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.

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

Some of the results are from 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.

The University of Minnesota, including the Agricultural Experiment Station, is committed to the policy that all persons shall have equal access to its program, facilities, and employment with regard to race, creed, color, sex, national origin, or handicap.

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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.

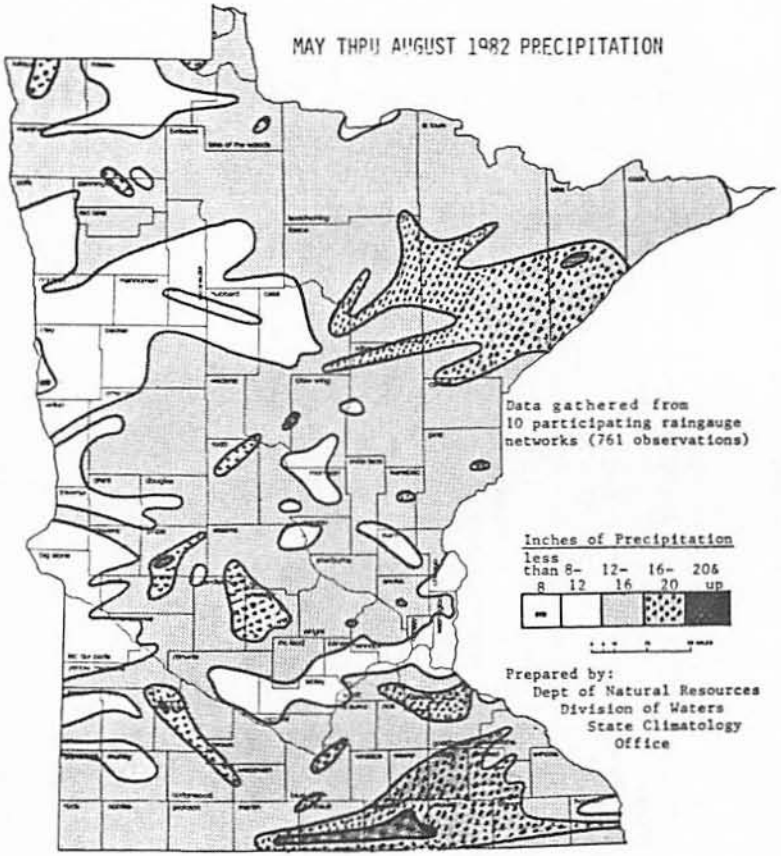


Figure 2.

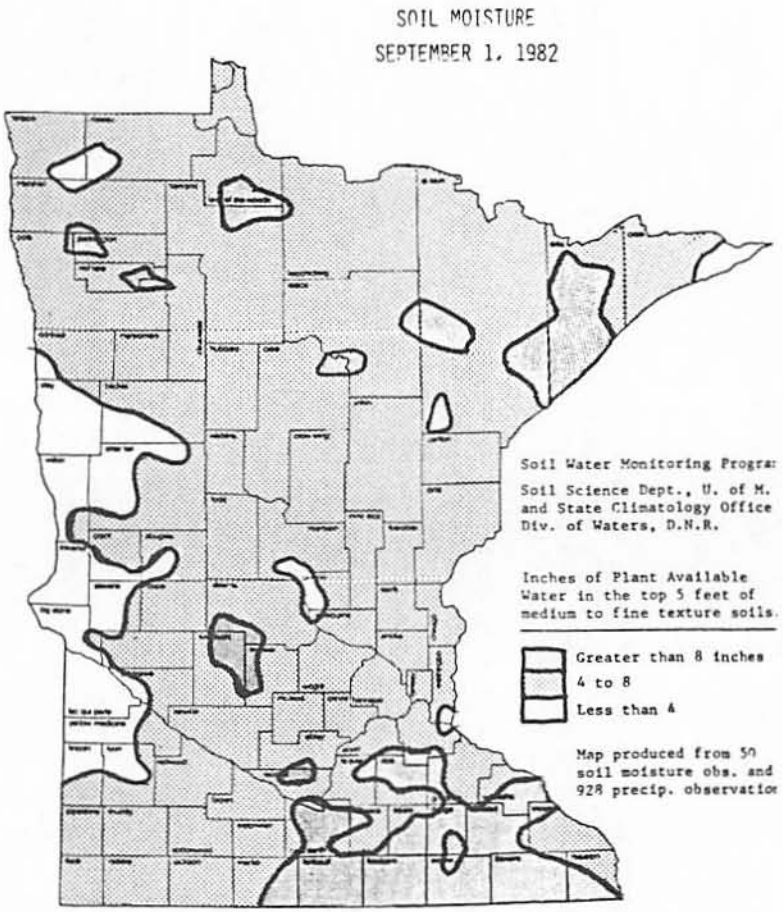
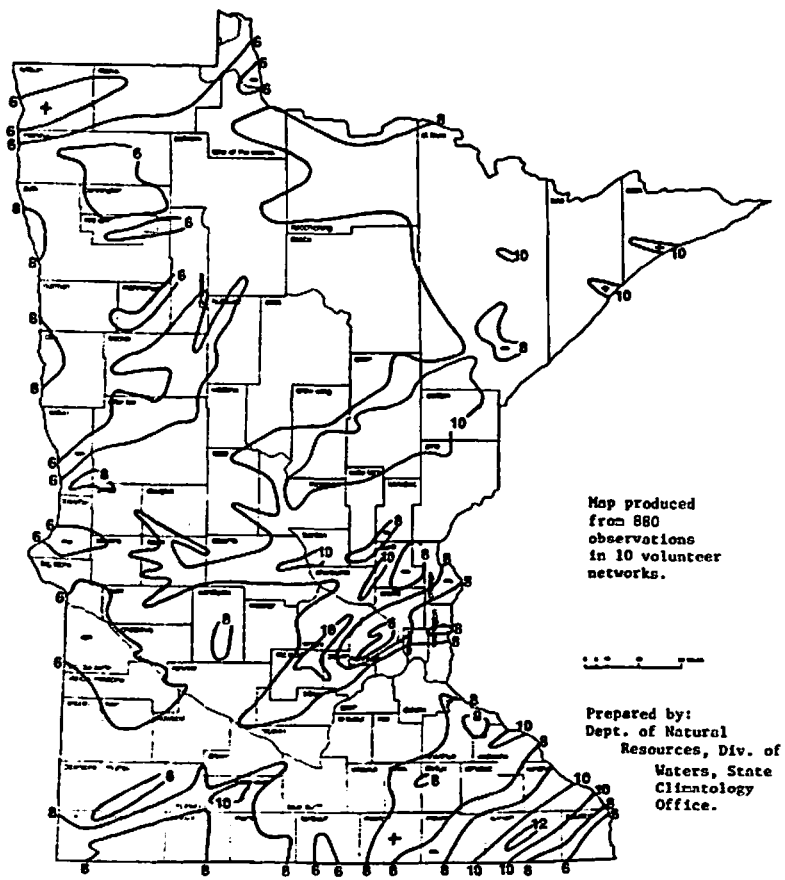


Figure 3.

SEPTEMBER-OCTOBER 1982
PRECIPITATION

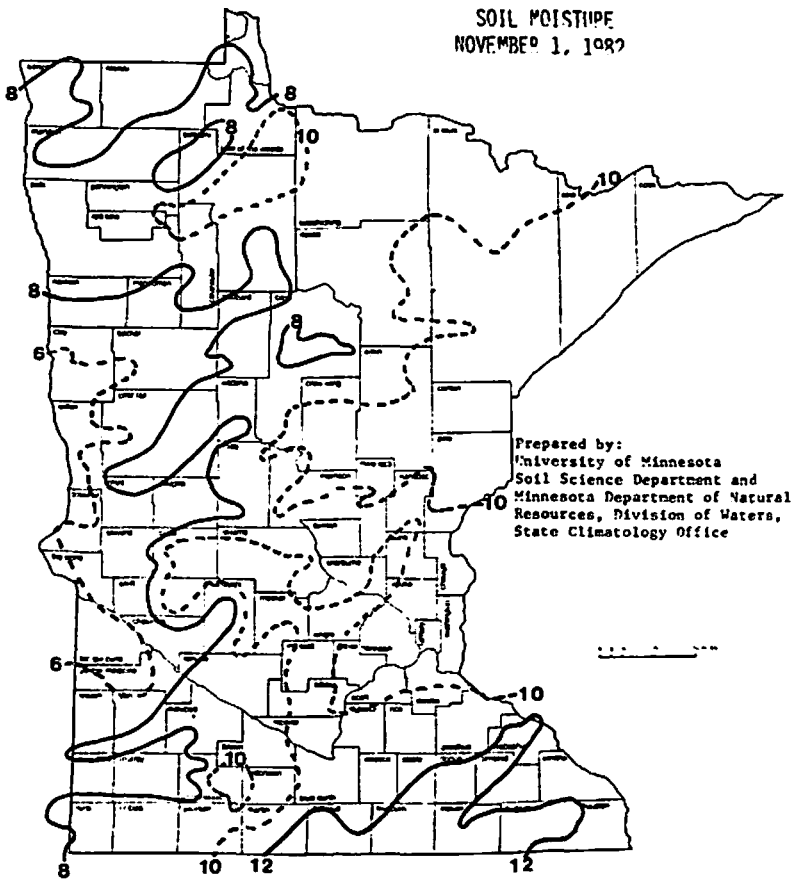


Map produced from 880 observations in 10 volunteer networks.

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

Cooperator	Address	Crop	September Date	September Available Water	November Date	November Available Water	Field Capacity
Viken	Roseau	Wheat	9/82	****	10/27	****	****
Riocelle	Argyle	Wheat	9/81	3.96	10/26	8.04	11.34
Driscoll	E. Grand Forks	Wheat	9/81	2.82	10/26	8.30	11.50
Christenson	Thief River Falls	Wheat	9/81	7.75	10/26	10.43	10.30
Buchholtz	McIntosh	Wheat	9/81	2.74	10/26	7.13	10.30
Brendzahl	Moorhead	Wheat	9/81	8.51	10/26	7.62	11.34
Lieseth	Moorhead	Barley	8/31	5.13	10/25	11.20	13.50
Sethre	Carlisle	Corn	8/31	4.85	10/25	5.17	12.75
Everson	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
Binberg	Ortonville	Corn	8/31	8.31	11/03	3.62	12.75
Nesvold	Madison	Corn	8/30	8.04	11/03	6.69	12.75
Pfau	Freeport	Corn	9/07	5.68	10/25	8.09	8.03
Powers	Hugo	Corn	9/07	1.86	10/20	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
Hasbrich	New Ulm	Corn	9/09	3.41	11/05	5.84	14.50
Jeremiason	Minneota	Corn	9/08	2.51	11/03	5.06	12.23
Horton	Pipestone	Corn	9/09	5.69	11/04	9.81	13.99
Keller	Slayton	Soys	9/03	7.33	11/04	11.02	12.23
Turner	Bingham Lake	Corn	9/08	10.09	11/04	12.73	13.02
Raschy	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		****
Nessing	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	11/05	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
Zickrick	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	Mayfield	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	6.84	—	—	****
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 (U.S. Forest Service)	Itasca Co.	Forest (7.5 Feet)	9/23	7.76	11/17	11.40	****

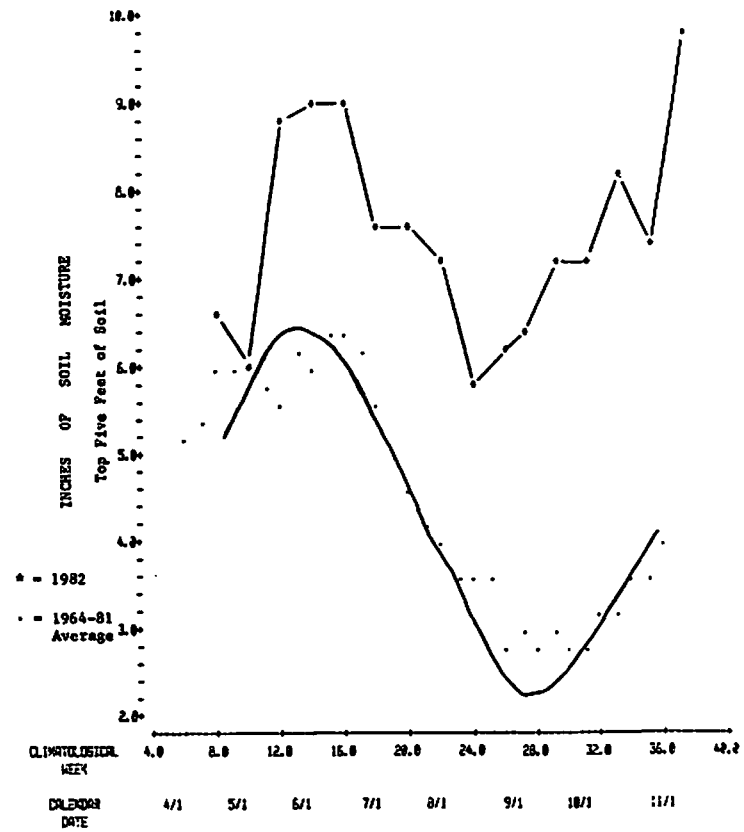
Figure 5.

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.

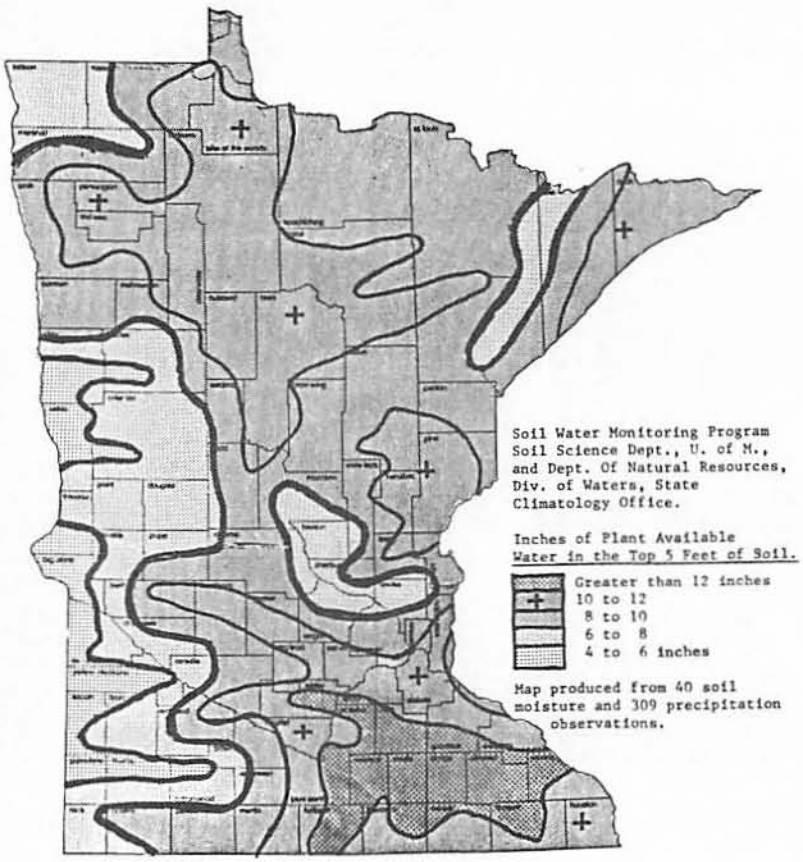
The accompanying maps show the May 1 soil moisture and May 1982 precipitation.

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	-

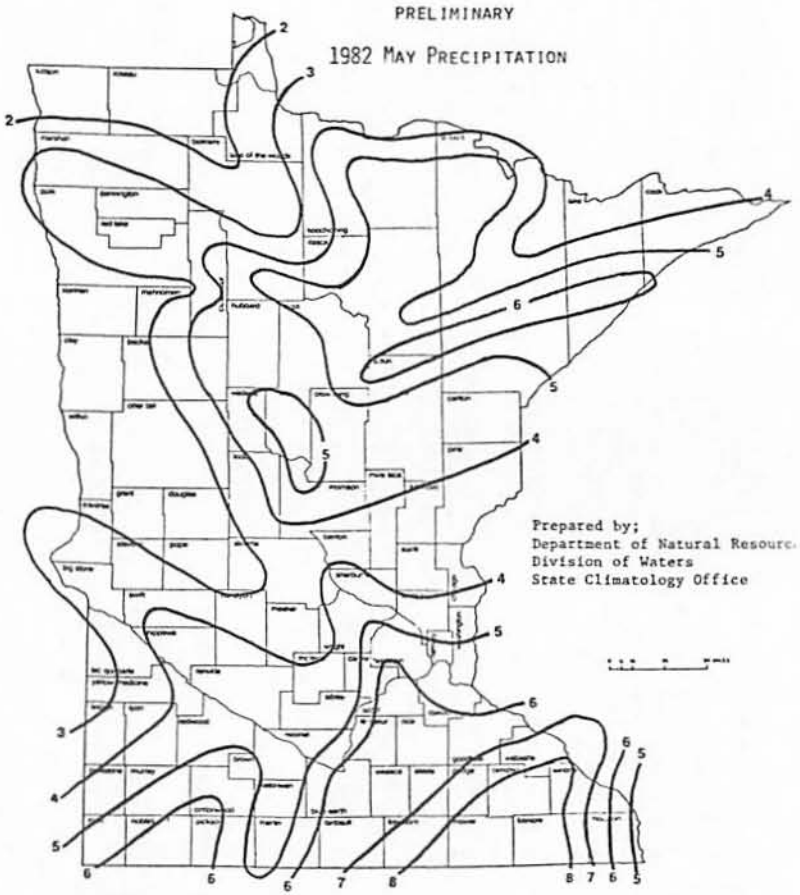
SOIL MOISTURE

MAY 1, 1982

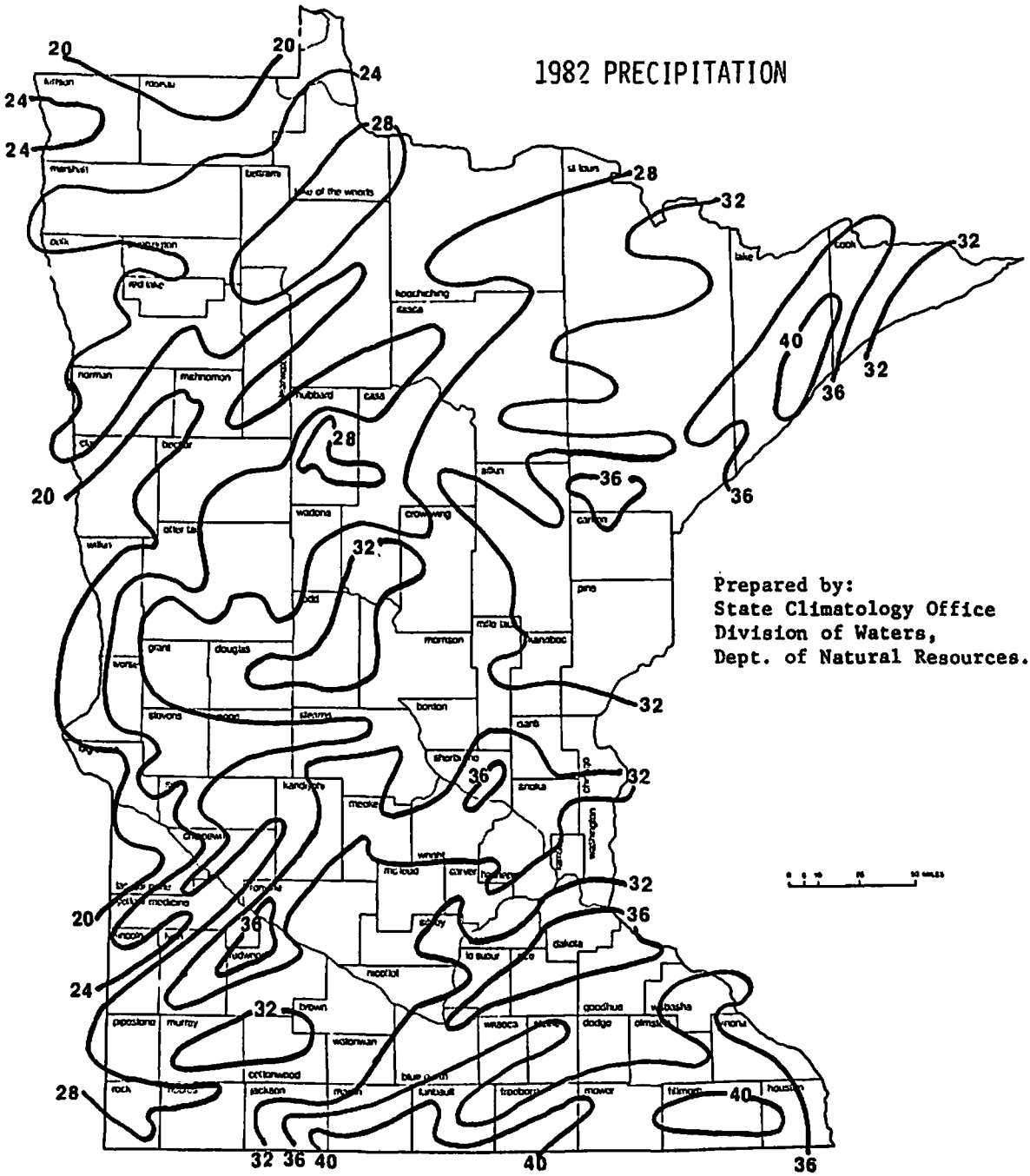


PRELIMINARY

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.

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FIGURE 1

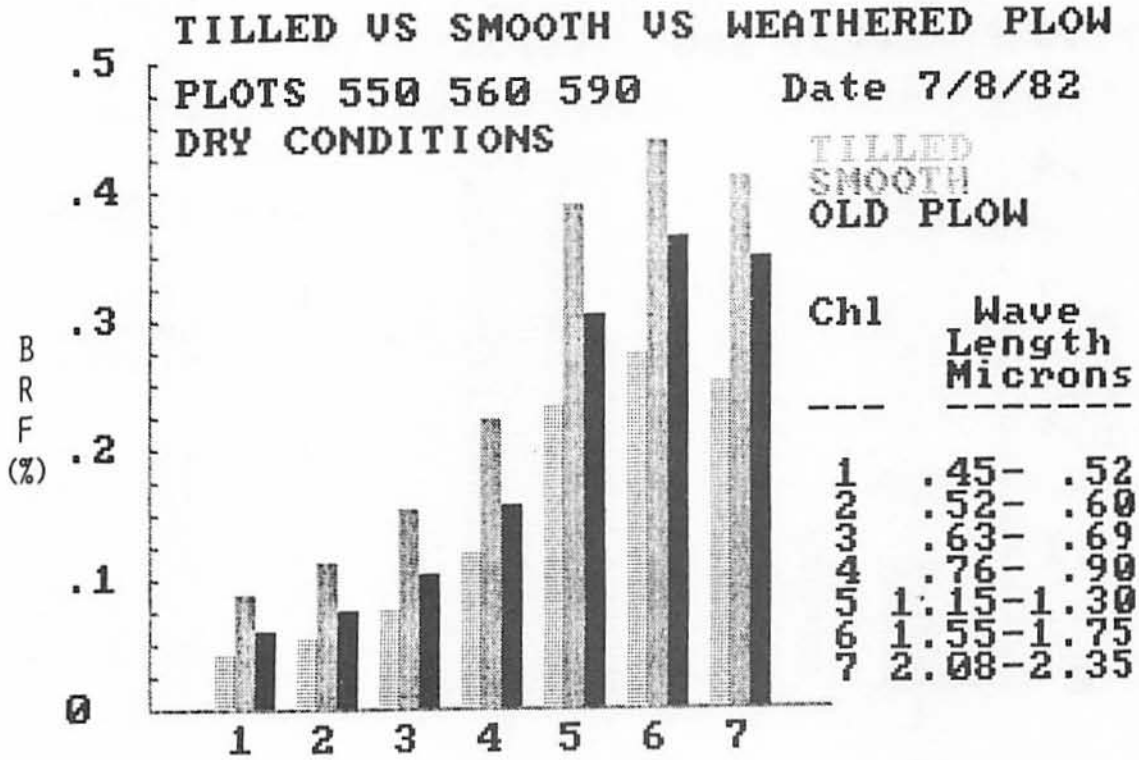


FIGURE 2

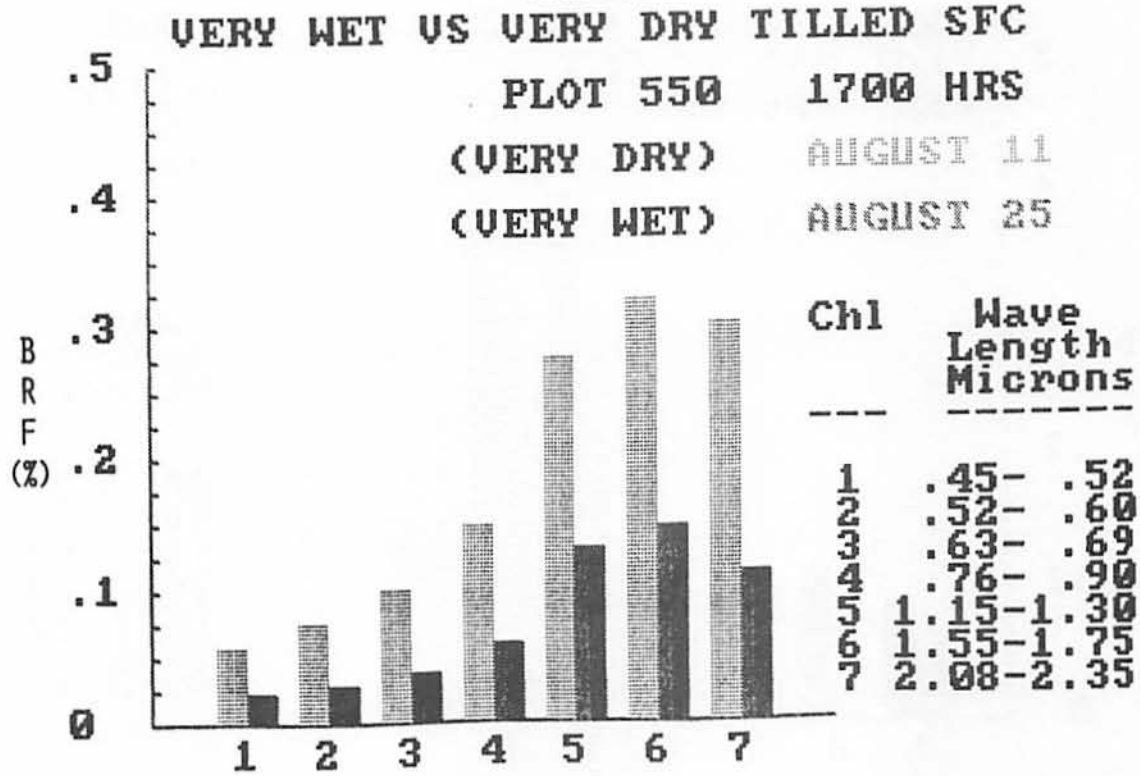


FIGURE 3

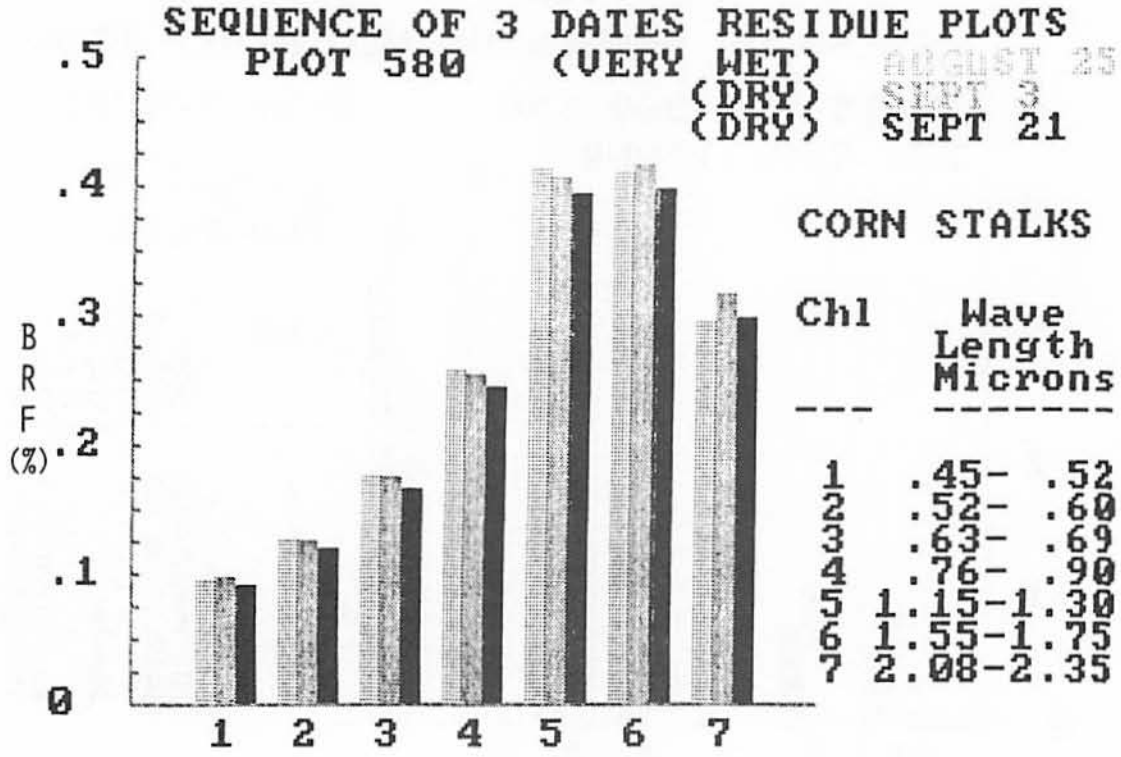


FIGURE 4

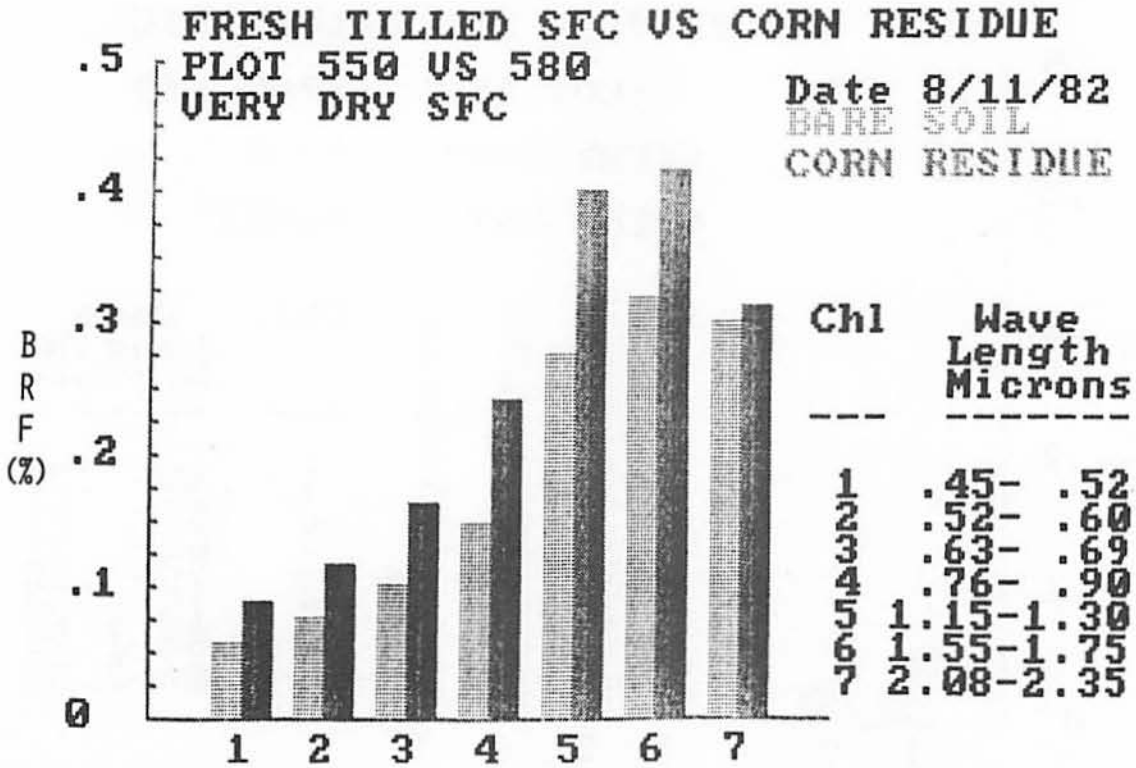
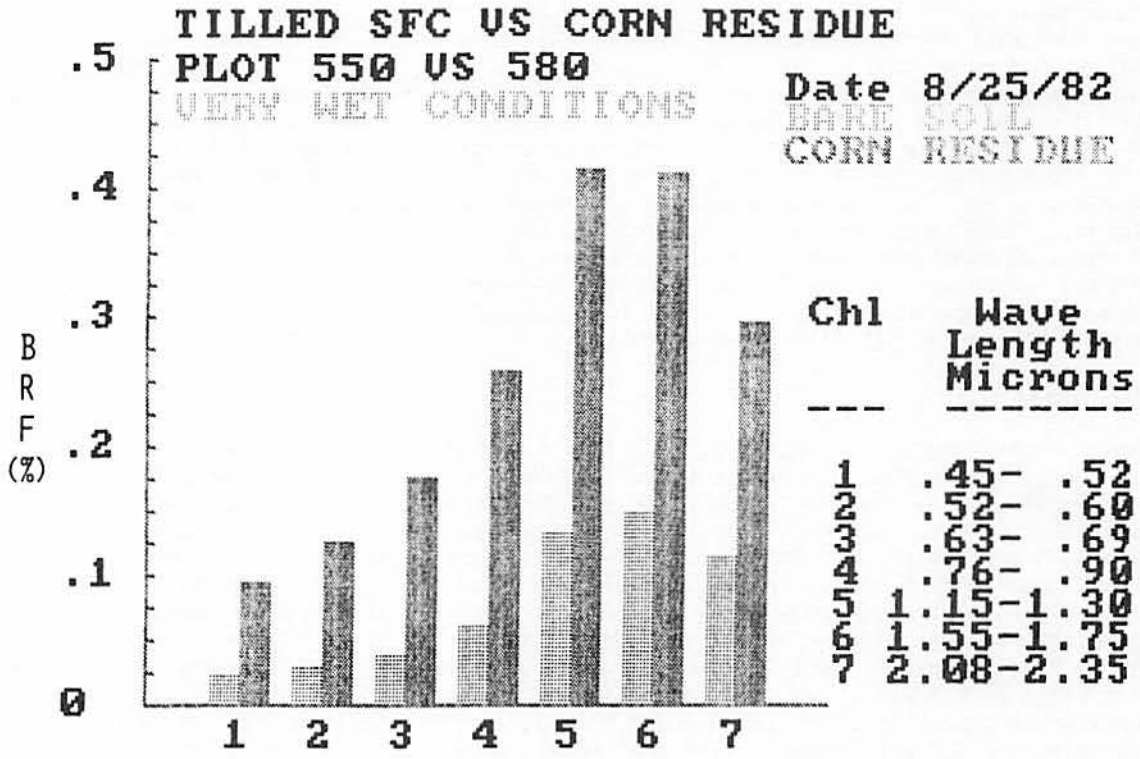


FIGURE 5


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 often 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 (1½ # 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					Dry Matter Production		
N-Rate	Appl. Time	Inh.	Leaf N	Grain 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					Dry Matter Production		
N-Rate	Appl. lime	Inh.	Leaf N	Grain Yield	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 Content		N Removal		
N-Rate	Appl. Time	Inh.	Grain	Stover	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	OAC-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)

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)

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 Inhibitor	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 addi-

tional 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	Leaf Concentration N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	#/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.

		Total Elemental Removal											
		Silage Stover											
Treatment	Rate/A	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	#/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	Soil Tests in ppm by Labs					
	A	B	C	D	E (U.M.)	Check (U.M.)
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	Laboratory				
	A	B	C	D	E
	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, ¼ preplant, ¼ at 8-leaf, ½ 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 ≥ 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.

	Precipitation					Mean Temperatures		Degree Days Accumulated		
Month	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	Elemental Analyses											
	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	%					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	Elemental Analyses											
	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	%					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			Forage			
		Yield	Protein	Test Weight	Dry Matter Yield	Uptake N	Uptake P	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	Elemental Analyses											
	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	%					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	Elemental Analyses											
	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	%					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				Forage			
		Yield	Protein	Test Weight	N Removal	Dry Matter Yield	Uptake N	Uptake P	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/	Elemental Analyses: 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.	Elemental Analyses											
	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.	Elemental Analyses											
	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	North Dakota State University				University of Minnesota							
	$NaHCO_3$-P		Exchangeable K		Bray P-1 10:1		Bray P-1 50:1		$NaHCO_3$-P		Exchangeable K	
No.	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 - - - - - - - - - - - -											
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