grain	$= e^{-3.6938} N^{1.9778-.16823 \ln N}$	$R^2 = .62$
Total Dry Matter	$= e^{-3.0370} N^{1.9410-.16572 \ln N}$	$R^2 = .65$
Grain N uptake	$= e^{-6.9337} N^{4.0524-.35789 \ln N}$	$R^2 = .28$
Total N uptake	$= e^{-6.5178} N^{4.0162-.34665 \ln N}$	$R^2 = .61$
Chisel		
Grain	$= e^{1.8592} N^{.041747}$	$R^2 = .05$ (ns)
Total Dry Matter	$= e^{-1.2472} N^{1.3629-.11870 \ln N}$	$R^2 = .21$
Grain uptake	$= e^{3.7918} N^{.13106}$	$R^2 = .29$
Total N uptake	$= e^{-2.3024} N^{2.4785-.20534 \ln N}$	$R^2 = .64$

[+]Grain yields are at 15.5 percent moisture, N = 32 for each regression.

Figure 1. The effect of tillage and nitrogen rate on yield and N uptake, Goodhue, MN., 1982.



THE EFFECT OF TILLAGE, N RATE, SOIL P AND K AND NITRAPYRIN ON CORN GROWTH LANCASTER, WI - 1981 and 1982

J. F. Moncrief, E. E. Schulte and K. C. Killian

INTRODUCTION

There are many examples in the research literature which show reductions in nutrient availability to be associated with conservation tillage extremes (systems which involve very little soil manipulation and a high percentage of the soil surface covered with crop residues). In southeastern Minnesota (as well as NE, NW, and SW Iowa, Illinois and Wisconsin respectively) the soils are generally steeply sloping alfasols which have been shown to result in reduced N availability when very little tillage is employed (in a continuous corn monoculture). The study reported here is designed to characterize the response of corn to N, P, and K under different tillage as well as an attempt to enhance the N recovery with the use of nitrapyrin.

OBJECTIVES

1. To assess the effect of tillage on the availability of N, P, and K to corn.
2. To evaluate the potential for increased N availability with nitrapyrin.

METHODS AND MATERIALS

Experimental plots are located at the Lancaster, Wisconsin Experiment Station. The soil is a Typic Hapludalf, fine-silty, mixed, mesic (Fayette, silt loam). The plots are on a contour strip that had been in alfalfa in 1976. A heavy application of manure was applied and plowed down by the farmer owner in 1977 prior to a corn crop in this year. In 1978, fertilizer applications were made to adjust N, P, and K levels to those desired. In 1978, corn yields and tissue concentrations of ear leaves exhibited no N response and only a modest response to P and K. Tillage variables were introduced in 1979. Tillage treatments comprise main plots with fertility subplots. Tillage treatments are: spring moldboard plow, disc, plant; spring chisel plow,disc,plant; and no tillage. The 1981 and 1982 results will be discussed. A 108 day single cross hybrid (Blaney 606) was planted May 7, 1981 and May 5, 1982 and thinned to a population of 72,000 plant/ha (91 cm row width). Whole plant samples were taken on September 5, 1981 and September 9, 1981 (dough stage). There has been only modest response to P and K at this site so only N will be discussed. Nitrogen was applied on April 17, 1981 as broadcast ammonium nitrate (0, 110, 120, 340 Kg/ha) and April 29, 1982 as anhydrous ammonia (0, ∿100, ∿200, ∿250). In 1982 the time spent in each plot in combination with the mass of N applied was used to calculate the rate. This was necessary because of wheel slippage caused by varying soil conditions due to tillage. Differing levels of N was obtained by keeping the nitrolator setting constant and changing the tractor speed. So in this year there are three groups of applied N levels with variation in each group due to wheel slippage. Plots were split in 1982 with and application of .56 Kg/ha nitrapyrin. Weeds were controlled with a pre-emergence application of Atrazine (2.2 Kg/ha) and Alachlor (5 l/ha). Glyphosate was applied on local problem areas to control perennials. Soil covered by crop residue was estimated in mid June by the meterstick method in 1981 and line transect method in 1982.

RESULTS AND DISCUSSION

The percent of the soil surface covered with crop residue is shown in table 1. There are differences due to tillage. Values are higher between the row with the no-till (both years) and chisel (1982) probably because of the incorporation by the fluted coulter at planting in addition to planting off the old row with no-till. Higher values in 1982 are due to trash accumulation and the method of measurement.

The effect of nitrapyrin on corn growth is shown in table 2. In four instances the N rate of the minus inhibitor treatment was significantly higher than the plus inhibitor treatment. A reverse trend was apparent with the first rate of N under the no-till system. If the rates had been equal these differences may have been significant. There was a significant grain response with chisel tillage even though the rate was lower. There were no significant responses under moldboard tillage. It is interesting to note that in the only instance with a significant grain response there was also an increase in harvest index.

Table 1. Percent of the soil surface covered with crop residue. Lancaster, WI+.

Tillage	1981 In	1981 Between	1982 In	1982 Between
No-till	56(25)	89 (12)	72(15)	92(7)
Chisel	18(14)	18 (10)	32(14)	44(13)
Moldboard	3(5)	6 (7)	10(7)	13(8)

+ "In" is defined as the 20 cm area centered over the row and "Between" is the remaining area between rows. Numbers in parenthesis are standard deviations, N = 32.

Least squares estimates of grain yields and N uptake are shown in table 3. The lines that these equations describe are shown in figure 1. In both years the response with chisel and moldboard plowing were similar. This is also consistent with 1979 and 1980 (not shown). Corn grown with no tillage consistently required more applied N (also consistent for four years of the study). In the four years of study the no-till system resulted in significantly higher grain yields than under moldboard tillage in two, lower in one and equal in one. This was found to be related to rainfall (not shown here). In a dry year residue proved to be an advantage and in a wet year a detriment. It took much higher rates of applied N however.

The total N uptake with no N applied for the four years of study is shown in table 4. This is a bioassay of available N. It reflects mineralization of soil organic matter as well as crop residues, immobilization by crop removal, denitrification and leaching. With the exception of the first year the chisel and moldboard systems resulted in similar uptake values. Introduction of the no tillage treatment hastened the disappearance of residual N from the alfalfa and manure plow down in 1976 and 1977 respectively. This treatment has also stabilized at a lower value. If losses of applied N under this system were due to denitrification and/or leaching these should be reduced with a nitrification inhibitor, ammonium sources of N and injection. Although there are some encouraging trends in this direction with the 1982 data, any conclusions at this point would be premature.

Table 2. The effect of tillage, nitrogen rate, and nitrapyrin on corn grain and stover yields, nitrogen uptake and harvest index at Lancaster, WI., 1982.

N rate Kg/ha		Grain Yields Mg/ha (dry wgt)		Total Dry Matter Mg/ha (dry wgt)		Total Uptake Kg/ha		Harvest Index+	
-	+	-	+	-	+	-	+	-	+
				No Till					
0	-	2.78	-	6.19	-	46.1	-	.446	-
115	100*	5.10	5.73	11.3	11.6	113	127	.466	.504
195	202	6.45	6.73	12.1	12.3	169	173	.545	.557
252	256	6.17	6.25	10.7	12.1*	149	171*	.583	.523
				Chisel					
0	-	3.65	-	7.95	-	73.9	-	.459	-
114	97*	6.27	7.03*	12.8	12.2	164	167	.492	.582*
191	196	6.59	6.69	12.3	13.3	166	169	.535	.510
248	248	6.74	6.69	13.8	13.5	202	189	.496	.503
				Moldboard					
0	-	3.80	-	8.31	-	72.5	-	.458	-
103	98*	6.73	6.44	12.7	12.5	170	164	.538	.526
197	195	6.67	6.46	12.9	13.1	183	174	.520	.490
249	259*	7.05	6.67	12.6	12.9	169	173	.573	.522

* Treatment means (- = without and + = with nitrapyrin) are significantly different at $\alpha = .10$ as the result of a paired t test, N = 12.

+ Harvest index is defined as the ratio of grain/total dry matter.

Table 3. Least squares estimates of response of grain yields and N uptake at Lancaster, WI+.

No Till

1981 Grain = $e^{5.14223} N^{1.0181-.33123 \ln N+.24627 \ln K} K^{-2.4627+.24627 \ln N}$ $R^2 = .83$

N uptake = $e^{-7.5700} N^{4.4427-.39146 \ln N}$ $R^2 = .80$

1982 Grain = $e^{-19.165} N^{.48311} K^{7.0417-.66691 \ln K}$ $R^2 = .62$

N uptake = $e^{-3.3002} N^{2.6326-.20414 \ln N}$ $R^2 = .76$

Chisel

1981 Grain = $e^{6.4435} N^{3.1197-.28174 \ln N}$ $R^2 = .58$

N uptake = $e^{-4.6899} N^{3.2085-.25860 \ln N}$ $R^2 = .67$

1982 Grain = $e^{11.975} N^{5.1050-.46345 \ln N}$ $R^2 = .63$

N uptake = $e^{-8.6483} N^{4.7516-.40733 \ln N}$ $R^2 = .70$

Moldboard

1981 Grain = $e^{-.41726} N^{1.9291-.28511 \ln N+.11873 \ln K} K^{1.1873+.11873 \ln N}$ $R^2 = .69$

N uptake = $e^{-11.816} N^{5.9015-.51156 \ln N}$ $R^2 = .79$

1982 Grain = $e^{-9.1595} N^{4.0422-.36377 \ln N}$ $R^2 = .58$

N uptake = $e^{-13.689} N^{6.4337-.58136 \ln N} K^{.19057}$ $R^2 = .71$

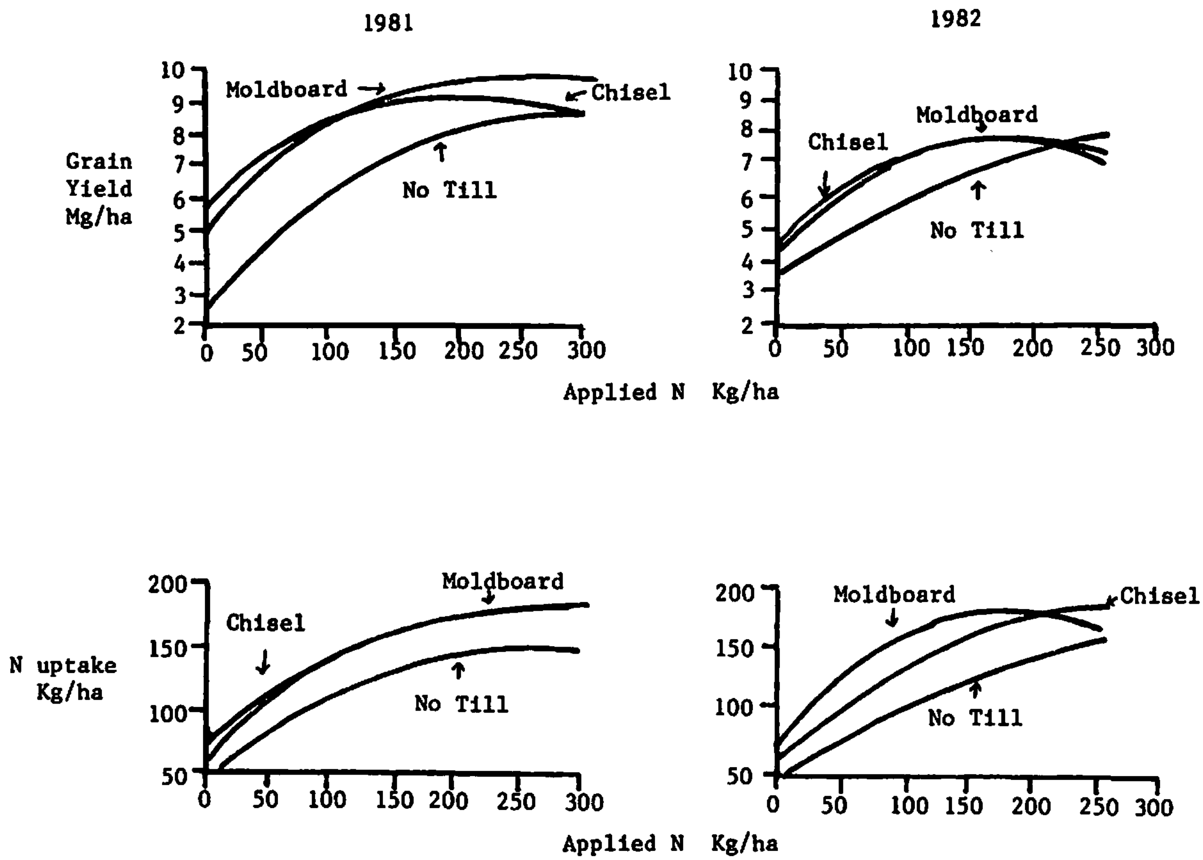
+ Grain yield estimates are at 15.5% moisture, N = 96 for each regression (averaged over inhibitor treatment).

Table 4. The effect of tillage on total N uptake of corn with none applied. Lancaster, WI+.

	1979	1980	1981	1982
No Till	108 a	61.1 a	44.0 a	46.1 a
Chisel	138 b	110 b	77.9 b	73.9 b
Moldboard	163 c	118 b	60.4 b	72.5 b

+Means within the same column followed by different letters are significant at $\alpha = .10$, N = 12.

Fig. 1 Response of grain yields (at 15.5 percent moisture) and N uptake to applied N at Lancaster, WI[+].



[+] In 1981 N was applied before spring tillage as ammonium nitrate and in 1982 after tillage as anhydrous ammonia.

CORN TILLAGE RESIDUE MANAGEMENT, LANCASTER, 1982

J.B. Swan, A.E. Peterson, W.H. Paulson, R.Higgs,
D. Linden, G. Randall, C. Sheaffer

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 on the Lancaster Experimental Farm. Five tillage treatments are replicated four times (table 1) the first replication is located on Palsgrove silt loam; the other three replications are located on Rozetta silt loam. Each treatment is split into normal and mulched subtreatments. On the slot plant and till-plant plots on additional subtreatment (bare) is established by removing all residue prior to planting; the residue is then placed on the adjacent mulched plots of the same tillage treatment. On mulched subtreatments, corn residue additions are made after tillage but before planting to obtain approximately 60 percent surface cover. Plots are approximately 90 to 100 feet in width and 80 feet in length. Row width is 36 inches in 1982, slightly less than the 38 inch row width which predominate in the region. In 1982 corn (Pioneer 3734) was planted (at 30,500 plants/A) on May 17 following spring primary tillage on May 13 and secondary tillage with a disc on plow and chisel treatments on May 14. A Hiniker planter was used for the till-plant, slot plant, fall chisel and spring plow treatments. An AC model 77 planter was used on the wheeltrack treatment.

Nitrogen (250 lbs/A as ammonium nitrate) was broadcast on April 26, 1982. On Nov. 18, 1981, 0-0-60 was applied to 2.5 acres at a rate of 600 lbs/A to equalize fertility levels between replications. Liquid starter was applied at planting. Insecticide used was Counter at 8 lbs/A. Chemical weed control used was: 2lbs/A Aatrex 1.5 qts/A. Prowl and 1 pt/A Banvel. The till plant treatment was cultivated on July 7-8 to create ridges using furrow opener (lister type) shovels without covering discs. Stand reduction from herbicide injury was observed on much of the plot area; sufficient unaffected plot area remained to permit yields to be taken on most plots.

Mulch rates, crust strength, planting depth, plant height, silking date and early growth measurements were made on designated portions of each plot. Random roughness measurements were made on all treatments in replication No. 2 on May 17 and again on June 7-8.

Ten plot frames (40x40 inch) were emplaced on May 18 and covered to protect the surface. Infiltration measurements were made on the wheeltrack plant bare, conventional mulch, conventional bare, till plant normal, slot plant normal treatments on June 7-11.

Neutron probe measurements were made on June 28; equipment failure precluded additional measurements. Soil nitrate-N content within the rooting depth was measured July 8, 1983. Bulk density measurements were made on the 1-3 inch depth.

Yields were determined by hand harvesting duplicate 60 foot samples from each subplot on November 4, 1982.

RESULTS

Differences in early growth due to the tillage-mulch treatments were significant at the 0.01 level. The greatest early growth occurred on the bare slot plant treatment and the least on the mulched wheeltrack plant treatment. The second highest early growth occurred on the mulched till plant treatment. All the other treatments did not differ significantly from each other. Early growth was consistently depressed (REG < 1) as mulch cover increased for all treatments except till plant

(REG > 1) where the trend was reversed (table 2). Thus mulch in the row consistently decreased early growth (REG < 1), while mulch between row did not affect or possibly increased early growth (REG < 1) if the row area was bare.

The strong effect of mulch on early growth was apparently related to the 4.5°F below normal average temperature in June (table 3). The response of relative yield (yield with mulch/yield without mulch) was similar to relative early growth and the two were closely correlated in 1982 as percent cover increased. Relative yield decreased for all treatments except till plant. The presence of cover significantly decreased yield when (O) and (IX) levels were analyzed as a 2 x 5 factorial; however, the effects of tillage system was not significant nor was the tillage cover interaction.

Plant height measurements were not significantly different when measured on July 8. All treatments reached 50% silking within 1-day of each other. Very little difference was observed in rate of emergence between treatments in 1982. Significant differences occurred in depth of planting within the wheeltrack plant treatment where the presence of residue reduced depth of planting by a factor of 2. The other treatments were planted with the Hiniker planter and no significant differences due to residue were detected within any tillage treatment.

Soil nitrate nitrogen amounts were measured on each replication for the conventional and slot plant treatment on July 8, 1982. Average values for the two treatments were nearly identical and were in excess of 260 lbs/A (table 4).

Large differences in final (60 minute) infiltration rates were measured between treatments (table 5). When mulch was present on the conventional tillage tillage, final infiltration rate was 50 percent greater than the bare conventional tillage treatment. Slot plant had the lowest final infiltration rate and the lowest amount of infiltration before runoff began of all the treatments, even though between 3 and 4-tons per acre of surface residue cover was present on the slot plant treatment. The infiltration rate for the till plant and wheeltrack plant treatments were intermediate between the conventional bare and conventional mulch treatment. These results illustrate the dual requirement of 1) a porous surface with high saturated hydraulic conductivity and 2) a protective mulch cover in order to have rapid sustained infiltration. Residue cover by itself is not sufficient to produce a high infiltration rate.

SUMMARY

Four year results of Lancaster with continuous corn show nearly equal average yield from conventional, chisel, slot plant, and till plant treatments (table 5).

Thus famers in the driftless soil area 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 also offer savings in time, labor, and fuel compared to conventional moldboard plow tillage methods.

Table 1. Effect of tillage and mulch treatments on planting depth, corn early growth, plant height, silking date and yield, Lancaster, 1982.

Treatment Tillage	Residue	Dry[1] matter T/A	Percent cover	Avg planting depth inches	Avg Early growth gms DM/ plants	Avg inches height July 8 inches	Date 50% plants silked day after July 1	Avg Population at harvest[4]	Avg yield bu/A *	Avg yield incl. plots with reduced population
Till plant	Bare (0)	-	3	1.5 bc	24.0 abc	29.3	30.5	18,000	151*	131
	Normal (IX)	2.1	20	1.8 bc	25.7 abc	31.5	30.3	19,000	147*	137
	Mulch (2X)	4.5	32	1.7 bc	28.6 ab	32.3	30.8	19,000	145	
Slot Plant	Bare (0)	-	5	1.7 bc	34.8 a	33.0	30.5	21,800	153	
	Normal (IX)	2.1	50	1.6 bc	16.2	29.2	31.0	20,000	141*	132
	Mulch (2X)	5.5	76	1.3 c	21.8 bcd	30.8	31.3	23,900	142	
Conventional[2]	Normal (0)	-	3	1.7 bc	23.9 abcd	35.5	30.5	20,100	151*	138
	Mulch	5.5	55	2.0 ab	16.1 abcd	32.3	30.8	22,200	151	138
Fall Chisel[3]	Normal (N)	1.3	12	1.7 bc	26.6 abc	33.3	30.8	21,400	154*	124
	Mulch (IX+N)	3.3	58	1.9 ab	15.6 cd	33.8	31.0	20,500	134	
Wheeltrack plant	Normal (0)	-	1	2.5 a	15.5 cd	32.3	31.0	26,900	147	
	Mulch (IX)	3.5	65	1.2 c	11.1 d	30.0	31.3	26,100	135	
Significance level				0.05	0.01	ns			ns	

* Plots with population 18,000 plants per acre due to herbicide injury were treated as missing plots

1 Reps 1 and 2

2 Spring moldboard plow, spring disk

3 Fall chisel, spring disk

4 Includes plots with severe stand reduction due to herbicide injury

Table 2. Effect of mulch on relative early growth (REG) and relative yield (RY)*

Where $REG = \frac{\text{Early growth with mulch}}{\text{Early growth without mulch}}$ $RY = \frac{\text{Yield with mulch}}{\text{Yield without mulch}}$

Tillage	Mulch level	Percent Cover	REG	RY
BTP	(IX)	20	1.07	1.021
	(2X)	32	1.19	1.069
Slot	(IX)	50	0.47	0.906
	(2X)	76	0.63	0.882
Conventional	(IX)	55	0.67	0.946
Chisel	(IX+N)	58	0.59	0.915
WTP	(IX)	65	0.71	0.936

*Yield adjusted to equal populations for each RY comparison

Table 3. 1982 Weather Summary, Lancaster Experimental Farm

Month	Precipitation inches		Growing* Degree Days		Air Temperature			
	Total	Departure	1982	Departure	Avg max	Avg min	Average	Departure
April	1.96	-1.25	(54)	-	54.5	31.0	42.8	-3.9
May	5.46	2.10	414	108	72.4	52.7	62.6	4.6
June	3.45	-1.16	405	-107	73.8	50.9	62.4	-4.5
July	5.27	0.93	688	33	81.5	62.1	72.3	1.1
August	4.06	-0.64	585	- 3	78.9	59.1	69.0	0.4
September	1.29	-2.14	368	19	71.5	51.1	61.3	0.5
October	3.28	1.14	(145)	-	63.5	41.5	52.5	2.0
April-Oct.	24.77	-1.02	2460	50				

Last day in spring with minimum temperature: 32° on <April 27 (31°)
28° on <April 21 (27°)

First day in fall with minimum temperature: 32° on <Oct. 16 (32°)
28° on <Oct. 21 (25°)

Table 4. Soil nitrate nitrogen for conventional and slot plant treatments measured July 8, 1982, Lancaster - Wisconsin.

	Rep I ppm		Rep II ppm		Rep III ppm		Rep IV ppm		
Sample depth	Conv	Slot	Conv	Slot	Conv	Slot	Conv	Slot	
0-1	27	47	30	37	44	35	53	32	
1-2	18	20	27	16	14	23	14	14	
2-3	*	*	10	12	5	13	7	8	
3-4			*	*	5	*	6	6	
4-5					*		6	6	
Total ppm	45	67	67	65	68	71	86	66	
Tillage	Total Profile Soil Nitrate-N in lbs/A								Avg lbs/A N
Conv	180		268		272		344		266
Slot		268		260		284		264	269

Table 6. Continuous corn tillage yield results at Lancaster, Wisconsin, 1979-1982.

Tillage	1979	1980 Bu/A	1981	1982	Average Bu/A
Till Plant*	162*	157	157*	147	156
Soil Plant	163	146	151	141	150
Chisel	160	150	167	154	158
Conventional	169	159	168	151	162

*Planted flat in 1979 and 1981.

Table 5. Infiltration rate

Tillage System	Residue T/A	Random Roughness	Inches inf. to start of runoff	Appl. rate in/hr	Infiltration rate* at time indicated after runoff commences (Inches/hour) 5 min	10	15	20	25	35	45	55	60	75	90 min	ic
Slot Plant					1.77	1.46	1.32	1.24	1.18	1.11	1.06	1.02	1.01		0	0.70
E	4.0	0.83	0.50	4.64												
W	8.3	0.53	0.23	4.64												
Conv-Plow Disk-Bare					2.59	2.14	1.94	1.82	1.74	1.63	1.56	1.51	1.49			1.05
E	T	1.30	0.89	3.92												
W	T	1.40	0.55	5.12												
Mulch					2.65	2.50	2.44	2.40	2.37	2.34	2.32	2.30	2.29	2.28	2.27	2.15
E	1.2	1.46	1.06	4.72												
W	0.9	1.64	1.02	5.12												
Wheeltrack Plant					2.81	2.51	2.38	2.30	2.25	2.18	2.13	2.10	2.09			1.80
E	T	1.72	0.61	5.04												
W	T	1.48	0.73	4.64												
Till Plant					3.72	2.89	2.52	2.31	2.16	1.96	1.84	1.75	1.71			0.90
E	1.4	1.07	0.81	5.28												
W	2.1	1.22	1.17	5.22												

*Calc. from regression EQ developed from paired infiltration runs ($i = ic + S/2\ t^{-y2}$)

	ic	S/2
Slot Plant	0.70	2.40
Conv. Bare	1.05	3.45
Mulch	1.12	2.15
WTP	1.80	2.27
Till Plant	0.90	6.30

SULFUR, BORON AND MAGNESIUM TRIALS ON A PROBLEM ALFALFA FIELD

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

Yields of irrigated alfalfa on sandy loam soils have been unsatisfactory at some locations in Stearns County. This led to the establishment of a trial with sulfur, boron and magnesium where phosphorus and potassium were maintained at very high levels. These trials were on the Eugene Heinen farm.

Tables 1 and 2 show alfalfa yields, related soil tests and plant analysis resulting from sulfur, boron and magnesium treatments.

Plant analysis shows only copper and magnesium for all cuttings to be below adequate levels. The sulfur soil test of 5 is considered below the adequate level.

There was no significant effect of treatments on yield. Except for sulfur at the first cutting the concentration of nutrients in the upper third of alfalfa plants was not affected by treatment.

The alfalfa stands were good but growth appeared to be less than expected. First cutting yields were below the other two cutting yields because irrigation was not possible for the first cutting. It would appear that there is some limiting factor affecting yields but the one year's data fails to reveal the problem.

It would appear on the basis of plant analysis that rates of copper should be included in the trial.

Table 1. Alfalfa yields by cutting and relationship to sulfur, boron and magnesium treatments. Stearns Co. 1982.

		Tons/A @ 15% M				Soil Test	
trt	lbs/A	1	2	3	Total		
check		1.00	1.27	1.35	3.62	Text	SL
S	100	0.91	1.48	1.46	3.85	O.M.	M
B	3	0.85	1.46	1.40	3.71	pH	7.3
Mg	300	0.93	1.58	1.43	3.94	P	200+
						K	443
significance		ns	+	ns	ns	Mg	204
C.V.		12.7	7.2	11.7	4.4	S	5 ppm

Table 2. Plant analysis of alfalfa for 3 individual cuttings according to sulfur, boron and magnesium treatments.

		Tissue Analysis									
		%					ppm				
1st cut		S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
trt	lbs/A										
check		.41	.44	3.28	1.67	.25	119	55	30	3	43
S	100	.44	.44	3.40	1.63	.25	110	52	31	3	40
B	3		.43	3.17	1.75	.25	116	55	30	3	43
Mg	300		.43	3.19	1.81	.26	116	57	29	3	36
adequate levels		.30	.25	2.40	1.70	.30	30	30	20	10	30
significance		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.		-	2.0	5.5	1.7	9.5	5.3	9.4	3.7	9.7	18.6
2nd cut		S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
check		.32	.44	2.81	1.96	.29	115	69	32	5	47
S	100	.35	.47	2.75	2.05	.28	118	72	33	5	45
B	3		.45	2.80	2.04	.27	110	65	31	6	42
Mg	300		.47	2.72	2.04	.27	111	65	33	5	38
adequate levels		.30	.25	2.40	1.70	.30	30	30	20	10	30
significance		*	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.		-	3.6	2.2	2.5	7.7	6.4	14.4	4.2	4.1	17.7
3rd cut		S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
check		.33	.37	2.65	2.12	.26	104	75	26	4	55
S	100	.34	.37	2.49	2.25	.26	104	76	26	4	51
B	3		.35	2.58	2.14	.24	99	70	26	5	50
Mg	300		.36	2.61	2.26	.26	104	78	27	5	45
adequate levels		.30	.25	2.40	1.70	.30	30	30	20	10	30
significance		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.		-	3.1	3.0	3.6	9.3	4.3	11.6	5.8	9.7	20.6

HIGH PHOSPHORUS AND POTASSIUM RATES FOR CONTINUOUS CORN

1982

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, '81
	----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 and 1981.

[6] 100 + 0 was applied at all locations in 1980 and 1981.

The P and K materials were broadcast on cornstalks and plowed down at all locations in the fall of 1981. Phosphorus was applied as CSP (0-46-0) and K as muriate of potash (0-0-60). Starter fertilizer was not used.

Specific experimental procedures used for soybeans at each of the stations are presented in Table 2. Management practices providing for optimum yields were employed at each location.

At Lamberton each of the plots were split with the east half planted to corn and the west half to soybeans. Corn (Pioneer 3732) was planted in 30-inch rows on April 28 at 24500 ppA. Nitrogen was applied at 150 lb N/A. Weeds were controlled with Lasso (2½#) and Bladex (1½#). The leaf opposite and below the ear was sampled at silking. Yields were taken on October 11.

Table 2. Experimental procedures for soybeans on the high P and K rate study at the three branch stations in 1982.

Variable	Lamberton	Morris	Waseca
Planting date	5/4	5/20	5/20
Row spacing	30"	6"	15"
Planting rate	9 seeds/foot	3 beans/foot	5 beans/foot
Variety	Corsoy-79	Evans	Corsoy-79
Herbicide	3/4# Treflan + 2# Amiben/A (Bdct)	3#Lasso + 2 1/2# Amiben + 3/4# Basagran/A (Bdct)	3 1/2# Lasso + 2 1/2# Amiben/A (Bdct)
Harvest date	10/25	10/18	10/25

RESULTS AND DISCUSSION

Soil samples taken at the end of the 1982 growing season indicate significant differences in Bray P_1 extractable P and exchangeable K 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 indicated about twice as much extractable P in this soil as with the 1:10 ratio at the higher levels and about 4 times as much at the low soil P levels. Soil P values obtained with Olsen's $NaHCO_3$ test on the calcareous soil at Morris were slightly lower than with the Bray P_1 test (1:10 ratio), but compared very similarly on a relative basis. The response to the annual K applications was not as pronounced as with P. A linear increase in soil test K with increasing K application rates was not always found. Soil pH was not related to the P and K treatments.

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

Treatment		pH			P					K		
No.	Description[2]	La	Mo	Wa	La	M_{10}	M_{01}	M_{50}	Wa	La	Mo	Wa
	lb P_2O_5+K_2O/A				lb/A							
1	0 + 0	6.0	7.7	6.6	51	6	4	26	25	275	286	311
2	0 + 100	6.1	7.8	6.5	44	6	4	25	17	390	448	369
3	50 + 100	6.4	7.7	6.3	71	32	24	71	58	375	385	380
4	100 + 100	5.9	7.7	6.5	94	64	45	126	92	366	376	355
5	0 + 100	6.3	7.7	6.5	72	22	14	52	53	374	369	406
6	100 + 0	5.8	7.7	6.5	95	69	48	134	96	280	305	331
7	100 + 50	6.0	7.7	6.5	94	60	53	134	91	342	327	327
8	100 + 0	6.0	7.6	6.4	100	72	56	140	83	316	313	320
9	0 + 100	6.2	7.8	6.5	48	22	14	51	31	321	285	349
10	100 + 0	6.2	7.8	6.5	88	13	8	38	68	303	297	318
	Signif.Level (%):[3]	56	NS	14	99	99	99	99	99	99	99	99
	BLSD (.05) :				22	11	10	16	13	46	51	40
	CV (%) :	5.6	21.	2.9	20.	23.	27.	15.	13.	10.	11.	6.5

[1] Samples were taken in October before the 1982 treatments were applied.

[2] Rates applied in fall of 1981 for 1982 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.

Table 4. Effect of high P and K rates on the nutrient concentrations in the soybean leaves at the three experimental sites in 1982.

Treatment		Nutrient Concentration[1]								
No.	Description	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb P_2O_5+K_2O/A	%				ppm				
					Lamberton					
1	0 + 0	.43	2.10	1.08	.49	132	49	49	10.9	67
2	0 + 100	.41	2.44	1.05	.38	129	47	50	11.6	69
3	50 + 100	.42	2.38	1.10	.41	137	52	44	9.5	64
4	100 + 100	.44	2.50	1.14	.42	131	49	46	8.5	67
5	0 + 100	.42	2.32	1.07	.41	135	52	46	10.3	66
6	100 + 0	.43	2.10	1.19	.51	134	53	45	7.6	67
7	100 + 50	.44	2.41	1.11	.44	128	54	48	8.5	68
8	100 + 0	.44	2.27	1.14	.46	138	53	45	7.4	70
9	0 + 100	.42	2.37	1.05	.41	140	54	49	11.4	66
10	100 + 0	.43	2.17	1.16	.49	134	49	44	9.0	69
	Signif. Level (%):	96	99	99	99	53	52	44	99	69
	BLSD (.05) :	.02	.21	.08	.02				0.8	
	CV(%) :	3.0	5.9	4.4	3.9	5.6	9.3	10.	6.0	5.0
					Morris					
1	0 + 0	.44	2.28	.85	.41	166	77	50	13.7	43
2	0 + 100	.40	2.33	.85	.40	162	82	53	14.0	42
3	50 + 100	.47	2.25	.86	.40	155	71	44	12.1	43
4	100 + 100	.47	2.40	.91	.38	157	79	41	11.1	45
5	0 + 100	.46	2.32	.85	.39	161	76	44	12.9	44
6	100 + 0	.49	2.22	.95	.45	156	75	41	10.3	47
7	100 + 50	.49	2.29	.93	.40	152	90	41	10.9	46
8	100 + 0	.49	2.31	.92	.40	153	72	40	9.9	45
9	0 + 100	.48	2.19	.90	.44	155	78	43	11.2	45
10	100 + 0	.46	2.29	.89	.42	151	77	45	12.9	44
	Signif. Level (%):	NS	NS	NS	*	NS	NS	99	99	*
	BLSD(.05) :				.04			7	1.4	3
	CV(%) :	10.	5.8	6.9	6.4	7.0	12.	10.	8.6	4.0
					Waseca					
1	0 + 0	.43	2.00	1.10	.49	110	42	44	9.9	45
2	0 + 100	.40	2.28	1.04	.41	111	44	44	10.7	45
3	50 + 100	.46	2.32	1.11	.43	112	46	43	9.2	48
4	100 + 100	.48	2.34	1.08	.42	107	45	41	7.6	46
5	0 + 100	.47	2.30	1.06	.42	109	44	42	9.1	44
6	100 + 0	.48	1.96	1.13	.50	110	46	41	7.6	47
7	100 + 50	.49	2.15	1.04	.45	109	45	42	7.5	44
8	100 + 0	.49	2.10	1.06	.47	106	44	44	7.5	46
9	0 + 100	.45	2.26	1.06	.42	109	45	42	9.7	45
10	100 + 0	.48	2.06	1.07	.48	108	46	42	8.2	46
	Signif. Level(%):	87	99	39	99	3	48	54	99	72
	BLSD(.05) :		.21		.04				0.7	
	CV(%) :	9.1	6.3	5.9	6.6	6.2	6.2	5.3	6.0	4.3

[1] Uppermost, mature trifoliate at the R2 stage.

Soybean leaf nutrient concentrations were affected significantly by the P and K treatments at Lamberton but to a lesser degree at Waseca and Morris (Table 4). At all locations leaf P was slightly less with the 0 + 100 treatment (no. 2) than with the 0 + 0 treatment (no. 1). Leaf Cu was reduced with increasing P rate at all three sites. At Lamberton, the increasing P rates increased leaf P, Ca and Mg. The K treatments had a lesser effect than P, but leaf K was increased slightly and leaf Mg decreased with increasing K rate. Although the trend toward higher leaf P was seen at Morris, the P treatments did not affect leaf P significantly due to the high variability (CV=10%). Leaf Zn was decreased significantly by the P treatments. The K rates had no effect on leaf K at Morris. Similar to Morris, leaf P showed an upward trend with increasing P rates at Waseca, but this was only significant at the 87% probability level. Leaf K was significantly improved with increasing K rates while Mg was reduced.

Soybean yields were influenced significantly (95% level) at all three locations by the treatments (Table 5). At Lamberton, no consistent relationship existed between the P or K treatments and yield. Oddly enough, the highest soybean yields at Lamberton occurred where K has not been applied during the 9-year course of study. Distinct yield responses to the annual 50-lb P_2O_5 rate were observed at Morris and Waseca. The annual 100-lb rate of P_2O_5 did not improve yields significantly over the 50-lb rate. When comparing the yield data in Table 5 with the leaf P data in Table 4, it appears that a leaf P concentration of at least 0.46% was needed to optimize soybean yields at Morris and Waseca. No yield response to K was seen at any of the sites.

All nutrient concentrations in the corn except B were increased by the P and K treatments at Lamberton (Table 6). The increasing P rates resulted in a slight but significant increase in leaf P (due to extremely low variability, CV=4.6%) and a signficiant reduction in leaf Cu. Leaf K was very low with those treatments that never contain K (trt. nos. 1 and 6) and was increased linearly with increasing rates of fertilizer K. Concomitant decreases in leaf Ca, Mg and Mn were found with increasing K rates.

Table 5. Soybean yields at the three sites as influenced by high P and K rates in 1982.

Treatment No.	Treatment Description	Lamberton	Morris	Waseca
	lb P_2O_5+K_2O/A	bu/A		
1	0 + 0	51.2	47.1	53.3
2	0 + 100	47.8	45.6	51.5
3	50 + 100	50.0	53.0	58.4
4	100 + 100	49.9	56.3	57.9
5	0 + 100	48.9	54.6	55.9
6	100 + 0	51.4	56.7	57.7
7	100 + 50	49.8	54.7	58.0
8	100 + 0	48.3	57.8	55.9
9	0 + 100	49.0	57.6	55.1
10	100 + 0	49.3	53.1	56.0
Significance Level(%):		95	99	99
BLSD(.05) :		2.8	4.8	3.2
CV(%) :		3.1	6.3	3.8

Table 6. Effect of high P and K rates on the nutrient concentrations in the corn earleaf at silking at Lamberton in 1982.

Treatment No.	Treatment Description	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		Nutrient Concentration								
	lb P_2O_5+K_2O/A	%				ppm				
1	0 + 0	.31	1.41	.46	.47	136	80	37	4.9	6.2
2	0 + 100	.29	2.02	.40	.31	126	60	27	4.9	5.2
3	50 + 100	.29	1.83	.39	.32	117	52	28	4.4	5.7
4	100 + 100	.33	1.83	.42	.34	130	64	31	3.8	5.8
5	0 + 100	.30	1.82	.41	.33	121	53	28	4.1	5.6
6	100 + 0	.31	1.32	.48	.50	130	75	36	3.7	6.3
7	100 + 50	.31	1.58	.45	.42	126	62	29	3.4	5.8
8	100 + 0	.31	1.49	.46	.43	123	64	27	4.0	5.7
9	0 + 100	.29	1.70	.42	.37	119	50	27	3.7	5.5
10	100 + 0	.31	1.48	.48	.46	126	69	31	4.2	5.6
Significance:		99	99	99	99	99	99	98	99	65
BLSD (.05) :		.02	.10	.03	.03	8	13	8	0.9	
CV (%) :		4.6	4.7	4.6	6.1	4.1	14.	15.	14.	11.

Due to the high variability (CV=25%), early plant weight was not significantly different at the 90% level (Table 7). However, early weight was increased by 36 and 57% with the annual 50 and 100-lb P_2O_5/A treatments over the 0 P_2O_5 rate (trt. no. 2). Weight increases with the same K_2O rates were only 5 and 16% over the 0 K_2O rate (no. 6).

Plant height was increased significantly (99% level) by both the P and K treatments. Small plant height was increased over the 0 lb P_2O_5 treatment (no. 2) by 42 and 47% with the annual 50 and 100-lb P_2O_5 treatments, respectively. Response to K was less but still showed 12 and 17% increases to the 50 and 100-lb K_2O rates, respectively.

Neither grain yield nor final population were related to or affected significantly by the P and K treatments at Lamberton in this year with good growing conditions (Table 7). Variability within the experiment was very low as shown by a CV of 4.1% for yield.

Table 7. Early plant growth, plant population, and grain yield as influenced by high P and K rates at the Lamberton site in 1982.

Treatment		Early plant		Final	Grain
No.	Description	Weight	Height	popl'n.	Yield
	lb P_2O_5+K_2O/A	g/dry plant	cm	x 10^{-3}	bu/A
1	0 + 0	1.2	19	21.6	146.9
2	0 + 100	1.4	19	21.4	147.5
3	50 + 100	1.9	27	21.5	151.5
4	100 + 100	2.2	28	21.6	149.0
5	0 + 100	1.6	25	21.6	151.4
6	100 + 0	1.9	24	21.4	146.4
7	100 + 50	2.0	27	21.9	155.3
8	100 + 0	2.1	27	21.6	150.7
9	0 + 100	1.6	21	21.8	150.4
10	100 + 0	1.9	24	21.2	148.9
	Signif. Level (%):	87	99	28	34
	BLSD (.05) :		3		
	CV (%) :	25.	10.	2.3	4.1

ACKNOWLEDGEMENT

Sincere appreciation is extended to the Tennessee Valley Authority-National Fertilizer Development Center for their financial assistance in this project.

NITROGEN, PHOSPHORUS, AND POTASSIUM FERTILIZATION OF POTATOES ON NONIRRIGATED MINERAL SOILS IN NORTHWESTERN MINNESOTA

W. E. Fenster, J. Grava, M. O'Leary, T. King, G. Buzicky, D. Preston

Five field experiments were conducted with potatoes at two locations in Polk County during 1982 to generate experimental data which would provide a basis for examination of current fertilizer recommendations based on soil tests. At the present time there are large discrepancies in the N, P, K recommendations between North Dakota and Minnesota, with Minnesota recommending considerably higher rates. Since the University of Minnesota has not conducted any recent research on potatoes in NW Minnesota it was felt that research needed to be done to ascertain if our recommendations could be lowered without sacrificing yield or quality.

EXPERIMENTAL PROCEDURE

Paul Hoff Farm, East Polk County

Effects of broadcast N, P, K, applied with and without row fertilizer were determined in three separate experiments on a calcareous loam soil. Wheat had been grown the previous year. Soil was plowed and field cultivated in fall 1981. Ammonium nitrate, triple superphosphate and muriate of potash were broadcast and incorporated into the soil on May 26, 1982. Row fertilizer, consisting of 300 lb/a of 10-10-10 was applied with a row-marker which places the fertilizer in a band directly below the seed. Burbank Russet potatoes were planted on May 29. Weeds and insects were controlled by farmer's regular practices. Potatoes had sprouted on June 15 and emerged on June 20.

Don Mack Farm, West Polk County

Effects of N and P, applied with and without row fertilizer were determined in two experiments on a calcareous silty clay soil. The field had been in wheat in 1981 and it was fall plowed. Broadcast and row fertilizers were applied on May 25 and incorporated into the soil with a row-marker. Norchip potatoes were planted on May 25. Farmer's regular practices were effective in controlling weeds and insects.

Treatments in these fertilizer experiments with potatoes consisted of broadcast N, P, and K rates with and without the row fertilizer (30+30+30) arranged in a split block design replicated four times. Individual plots were 38 ft wide and 40 ft long (Mack Farm), and 26 ft wide and 40 ft long (Hoff Farm); a half of each plot received row fertilizer and another half received none.

Soil samples were collected in spring of 1982 prior to fertilizer application and were analyzed by the University of Minnesota Soil Testing Laboratory. Soil test results (Table 1) indicated very high levels of Olsen extractable phosphorus in the plow layer at both locations; exchangeable K was very high on the Mack Farm (499 lb/a) and medium on the Hoff Farm. Medium levels of NO_3-N in the top two feet of soil were found on these two fields (55 and 34 lb/a).

The petiole and leaflets of the 4th leaf from the growing tip of 15 plants were collected at random from each half-plot at two different times during the growing season. At the early season sampling on July 20, about 30 days after plant emergence, the plants were in the early flowering stage with some flowers open. At the midseason sampling which occurred on August 9, or about 50 days after emergence, after full bloom and late flowering, Kjeldahl N, and elemental analyses were made by the Research Analytical Laboratory, University of Minnesota.

Potatoes were harvested with a potatoe digger. Total weight of nongraded tubers was determined and expressed as cwt/acre.

RESULTS

The experimental results should be viewed in light of a rather atypical growing season in 1982. Planting was delayed 2 weeks due to three inches of rain that fell between May 4 and May 19. In addition, June was abnormally cool, having the lowest mean monthly temperature in the past 93 years.

Hoff Farm

Broadcast nitrogen applied at rates ranging from 0 to 150 lb/a markedly increased the N concentration in the leaf at both samplings but depressed the total weight and specific gravity of tubers (Table 2). While row fertilizer (30+30+30) had no effect on tuber weight or quality, it resulted in slightly higher leaf-N in early season.

In the phosphorus experiment, neither broadcast P nor row fertilizer had any effect on the yield or quality of tubers, and the concentration of P and other chemical elements in the leaf (Table 3). It should be noted that Olsen P at this location was 57 lb/a indicating a very high level of this plant nutrient.

Broadcast potassium applied at five rates ranging from 0 to 500 lb K_2O/a to a soil having a medium level of exchangeable K (126 lb/a) increased the yield of tubers from 182 to 217 cwt/a, decreased the specific gravity from 1.084 to 1.074, and significantly increased the concentration of leaf K at both samplings (Table 4). While row fertilizer had no effect on tuber yield or specific gravity, leaf K was slightly increased by it at early and midseason.

Mack Farm

Generally, neither broadcast N nor row fertilizer had any effect on the yield or specific gravity of tubers, and the leaf-N (Table 5). The only exception to this was an increase in leaf-N at midseason associated with the application of 150 lb N/a. At this location, 55 lb/a of NO_3-N were measured in the top 2 ft of the soil. The tuber yield ranged from 134 to 174 cwt/a.

The potato yield in the phosphorus experiment ranged from 152 to 195 cwt/a (Table 6). Generally, neither broadcast P nor row fertilizer had any effect on the yield and specific gravity of tubers or the concentration of plant nutrients in the leaf tissue of potatoes. Extractable P by the Olsen method in the plow layer was 31 lb/a, considered to be a very high level.

Table 1. Soil Test Results[1/] of samples collected from experimental sites.

Location Experiment	Sampling depth (inches)	pH	O. M. %	Bray 1 1:10 P lb/A	Bray 1 1:50 P lb/A	Olsen P lb/A	Exch. K lb/A	Zn ppm	NO_3-N lb/A	Exch. Mg lb/A
Hoff Farm	0-6	8.0	4.2	88	158	57	134	0.8		
Phosphorus trial	6-12	8.1		34	61	16				
Nitrogen trial	0-24								34	
Potassium trial	0-6	8.0		75	133	44	126			633
Mack Farm	0-6	8.2	5.2	13	145	31	499	0.8		
Phosphorus trial	6-12	8.4		2	9	8				
Nitrogen trial	0-24								55	

[1/] Soil test results are averages of 4 samples

Table 2. The effect of broadcast Nitrogen and row fertilizer on yield, specific gravity, and N content of leaf tissue of potatoes. Hoff Farm, W. Polk Co., 1982.

Treatment		Yield Cwt/A	Specific Gravity	Sampling Early Season Leaf-N %	Sampling Midseason Leaf-N %
Main Effects					
Broadcast N, lb/A					
0		229	1.083	5.08	4.47
50		202	1.076	5.23	4.98
100		192	1.072	5.41	5.30
150		180	1.070	5.38	5.35
Significance		**	**	*	**
BLSD (.05)		19	.009	.38	.19
Row Fertilizer					
-		201	1.075	5.19	4.92
+		200	1.076	5.36	5.13
Significance		ns	ns	*	ns
Broadcast N, lb/A	Row Fertilizer				
0	-	227	1.083	4.91	4.31
0	+	231	1.083	5.25	4.63
50	-	201	1.078	5.24	4.79
50	+	203	1.075	5.22	5.18
100	-	194	1.069	5.29	5.28
100	+	189	1.075	5.54	5.32
150	-	182	1.069	5.33	5.29
150	+	177	1.070	5.44	5.40
Significance		ns	ns	ns	ns
C.V. (%)		9	.4	5	3

All plots received broadcast 0+100+300+10 Zn lb/A of P_2O_5, K_2O and Zinc; row treatment consisted of 300 lb/A of 10-10-10.

Table 3. The effect of broadcast phosphorus and row fertilizer on yield, specific gravity, and elemental analyses of leaf tissue of potatoes. Hoff Farm, W. Polk Co., 1982.

Treatment		Yield Cwt/A	Specific Gravity	Sampling: Early Season									Sampling: Midseason								
				Elemental Analyses																	
				P	K	Ca	Mg	Fe	Mn	Zn	Cu	B	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
				---------%---------				---------ppm---------					---------%---------				---------ppm---------				
Main Effects																					
Broadcast P_2O_5, lb/A																					
0		216	1.075	.37	4.04	1.82	1.01	392	61	22	3	22	.41	2.95	1.49	.98	120	48	23	3	19
25		186	1.077	.40	4.21	1.85	1.00	415	55	22	2	22	.41	2.96	1.50	.96	118	43	22	3	19
50		199	1.074	.39	4.04	1.79	.96	365	54	22	2	22	.40	3.14	1.46	.98	114	44	24	3	19
100		197	1.076	.42	3.87	1.89	1.04	375	63	22	2	22	.43	2.84	1.66	1.08	118	50	22	3	18
150		210	1.078	.42	4.02	1.85	.94	414	61	21	2	22	.42	2.98	1.68	.99	124	48	21	3	19
Significance		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	**	ns	ns	ns	ns	ns	ns
BLSD (.05)		-	-	-	-	-	-	-	-	-	-	-	-	-	.14	-	-	-	-	-	-
Row Fert.																					
-		214	1.077	.40	3.92	1.87	1.02	402	56	22	2	22	.42	2.89	1.49	.94	116	46	22	3	19
+		189	1.075	.41	4.15	1.81	.96	382	61	22	2	22	.42	3.06	1.63	1.06	121	48	23	3	19
Significance		ns	*	ns	ns	+	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Broadcast P_2O_5, lb/A	Row																				
0	-	234	1.076	.38	4.03	1.80	1.02	418	58	21	3	23	.41	2.88	1.46	.92	115	47	22	3	19
0	+	198	1.074	.40	4.05	1.83	.99	367	64	22	2	22	.42	3.02	1.52	1.04	124	50	24	3	19
25	-	205	1.080	.39	4.10	1.84	1.04	406	54	22	2	22	.41	2.90	1.40	.89	110	44	22	3	21
25	+	197	1.075	.40	4.31	1.85	.96	424	56	22	2	22	.41	3.01	1.60	1.02	126	42	22	3	18
50	-	203	1.074	.39	3.87	1.82	.98	374	54	22	2	22	.41	3.10	1.37	.90	115	43	24	3	19
50	+	194	1.073	.40	4.21	1.76	.95	356	55	22	2	22	.40	3.18	1.56	1.05	112	45	24	3	19
100	-	202	1.077	.42	3.71	1.93	1.10	402	58	22	2	22	.42	2.72	1.64	1.07	119	48	22	3	17
100	+	192	1.075	.44	4.03	1.85	.98	349	68	22	2	21	.43	2.96	1.68	1.10	117	52	22	3	18
150	-	228	1.080	.42	3.90	1.94	.96	411	60	21	2	22	.43	2.85	1.58	.91	122	48	21	3	19
150	+	192	1.076	.43	4.14	1.77	.92	416	62	22	2	22	.42	3.11	1.79	1.08	126	48	21	2	20
Significance		+	ns	ns	ns	ns	ns	ns	ns	ns	+	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.		5.9	.3	3.7	5.2	5.5	8.2	20.3	12.1	7.3	13.6	3.8	3.3	8.0	7.1	7.0	12.1	5.2	5.9	12.2	11.9

All plots received broadcast 150+0+300+10 Zn lb/acre of N, K_2O and zinc; row treatment consisted of 300 lb/A of 10-10-10.

Table 4. The effect of broadcast potassium and row fertilizer on yield, specific gravity, and elemental analyses of leaf tissue of potatoes. Hoff Farm, W. Polk Co., 1982.

Treatment	Yield Cwt/A	Specific Gravity	Sampling: Early Season									Sampling: Midseason								
			Elemental Analyses																	
			P	K	Ca	Mg	Fe	Mn	Zn	Cu	B	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
			%				ppm					%				ppm				
Main Effects																				
Broadcast K_2O, lb/A																				
0	182	1.084	.40	2.76	2.07	1.34	374	59	19	3	23	.41	1.79	1.64	1.31	139	43	21	4	20
100	205	1.085	.41	3.24	2.01	1.17	350	56	19	2	23	.41	2.28	1.67	1.15	123	42	20	3	20
200	206	1.082	.41	3.61	1.90	1.03	376	58	20	2	23	.41	2.71	1.66	1.05	120	45	21	3	19
300	217	1.075	.38	3.80	1.81	1.02	353	60	21	3	23	.39	3.10	1.51	1.06	106	48	22	3	20
500	215	1.074	.40	4.21	1.75	.94	379	58	22	2	22	.41	3.44	1.50	.96	114	48	22	3	20
Significance	*	*	ns	**	**	**	ns	ns	**	ns	ns	ns	**	ns	**	*	ns	ns	ns	ns
BLSD (.05)	33	.010	-	.54	.12	.19	-	-	2	-	-	-	.40	-	.24	33	-	-	-	-
Row Fertilizer																				
-	204	1.080	.39	3.38	1.94	1.16	369	56	20	3	23	.41	2.54	1.53	1.05	114	43	21	3	19
+	206	1.080	.41	3.66	1.87	1.04	364	60	20	3	23	.40	2.79	1.66	1.16	126	47	21	3	20
Significance	ns	ns	**	+	+	+	ns	ns	ns	ns	ns	ns	+	ns	ns	ns	ns	ns	ns	ns
Broadcast K_2O, lb/A / **Row**																				
0 -	181	1.085	.38	2.69	2.10	1.39	330	54	19	3	22	.42	1.76	1.61	1.28	126	40	21	4	20
0 +	183	1.083	.41	2.83	2.04	1.30	418	63	19	3	23	.41	1.83	1.67	1.34	153	46	21	4	20
100 -	204	1.085	.39	2.96	2.10	1.26	390	55	20	2	22	.41	2.22	1.58	1.07	118	40	20	3	19
100 +	206	1.086	.42	3.52	1.93	1.08	310	56	19	2	23	.41	2.34	1.77	1.22	128	45	20	3	20
200 -	210	1.079	.40	3.41	1.94	1.12	398	54	20	2	23	.42	2.58	1.57	.98	114	42	21	3	18
200 +	201	1.081	.41	3.81	1.85	.95	354	62	20	2	22	.41	2.83	1.76	1.12	126	48	20	2	20
300 -	220	1.075	.38	3.66	1.82	1.08	340	59	22	3	23	.40	3.00	1.45	1.00	104	48	22	3	20
300 +	215	1.076	.39	3.94	1.81	.96	367	60	21	3	23	.38	3.20	1.58	1.12	107	48	21	3	21
500 -	205	1.076	.39	4.20	1.76	.97	389	56	22	2	22	.42	3.12	1.46	.92	111	46	22	3	18
500 +	224	1.073	.40	4.22	1.74	.90	370	59	21	2	22	.40	3.76	1.54	.99	118	49	21	3	21
Significance	ns	ns	ns	ns	ns	ns	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V. (%)	9.2	.3	3.8	6.8	5.7	7.6	12.6	10.8	20.4	2.6	4.5	3.4	7.9	8.5	9.7	14.1	7.0	5.4	14.3	5.2

All plots received broadcast 150+100+0+10 Zn of N, P_2O_5 and Zinc; row fertilizer consisted of 300 lb/A of 10-10-10.

Table 5. The effect of broadcast Nitrogen and row fertilizer on yield, specific gravity, and N content of leaf tissue of potatoes. Mack Farm, W. Polk Co., 1982.

Treatment		Yield Cwt/A	Specific Gravity	Sampling: Early Season Leaf-N %	Sampling: Midseason Leaf-N %
Main Effects					
Broadcast N, lb/A					
0		136	1.085	5.04	3.86
50		150	1.084	5.02	3.97
100		152	1.082	5.26	4.22
150		158	1.083	5.19	4.36
Significance		ns	ns	ns	*
BLSD (.05)		-	-	-	.44
Row Fertilizer					
-		145	1.083	5.12	4.16
+		152	1.084	5.14	4.04
Significance		ns	ns	ns	ns
Broadcast N, lb/A	Row Fertilizer				
0	-	138	1.085	4.99	3.94
0	+	134	1.085	5.09	3.78
50	-	152	1.082	5.10	4.06
50	+	148	1.085	4.93	3.88
100	-	150	1.082	5.28	4.25
100	+	154	1.083	5.24	4.20
150	-	142	1.083	5.09	4.41
150	+	174	1.083	5.29	4.31
Significance		ns	ns	ns	ns
C.V. (%)		12	.2	7	4

All plots received broadcast 0+100+0 lb/A of P_2O_5; row fertilizer consisted of 300 lb/A of 10-10-10.

Table 6. The effect of broadcast phosphorus and row fertilizer on yield, specific gravity, and elemental analyses of leaf tissue of potatoes. Mack Farm, W. Polk Co., 1982.

Treatment		Yield Cwt/A	Specific Gravity	Sampling: Early Season									Sampling: Midseason								
				Elemental Analyses																	
				P	K	Ca	Mg	Fe	Mn	Zn	Cu	B	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
				--------- % ---------				--------- ppm ---------					--------- % ---------				--------- ppm ---------				
Main Effects																					
Broadcast P_2O_5, lb/A																					
0		184	1.082	.43	4.53	1.51	1.09	583	66	23	9	32	.31	2.85	1.12	1.00	268	47	17	9	21
25		168	1.082	.42	4.16	1.66	1.11	768	72	22	10	28	.31	3.10	1.15	.99	361	48	17	9	21
50		182	1.082	.43	4.52	1.59	1.09	558	64	21	9	30	.31	2.89	1.15	1.01	272	45	16	9	22
100		159	1.082	.43	3.98	1.63	1.12	595	69	22	10	31	.31	3.06	1.21	1.06	344	50	16	9	22
150		184	1.083	.45	4.48	1.62	1.15	625	66	22	9	31	.31	3.06	1.18	1.07	277	46	16	9	22
Significance		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	+	ns	ns	ns	ns	ns	ns	ns	ns	ns
Row Fertilizer																					
-		170	1.081	.43	4.47	1.58	1.12	587	66	22	9	31	.31	2.92	1.20	1.05	318	48	16	9	22
+		181	1.083	.43	4.19	1.62	1.10	664	68	22	10	30	.31	3.06	1.13	1.00	291	46	17	9	21
Significance		ns	ns	ns	+	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Broadcast P_2O_5, lb/A	**Row**																				
0	-	173	1.081	.42	4.60	1.50	1.10	588	65	22	9	32	.31	2.80	1.20	1.06	297	50	16	9	22
0	+	195	1.083	.44	4.47	1.52	1.09	577	67	24	10	32	.32	2.92	1.04	.94	239	43	17	9	20
25	-	164	1.080	.44	4.18	1.60	1.08	688	68	22	10	29	.31	3.08	1.15	1.00	390	48	18	9	22
25	+	171	1.084	.40	4.14	1.72	1.14	848	76	22	10	27	.31	3.13	1.15	.99	333	48	16	9	21
50	-	180	1.082	.42	4.60	1.60	1.09	518	65	20	9	30	.31	2.96	1.19	1.02	274	46	15	8	22
50	+	184	1.082	.45	4.44	1.58	1.08	597	63	22	10	30	.32	2.83	1.12	1.00	269	44	16	9	21
100	-	152	1.081	.44	4.13	1.59	1.14	527	69	22	9	33	.31	2.82	1.21	1.06	316	50	16	8	22
100	+	165	1.082	.43	3.82	1.66	1.11	662	69	22	10	28	.31	3.30	1.21	1.08	372	50	17	9	22
150	-	180	1.082	.45	4.86	1.62	1.20	614	65	22	9	31	.31	2.96	1.24	1.13	312	48	16	9	22
150	+	188	1.084	.45	4.10	1.63	1.10	636	67	21	9	32	.31	3.15	1.12	1.01	242	43	16	8	22
Significance		ns	ns	**	ns	ns	ns	ns	+	+	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V. (%)		11	.3	3	10	4	4	21	5	5	7	31	6	13	7	9	28	8	7	9	8

All plots received broadcast 100+0+0 lb/A of N; row fertilizer consisted of 300 lb/A of 10-10-10.

THE RELATIONSHIP OF SOIL SOLUTION CHEMISTRY TO IRON CHLOROSIS AND YIELD OF SOYBEANS ON HIGH LIME SOILS

P.R. Bloom and W.P. Inskeep

Iron chlorosis is a common problem on soybeans on the high lime soils of in the western part of the state. The problem occurs in the high lime soils surrounding depressions and is generally most severe in isolated areas in fields. The objective of this study was to determine the relationship of the chemical composition of soil solutions to the expression of chlorosis and to the reducton in yields that results from chlorosis.

METHODS

Three varieties of soybeans, Anoka, Hodgson and Swift each with different susceptibilities to chlorosis were planted in 4 row strips across spots in field where soybean chlorosis was observed in 1981. The plots were located on the Hustoff farm 2 miles south of Willmar and on the Southwest Experiment Station. Throughout the growing season soil and plant samples were taken at sampling stations 25 ft apart along the 4 row strips. Soil samples were taken between the center rows and plant samples and yields were taken from the two inner rows. Soil samples were taken from the 0-6" depth, sealed in Whirl-Pak bags and brought to the laboratory in an ice chest. The most recently mature trifoliate leaves were sampled for chlorophyll content (DMF extraction) and for total elemental content.

After transport to the laboratory the soils were brought to 50% moisture with distilled water. The soil slurry was centrifuged at 13,200 g for 40 minutes and the supernatant was decanted and filtered through a 0.45 μm membrane filter under pressure. Bicarbonate was determined immediately by titration with HCl. A portion of the sample was submitted for elemental analysis by ICP. Anions were determined by ion chromatography. The soil and plant composition data presented here are for samples taken on July 12 and 13. The grain yields were determined by sampling 10 ft. sections of the inner two rows of mature field-dry plants. The sampling of the Southwest Experiment Station was of a preliminary nature and not as intense as at the Willmar site. Only data from the Hodgson variety is presented here.

RESULTS

The yields reported in Table 1 show that at Willmar chlorosis was severe enough in part of the plot to result in plant death. With increasing distance from sampling station no. 1 both yield and relative chlorophyll control. The chlorophyll contents for Swift and Hodgson attained a maximum value and then did not change. For the Anoka variety the chlorophyll content did not reach a maximum value. For Swift and Hodgson the yields appeared to reach a maximum value and then decrease. The statistical significance of this phenomenon could not be tested with the data available.

Table 1. Relative chlorophyll contents of third trifoliate leaves sampled July 12 and 13, and grain yields in bushels per acre.

Location	-Willmar-						Southwest Exp. Station	
Variety	Swift		Hodgson		Anoka		Hodgson	
Sampling Station	Chlorophyll	Yield	Chlorophyll	Yield	Chlorophyll	Yield	Chlorophyll	Yield
1	.26	2	.29	0	.19	0	.61	37
2	.24	0	.41	6	.26	0	.56	37
3	.19	4	.38	30	.23	0	.76	37
4	.19	3	.63	49	.33	0	1.0	39
5	.29	43	.68	61	.24	0	1.0	46
6	.38	53	.89	54	.44	14	.73	43
7	.66	48	.85	57	.42	31		
8	.68	41	.93	47	.54	47		
9	.68	39	.90	43	.69	42		
10	.83	39						

At the Southwest Experiment Station the chlorosis was not as severe at Willmar and the yields did not vary greatly although there was a very significant variation in chlorophyll contents. At both sites the increases in chlorophyll contents corresponded to increase in elevation with respect to the depression. Chlososis as measured by chlorophyll contents was well correlated with the Mg/Ca ratio in the soil solution extracts (Table 2). Chlorosis was also correlated with soil bicarbonate but at a lower level of significance. The correlation with soil bicarbonate is confirmation of the conclusions of Chaney, USDA Beltsville, who found that in solution culture bicarbonate is the causative factor in iron chlorosis when adequate iron is supplied to the nutrient solution. The low level of significance for the correlation of chlorophyll with bicarbonate in some of the varieties may reflect the difficulty of getting good bicarbonate values especially in a system in which the partial pressure of CO_2 is greater than that in the ambient air. Our data from soil gas wells in the calcareous soils (not reported) suggest that the partial pressure of CO_2 in soil air can be as high as 100 times that in ambient air.

Table 2. Regression r^2 values for the linear regression of soil solution HCO_3^-, soil Mg/Ca and chlorophyll against plant Mg/Ca, chlorophyll content and yield.

Location	Willmar			Southwest Exp. Station
Regression \ Variety	Swift	Hodgson	Anoka	Hodgson
Chlorophyll *vs.* HCO_3^-	0.36d	0.93a	0.54d	0.56e
Chlorophyll *vs.* Soil Mg/Ca	0.89a	0.96a	0.84a	0.67d
Yield *vs.* Soil Mg/Ca	0.68b	0.62c	0.87a	0.64d
Yield *vs.* HCO_3^-	NS	0.70c	0.55d	0.77c
Yield *vs.* Chlorophyll	0.47c	0.62c	0.81b	NS
Plant Mg/Ca *vs.* Soil Mg/Ca	0.88a	0.98a	0.99a	0.81b

Significance:
a) $\alpha = 0.001$
b) $\alpha = 0.005$
c) $\alpha = 0.010$
d) $\alpha = 0.025$
e) $\alpha = 0.05$
NS not significant

The correlation of chlorosis with soil Mg/Ca was not expected. The Mg/Ca ratio may indicate that the carbonates in the high chlorosis areas have a higher Mg content. Magnesium substituted $CaCO_3$ is more soluble than pure $CaCO_3$ and at a given pH, bicarbonate concentrations would be higher at higher Mg/Ca. An alternative explanation is that with high Mg the rate of precipitation of $CaCO_3$ is decreased and higher bicarbonate concentrations may result.

Plant response was not correlated with soil pH nor with other components in the soil solution. The soil solution pH was invariant at both sites (pH aproximately 8). At the Southwest Experiment station the calcareous soil contained gypsum and the soil solutions were high in sulfate. The sulfate, however, did not affect the plant response variables reported here.

The Mg/Ca ratio in the plants was very well correlated with Mg/Ca in soil (Table 2). The ratio of Mg/Ca in the plants, however, is not high enough to produce severe plant nutrition problems.

Yield was most consistently correlated with Mg/Ca in the soil (Table 2). Yield was also correlated with plant chlorophyll at Willmar and with soil bicarbonate at the Southwest Experiment Station and at Willmar with Hodgson and Anoka. The lack of highly signficant correlation of yield with chlorosis as measure by plant chlorophyll is not unexpected given the 1981 data of Bill Kennedy of the Department of Plant Pathology that show that yields are not well correlated with subjective ratings of chlorosis early in the season. However, it is evident that relative chlorophyll contents less than 0.30 resulted in extreme yield losses on all varieties.

CONCLUSIONS

Chlorosis as measured by leaf chlorophyll ocntent was correlated with both Mg/Ca and bicarbonate in soil solution extracts. The correlation was especially strong (α = 0.001) for soil Mg/Ca at Willmar where the soil did not contain gypsum. Grain yield was inconsistently correlated with plant chlorophyll and soil bicarbonate but the best predictor of yield wa the soil solution Mg/Ca ratio.

WILD RICE FERTILIZATION RESEARCH - 1982

John Grava
Department of Soil Science

Research was continued during 1982 on fertilization and nutrient requirement of wild rice. Soil, water and air temperatures were monitored during the growing season at Grand Rapids and St. Paul. A nitrogen experiment was conducted with the Netum variety on a mineral soil at Grand Rapids. An NPK fertilization trial with the K2 variety was conducted on peat in Aitkin County.

A. WEATHER CONDITIONS AND PLANT DEVELOPMENT

Average temperatures recorded at three U.S. weather stations were above normal in May and, generally, below normal during April, June, July and August (Table 1).

Soil, water and air temperatures were measured at Grand Rapids within the experimental paddy No. 1 West, and on the St. Paul Campus within an area where experiments in 4 x 4 ft. boxes were conducted (see Fig. 1 and 2).

At Grand Rapids, plants emerged on May 3 (Fig. 3). The jointing stage by Netum wild rice was reached on June 17th, 45 days after emergence. Wild rice was harvested on August 12th, 102 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 1982 season were 793 at jointing and 2275 at harvest, respectively.

B. NITROGEN STUDIES ON MINERAL SOILS

The nitrogen rate and time of application trial, initiated in the fall of 1979, was continued with 3rd year stand of Netum wild rice in paddy No. 1 West at the North Central Experiment Station, Grand Rapids. The soil is classified as an Indus clay loam (very fine, montmorillonitic, frigid Typic Ochraqualf). Soil tests (Table 2) indicated very high levels of extractable phosphorus (63 pp2m) and exchangeable potassium (300 pp2m). It should be noted that these two plant nutrients have remained at such very high levels since 1974 although no phosphate or potash fertilizers have been applied to this soil. It has been a common practice, however, to incorporate wild rice stubble and straw into the soil. Since nearly 75% of total P and 97% of total K taken up by the wild rice plant remain in stems and leaves, a certain recycling of these nutrients occurs.

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 5, 1981 and the fertilizer was incorporated into the soil by rototilling. Additional N was topdressed by hand at jointing (on June 23) or early flowering (on July 9). 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. Water level was maintained at about 6 to 10 inches. Plant density, at harvest, ranged from 7 to 11 plants per square foot. Ten plants were collected at random from each plot at jointing, and five plants at late flowering for weight measurement and plant analysis. The jointing stage was reached on June 17th (Fig. 3). A 16 sq. ft. area from each plot was hand-harvested on August 12th.

The plants in this experimental paddy were very short, spindly and had a "grassy" appearance. One may speculate that poor plant growth on this mineral soil resulted from relatively high density and the age of stand.

Individual plants at jointing had accumulated less than one gram of dry matter and 15 to 20 milligrams of nitrogen (Table 3). The second leaf at jointing contained 2.53 to 2.68% N, considered to be a relatively low concentration. It should be noted that the concentration of leaf nitrogen at jointing ranged from 4.33 to 5.55% during the first year (1980).

Netum grain yield (7% moisture) ranged from 332 to 445 pounds per acre (Table 4). The yield of wild rice was not affected by any of the nitrogen treatments. At late flowering, the plant had accumulated from 1.72 to 3.74 grams of dry matter and 22 to 57 milligrams of nitrogen.

C. FERTILIZATION STUDIES ON PEAT

A fertilizer experiment was conducted with the K2 variety of wild rice on an organic soil in a Kosbau Bros. paddy in Aitkin County. A medium level of extractable phosphorus (15 pp2m) and a low level of exchangeable potassium (90 pp2m) were indicated by soil tests (Table 5). The soil pH was 5.8. 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, 0-0-60) were applied by hand on October 7, 1981 and incorporated into the soil by disking. Wild rice reached the jointing stage on June 29. A 32 sq. ft. area from each plot was harvested on August 17.

The concentration of nutrient elements in the 2nd leaf at jointing (see Table 6) was relatively high: 2.85 to 3.06% N, 0.44 to 0.48% P, 3.37 to 3.56% K. The grain yield (7% moisture) ranged from 671 to 720 pounds per acre (Table 7). Neither the yield nor the total uptake of N, P and K at late flowering were affected by fertilization.

ACKNOWLEDGEMENTS

Grateful acknowledgements are made to the following cooperators and University personnel for their assistance during 1982 in obtaining the information reported here: Messrs. Franklin and Harold Kosbau, Aitkin County; the Staff of the North Central Experiment Station; Dr. E. A. Oelke, Messrs. Jeffrey Schmidt and Henry Schumer, University of Minnesota.

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
1982	37.0	55.1	55.5	66.8	63.0	55.5	2477
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
1982	38.6	57.7	58.5	68.0	64.4	57.6	2753
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
1982	38.3	57.4	57.6	68.6	64.8	57.3	2723
St. Paul, U of M							
1982	43.4	61.3	62.4	73.9	67.3	61.6	3332

1/ Source: Climatological Data, Minnesota, Vol. 80-88 (1974-82), U.S. Dept. of Commerce.
2/ Normals for the period 1931-1960.
3/ M = less than 10 days record missing.

Fig. 1

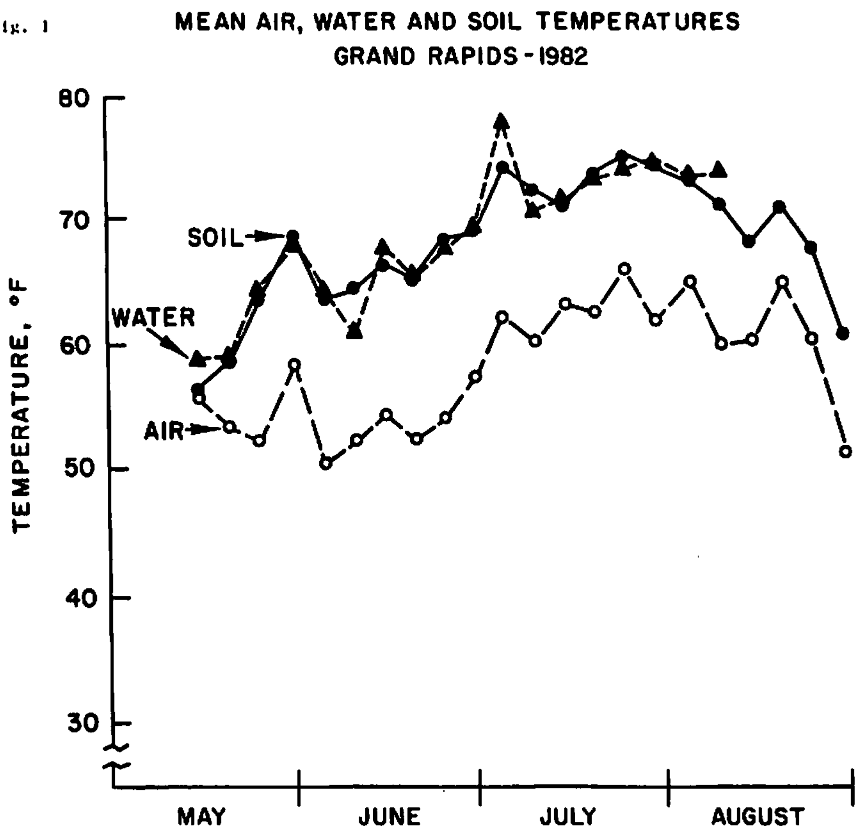

MEAN AIR, WATER AND SOIL TEMPERATURES
GRAND RAPIDS - 1982
TEMPERATURE, °F
80
70
60
50
40
30
SOIL
WATER
AIR
MAY
JUNE
JULY
AUGUST

Fig. 2

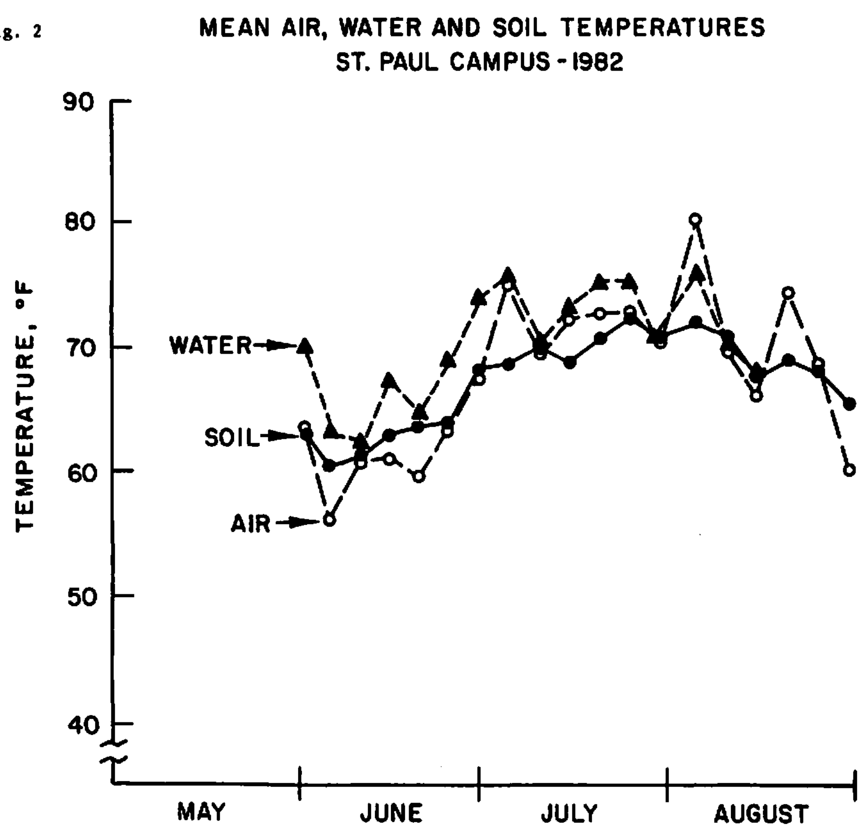

MEAN AIR, WATER AND SOIL TEMPERATURES
ST. PAUL CAMPUS - 1982
TEMPERATURE, °F
90
80
70
60
50
40
WATER
SOIL
AIR
MAY
JUNE
JULY
AUGUST

Fig. 3

WILD RICE DEVELOPMENT
NETUM VARIETY, 3RD YEAR STAND
GRAND RAPIDS, 1982

Phase	STAGES OF DEVELOPMENT	DAYS	DATE	GDD [1/]
VEGETATIVE GROWTH PHASE	EMERGENCE	0	MAY	0
	FLOATING LEAF	11		156
	AERIAL LEAF	24		400
	TILLERING	38	JUNE	662
REPRODUCTIVE GROWTH PHASE	JOINTING	45		793
	BOOT	53		943
	HEADING	64	JULY	1220
	EARLY-FLOWERING	67		1312
	LATE-FLOWERING	89		1797
	MATURITY	102	AUGUST	2275

1/ - ACCUMULATED GROWING DEGREE DAYS, $T_b = 40°F$

Table 2. Soil test values of experimental paddy No. 1 West, Grand Rapids.[1)]

pH	Extractable P pp2m	Exchangeable K pp2m	Nitrate-N lb/A
6.1[2)]	63	300	7

1) Samples collected from 0-6 inch depth on 11/5/81.
2) Average of two composite samples.

Table 3. Effect of nitrogen application on weight of dry matter, N-concentration in 2nd leaf, and total uptake of N by wild rice plant at jointing, Netum variety, 2nd year stand, Grand Rapids, 1982.

N Rate lb/acre	Dry Matter grams per plant	N% in dry matter	N in milligrams per plant
0	0.66[2)]	2.68[2)]	18[2)]
20[1)]	0.64	2.68	15
40	0.69	2.67	18
80	0.91	2.53	20
Significance	ns	ns	ns

1) Applied in fall 1981.
2) Average of four replications.

Table 4. Effect of nitrogen application on the weight of dry matter, total uptake of N, and the yield of Netum wild rice, 3rd year stand, Grand Rapids, 1982.

Treatment No.	N Rate lb/acre	Time of Application: Fall 11/5/81	Jointing 6/23/82	Early Flowering 7/9/82	Dry Matter at late Flowering g/plant	N Uptake mg/plant	Grain Yield[1)] lb/acre
1	0	-	-	-	3.69	57	343
2	20	20	-	-	2.29	28	332
3	40	40	-	-	2.14	27	414
4	40	20	20	-	3.74	47	390
5	40	20	-	20	3.21	36	423
6	80	80	-	-	2.68	29	439
7	80	40	40	-	2.48	26	404
8	80	40	-	40	1.72	22	445
Significance					ns	ns	ns
C.V. %					50	58	30

1) At 7% moisture, average of four replications.

Table 5. Soil test values of experimental area, Kosbau Bros., Aitkin Co.

pH	Extractable P pp2m	Exchangeable K pp2m	Magnesium pp2m	Copper ppm	Sulfur ppm
5.8	15	90	604	0.9	11

Samples collected from 0-6 inch depth on 10/7/81.

Table 6. Effect of fertilization on N, P, and K concentration in 2nd leaf of K2 wild rice at jointing, Kosbau Bros., 1982.

Treatment N	P_2O_5	K_2O	N%	P%	K%
lb/acre			in Dry Matter		
none			2.85[1)]	0.44	3.38
0 +	40 +	60	2.98	0.44	3.56
30 +	40 +	0	2.98	0.47	3.42
30 +	0 +	60	3.06	0.47	3.44
30 +	40 +	60	2.85	0.46	3.37
60 +	40 +	60	2.96	0.48	3.47
Significance			ns	ns	ns

1) Average of six replications.

Table 7. Effect of fertilization on total uptake of N, P, and K and the yield of K2 wild rice, Kosbau Bros., Aitkin Co., 1982.

Treatment N	P_2O_5	K_2O	Total Uptake at Late Flowering N	P	K	Grain Yield[1)]
lb/acre			mg/plant			lb/acre
none			26	7	56	720
0 +	40 +	60	34	8	64	690
30 +	40 +	0	30	7	59	708
30 +	0 +	60	28	7	54	700
30 +	40 +	60	27	7	52	671
60 +	40 +	60	35	8	66	691
Significance			ns	ns	ns	ns
C.V. %						12

1) At 7% moisture, average of six replications.