SOIL SERIES

A REPORT ON FIELD RESEARCH IN SOIL SCIENCE

The 1979 edition of the "Bluebook" is a compilation of data collected and analyzed throughout Minnesota. Information was contributed by personnel of the Department of Soil Science including Extension Soil Specialists, Scientists at the branch stations of Crookston, Grand Rapids, Lamberton, Morris, Rosemount and Waseca; the "Sand Plain" experimental sites; and Soils and Crop area agents. Associated personnel from the Soil Conservation Service, the Soil and Water Research group of the SEA-USDA, the Tennessee Valley Authority, the Department of Natural Resources and the Departments in Agriculture also contributed information.

Some of the results are from 1978 experiments only and should be regarded on this basis. Since most data are from only 1978 studies, conclusions are not conclusive and are thus not for further publication without the written consent of the individual researchers involved.

Sincere appreciation is expressed for materials and/or financial assistance or program support from several organizations including: Potash and Phosphorus Institute of North America, CENEX, Farmland, Midland Cooperatives and Howe Incorporated, Minnesota Crop Improvement Association, National and State Soybean Associations, Minnesota Golf Course Superintendents Association, Minnesota Limestone Producers Association, U.S. Gypsum Corporation, Minnesota Plant Food and Chemicals Association, Minnesota Soil and Water Conservation Committee, The Minnesota Resources Commission, the Minnesota State Planning Agency, The Water Resources Research Center of the Graduate School, The Staples Vo-Tech Institute, The Red River Valley Potato and Sugar Beet Growers Associations, The Tennessee Valley Authority and the North Central Forest Experiment Station.

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

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AGRICULTURAL METEOROLOGY STUDIES

Donald G. Baker

Several studies are underway that may be of interest to readers of the bluebook. None are complete and therefore only brief examples of each can be shown. They are as follows -

1. Soil Temperature
2. Solar Radiation Reception
3. Wind Climatology of Minnesota

SOIL TEMPERATURE

Analysis of the temperature records at St. Paul has begun again after a period of some years following the publication of "Spring Soil Temperatures" in 1966. This time the analysis will include all four seasons and more than the usual kinds of measurements. These measurements are all made at the agricultural weather station on the St. Paul Campus. The soil is Waukegan silt loam, a well drained loessial soil that is about 75 cm (30 in) thick and is underlain by sand and gravel to a depth greater than 50 m.

Fig. 1 shows the average monthly air temperature and soil temperatures at 10 cm (4 in) depth under bare and sod covers to illustrate several points. The 10 cm (4 in) depth was chosen since this is a common seeding depth and because a great concentration of roots, at least in the first half of a season, are found at this depth.

The presence of a cover such as grass sod throughout the year provides an appreciable amount of insulation during the winter. Thus not only are the winter temperatures under sod higher than both the air temperature and the bare soil temperature at 10 cm depth, but the sod minimum temperature lags the other minima by one month. It occurs in February rather than January. Also noteworthy is the fact that the temperatures under a bare soil at 10 cm depth are higher in the summer than either the air or 10 cm sod cover soil temperatures. During the summer the sod continues to act as an insulator. However, the lower temperatures undersod than under the bare soil are due more to the cooling effect of the evapotranspiration of the sod than the insulation provided by the sod and sod roots.

Fig. 2 illustrates the variability of temperatures. As expected the air temperatures show a greater degree of variability than the 4 cm soil temperatures, and the bare soil more variability than the sod covered soil.

A feature of special interest is that the greatest variation in air temperatures occurs in the winter and a minimum in July. A second minimum in the standard deviation of air temperatures occurs in November, generally the cloudiest month of the year. The winter maximum indicates that the greatest contrast in the air masses that pass the station occurs in the winter while the least is in July and November.

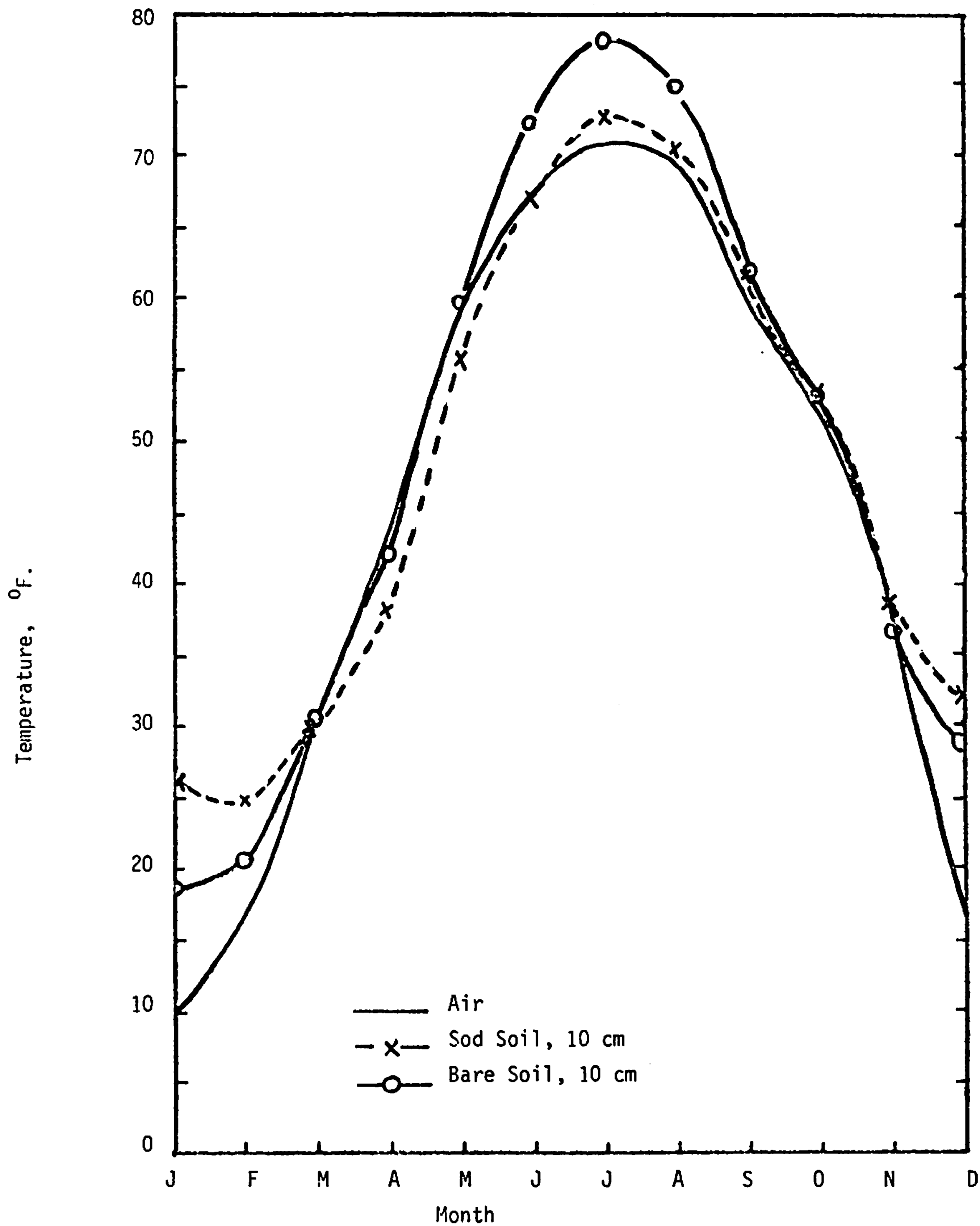


Fig. 1. Average Monthly Air and Soil Temperatures, St. Paul, Minn.

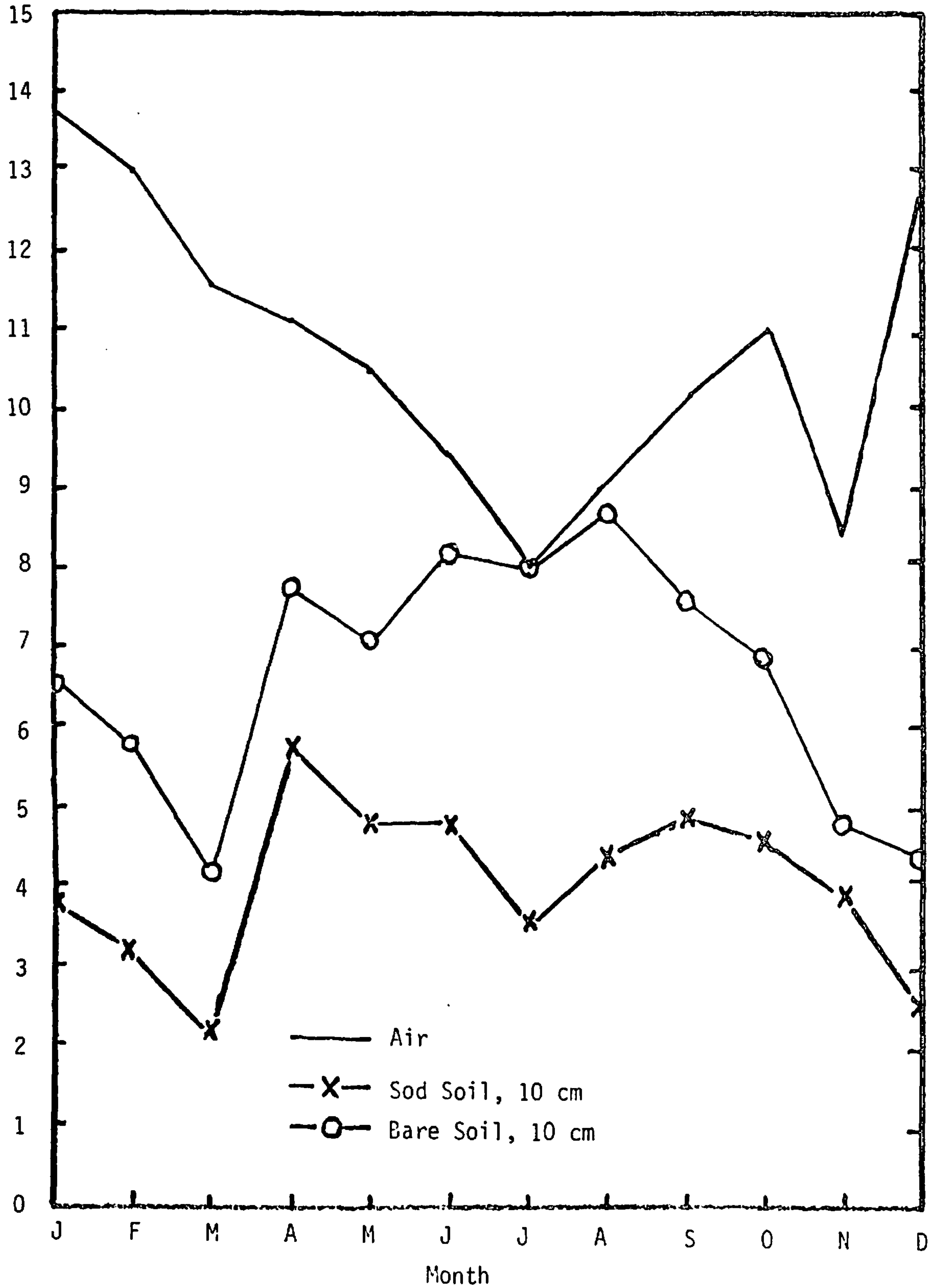


Fig. 2. Average Monthly Standard Deviation of Air and Soil Temperatures, St. Paul, Minn.

In contrast the variability of the soil temperatures is least in March. This is probably due to the March snow cover, usually the deepest of the year, which serves to insulate the soil from the changes occurring at the surface. It is most interesting that in the following month of April a large variability in the soil temperatures is shown. This, of course, is when the snow cover disappears, the soils thaw, and the warming of the soil begins. The bare soil shows a maximum temperature variability in August. It might be assumed that this is when the bare soil is the driest and the temperature can therefore fluctuate widely. This is not evident in the sod covered soil due to the insulating effect of the sod cover.

The average time of the occurrence of the maximum and the minimum temperature in July in the bare soil and in the air (in the temperature shelter) is shown in Fig. 3. The most obvious feature is the increasing lag in the occurrence of the temperature maximum and minimum with depth. Surface temperature measurements are not available, but the maximum could be expected at about solar noon. In mid-July solar noon at St. Paul occurs at about 12:18 Central Standard Time.

The data shown in Fig. 3 permit the calculation of two interesting soil physical parameters related to soil thermal properties. One is the velocity of the heat wave through the soil, and the other is the soil thermal diffusivity. The rate of the heat wave passage through the soil is about 6.7×10^{-4} cm sec^{-1}. This is the mean value for the maximum temperature to pass from 1-80 cm in July. In other words it takes 32.75 hours for the maximum temperature to move from the 1 cm to the 80 cm depth.

The velocity (v) of the heat wave equals the following:

$$v = \left(\frac{4\pi x}{P}\right)^{\frac{1}{2}}$$

where x = k/pc = the thermal diffusivity, and P = the period of the daily heat wave. Since we now have a value for v we can solve for x. With v = 6.7×10^{-4} cm sec^{-1} it is calculated that x = 0.0031 cm^2 sec^{-1}.

The data (not shown) indicate a slightly faster movement through the soil with a sod cover, 7.8×10^{-4} cm sec^{-1}, and therefore the thermal diffusivity has a slightly higher value also, x = 0.0042 cm^2 sec^{-1}.

Ideally the data shown in Fig. 3 would plot as straight lines. That they do not indicates minor errors, perhaps in the temperature and depth measurements. Of greater importance, however, is the variation in the soil properties with depth which influence the transmission of heat. The data are averages for different soil moisture contents and thus represent a host of different conditions. At any particular time both the velocity of the temperature wave and the thermal diffusivity may differ appreciably from the calculated values obtained.

The complete analysis of the soil temperature data will emphasize conditions during the growing season.

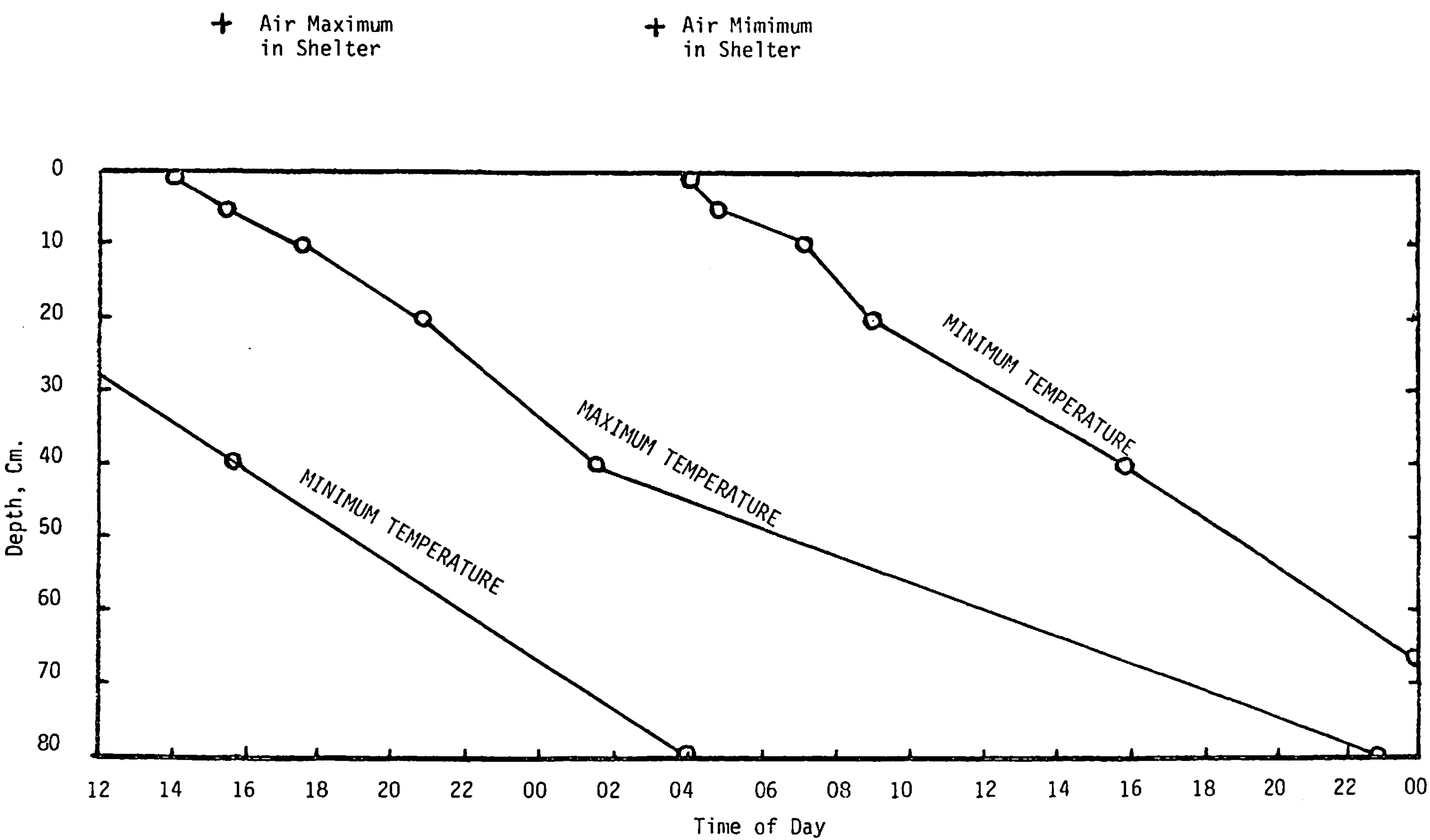


Fig. 3. Average Time of Occurrence of Maximum and Minimum Air and Bare Soil Temperatures, July, St. Paul, Minn.

SOLAR RADIATION

Solar radiation reception at the St. Paul agricultural weather station continues to be measured. Currently measurements include the fluxes of incoming short and longwave radiation, outgoing short and longwave radiation, diffuse radiation, and net radiation. Soon the measurement of radiation reception on an inclined surface will be added.

Studies of special interest to solar collector design include the distribution of hourly radiation values during the year; a second one is a comparison between the amount of radiation incident on a surface perpendicular to the sun and that incident on a horizontal surface. Examples of both will be shown.

The maximum, median,and mean amounts of radiation received on the hour on a horizontal at St. Paul for the period 1971-1977 are shown for the week of June 18-24 in Fig. 4. The distribution of these hourly values is shown in Fig. 5. It is obvious in both Fig. 4 and Fig. 5 that the mean fails to divide the population into two equal parts, since the mean is not equal to the median. This fact is of importance when it comes to determining the probability of occurrence of the hourly values. Because the hourly values are not normally distributed then the mean and standard deviation lose their value as descriptive and useful statistics.

An interesting feature relative to the ratio of the median hourly values (on all days, 1971-1977) to the clear-day hourly values is shown in Table 1. Curiously, the ratio for the three

Table 1. Ratio of the median hourly values of solar radiation, 1971-1977, to clear-day hourly values on four days of the year at St. Paul.

Date	Ratio
March 21	0.73
June 21	0.73
September 21	0.73
December 21	0.51

days (March 21, June 21, and September 21) remains constant while on December 21 the ratio is substantially different. Why the first three days should have ratios exactly alike, except as a matter of chance, is not known at this time. The low ratio for December 21 simply seems to be a reflection of the greater cloudiness that is usually associated with the months of November and December.

The calculated amount of clear-day radiation incident on horizontal surfaces and surfaces oriented perpendicular to the sun's rays is shown in Fig. 6 for December 21. The advantage to having a solar collector oriented perpendicular to the solar rays is obvious. The radiation incident upon horizontal and perpendicular surfaces is also being calculated for the 15th day of each month plus the equinoxes and solstices. As shown in Fig. 6 the calculations will were made for both the direct beam and the diffuse radiation. It is also our intention to compare the results of different solar radiation calculation methods used to obtain direct beam and diffuse radiation with measured values.

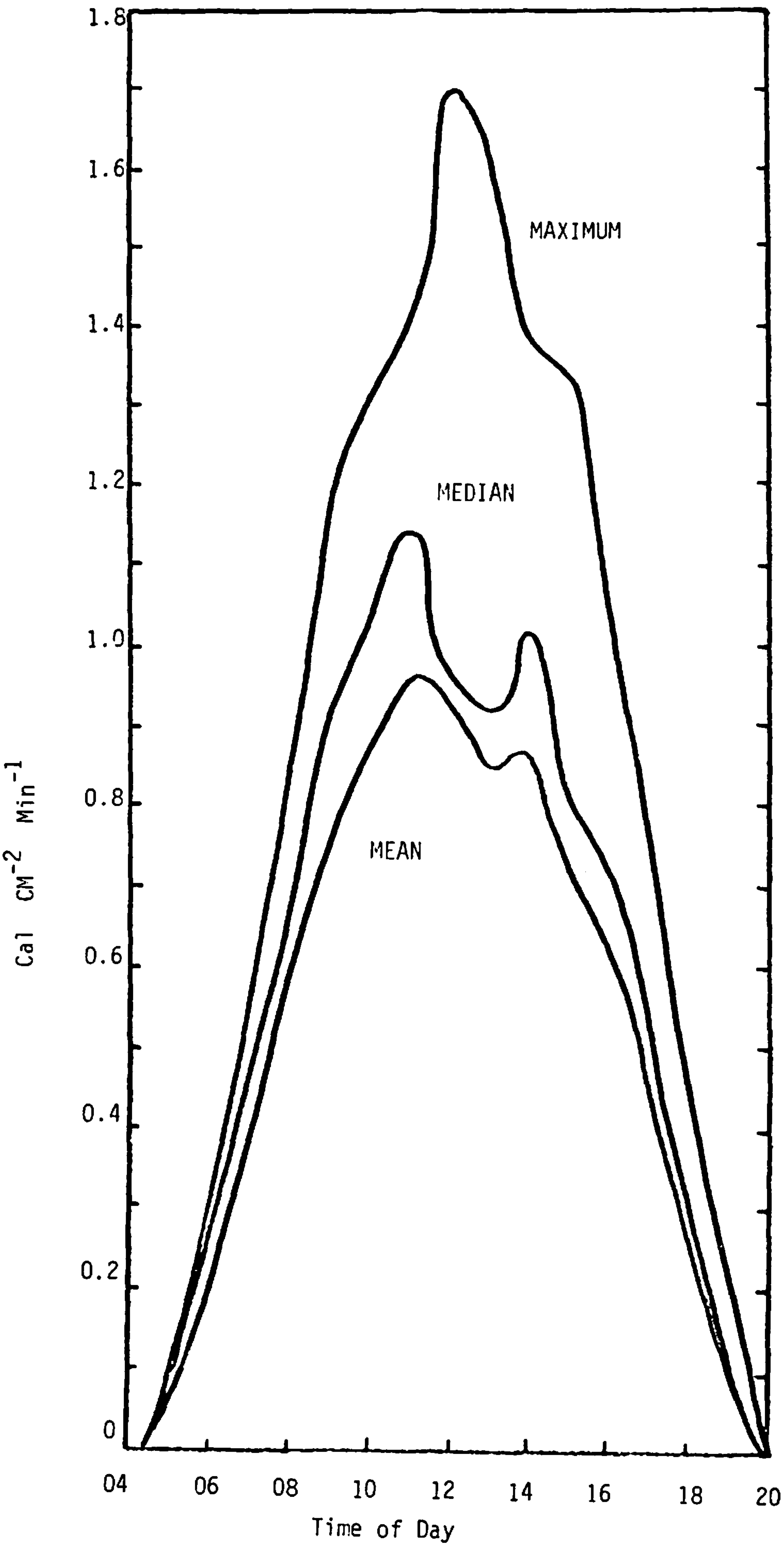


Fig. 4. Mean, Mediam and Maximum Hourly Solar Radiation Values, June 18-24, 1971-1977, St. Paul.

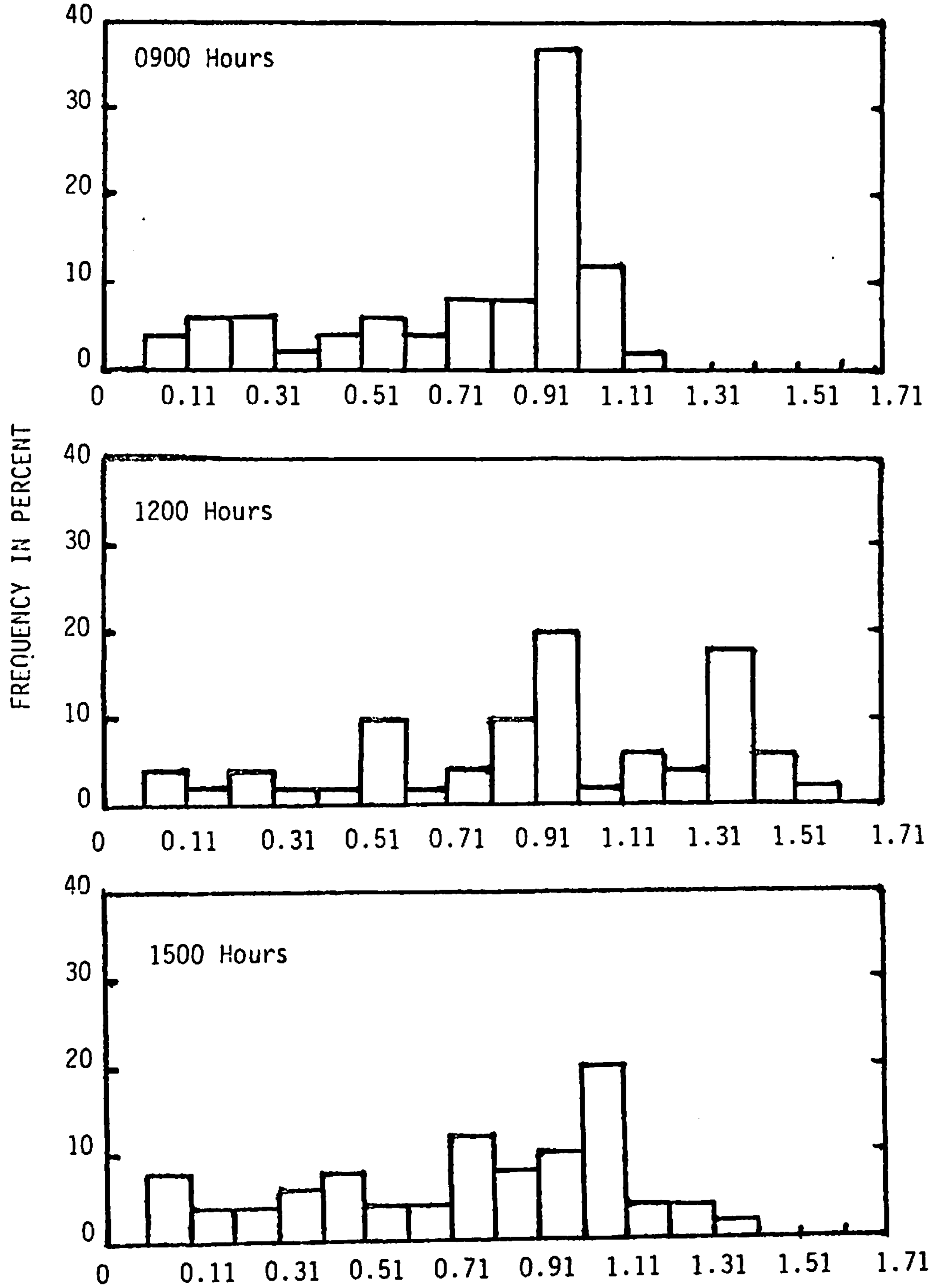


Fig. Frequency Distribution of Hourly Solar Radiation Values, June 18-24, 1971-1977, St. Paul Minn.

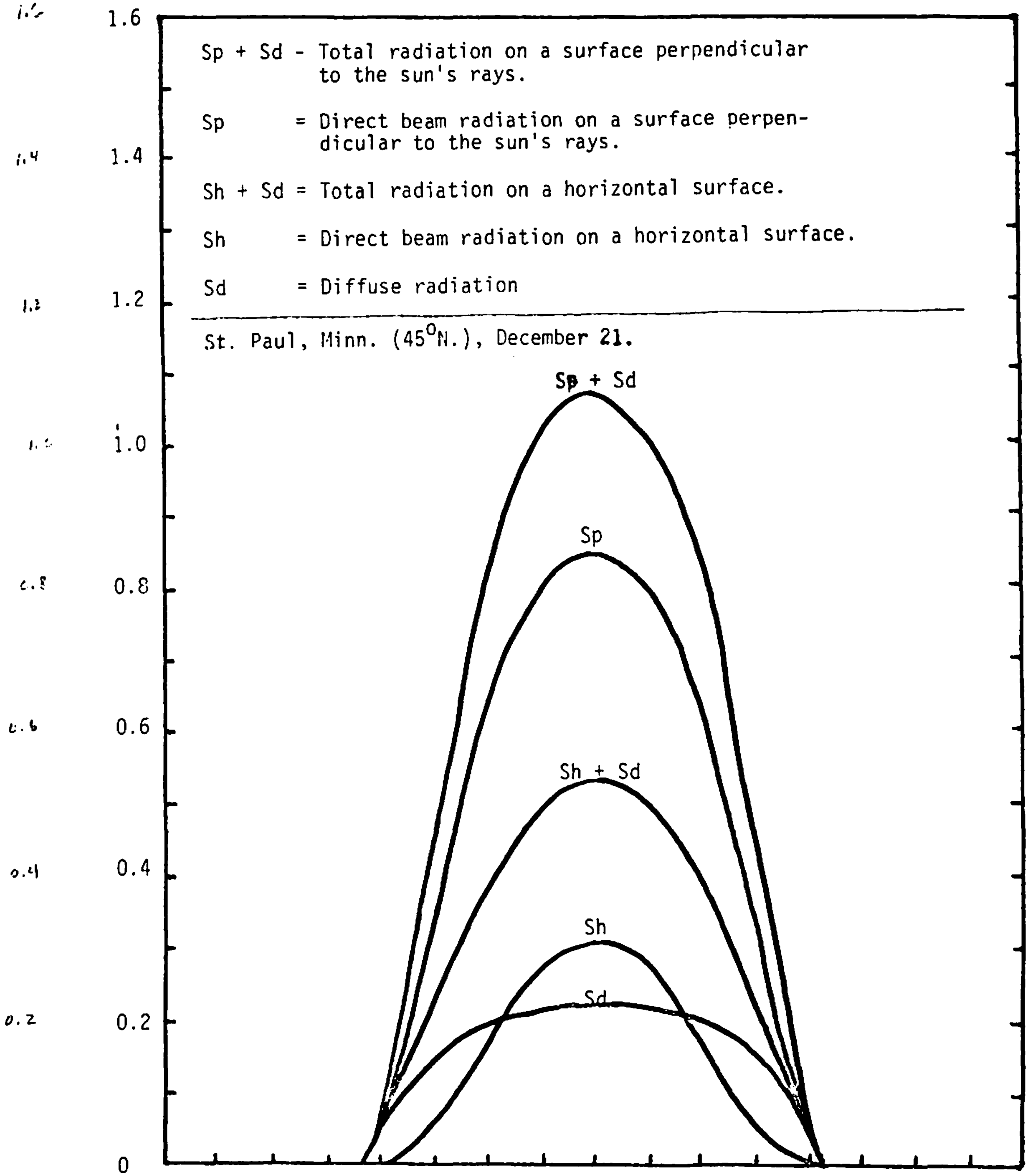


Fig. 7. Calculated amount of direct diffuse and total solar radiation received on horizontal surfaces and perpendicular to the sun at 45°N.

WIND

Just as solar energy is looked upon as an untapped source of energy that would be an excellent source given a satisfactory means of capturing and storing it, so too is wind energy. For this reason we are also studying the climatology of wind. It is our desire to provide the kind of information that an engineer can use to determine the availability and reliability of the wind as an energy source.

A number of different analyses of the available wind data have been made. A few of the results are shown in Table 2.

Table 2. Wind patterns at Minneapolis-St. Paul, 1951-1960.*

Month	Average Speed, mph.	Resultant Direction	Vector Speed, mph.	Constancy of Wind, %
January	10.5	285°	2.1	20.0
April	13.2	337°	1.7	12.9
June	11.4	150°	1.6	15.5
September	10.9	207°	2.4	22.1
December	10.7	279°	2.0	18.8
Annual	11.2	252°	0.9	8.4

*Calculations are based upon raw data from the National Weather Service Statio

The average wind speed is lowest in July and August (not shown) and is at a maximum in April. The secondary maximum is in November (not shown). Both April and November are months when the polar front lies over the region and storm activity is at a maximum. The resultant wind direction shows the monsoon-like character of the wind in Minnesota; that is, it shows a seasonal wind shift. For example, from November through April the resultant wind is westerly or northwesterly, while from May through August it is southeasterly to southerly. The constancy of the wind is never very great, as any resident can verify, because of the number of storm systems and the rapidity with which they move through the area. This, of course, brings about a rapid fluctuation in wind direction. Generally the wind is most constant in August (from 153° or SSE) and least constant in May, when all directions are nearly equally represented.

It is apparent a wind-mill or turbine to be most effective should be constructed so that it moves with the change in wind direction. Or if it is rigid then it should be constructed with the rotor in a horizontal plane so the wind direction is unimportant with respect to the capture of wind energy.

Other calculations are being made which include the amount of wind power available in different wind speed classes and times of the year. The power within wind speed classes is important since there are wind speeds above and below which most mills or turbines cannot operate. These kind of data and monthly wind roses are being determined for seven other stations besides Minneapolis-St. Paul. Examples of the monthly wind roses for the Minneapolis-St. Paul National Weather Service station are shown for January, Fig. 7, and July, Fig. 8. It is apparent that Minnesota undergoes a seasonal wind shift as is also shown in Table 2.

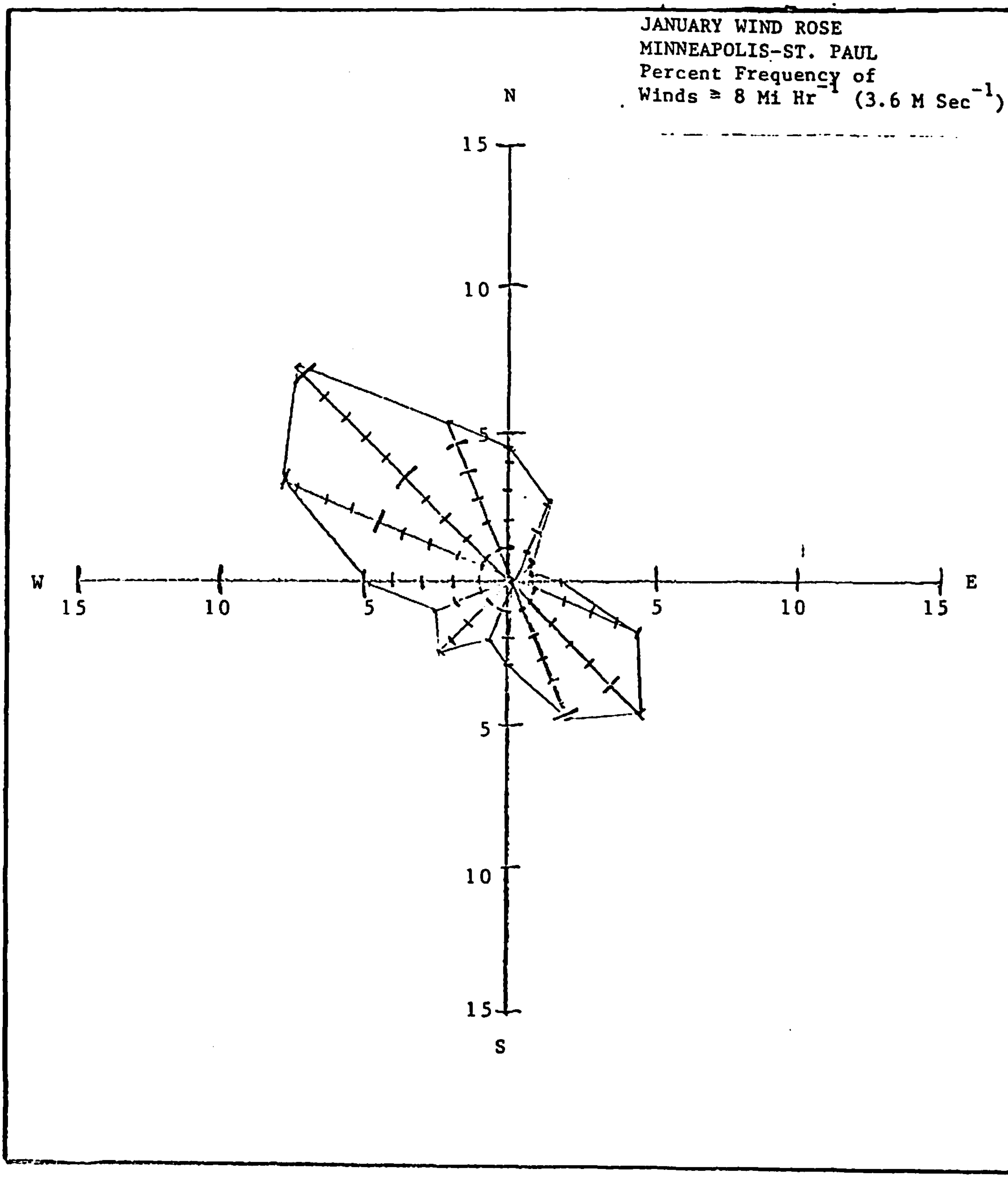


Fig. 7. Frequency distribution of wind directions for winds at least 8 mph in January at Minneapolis-St. Paul, 1951-1960.

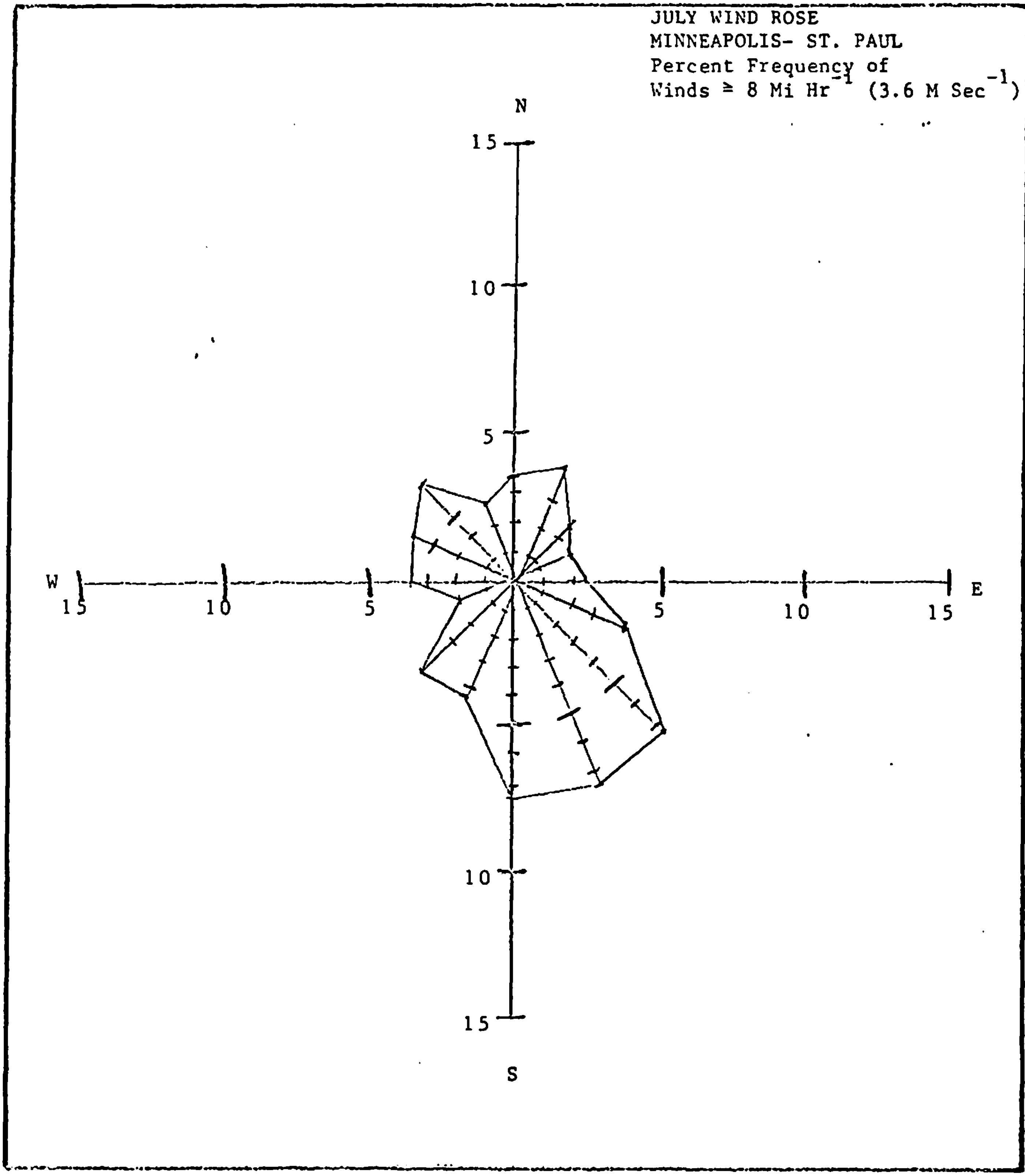


Fig. 8. Frequency distribution of wind direction for winds at least 8 mph in July at Minneapolis-St. Paul, 1951-1960.

MINNESOTA SPRING SOIL MOISTURE SITUATION MARCH 1979

D. Ruschy(Soil Sci. Dept.), E.L. Kuehnast(Minn. Dept. of Natural Res.), D.G. Baker(Soil Sci. Dept.)

Climatic conditions a year ago were quite different from today. Going into the winter of 1977-78 soil moisture was exceptionally high, nearly at the maximum water holding capacity for plants except in west-central and the southeast, but even here the soil moisture was also above normal. The 1978 crop season across the state as a whole was nearly ideal for the farmers with excellent spring soil moisture conditions, a warm and early spring for planting, timely and near or above normal summer rains with few exceptions, and a dry fall giving ideal harvesting weather.

PRECIPITATION:

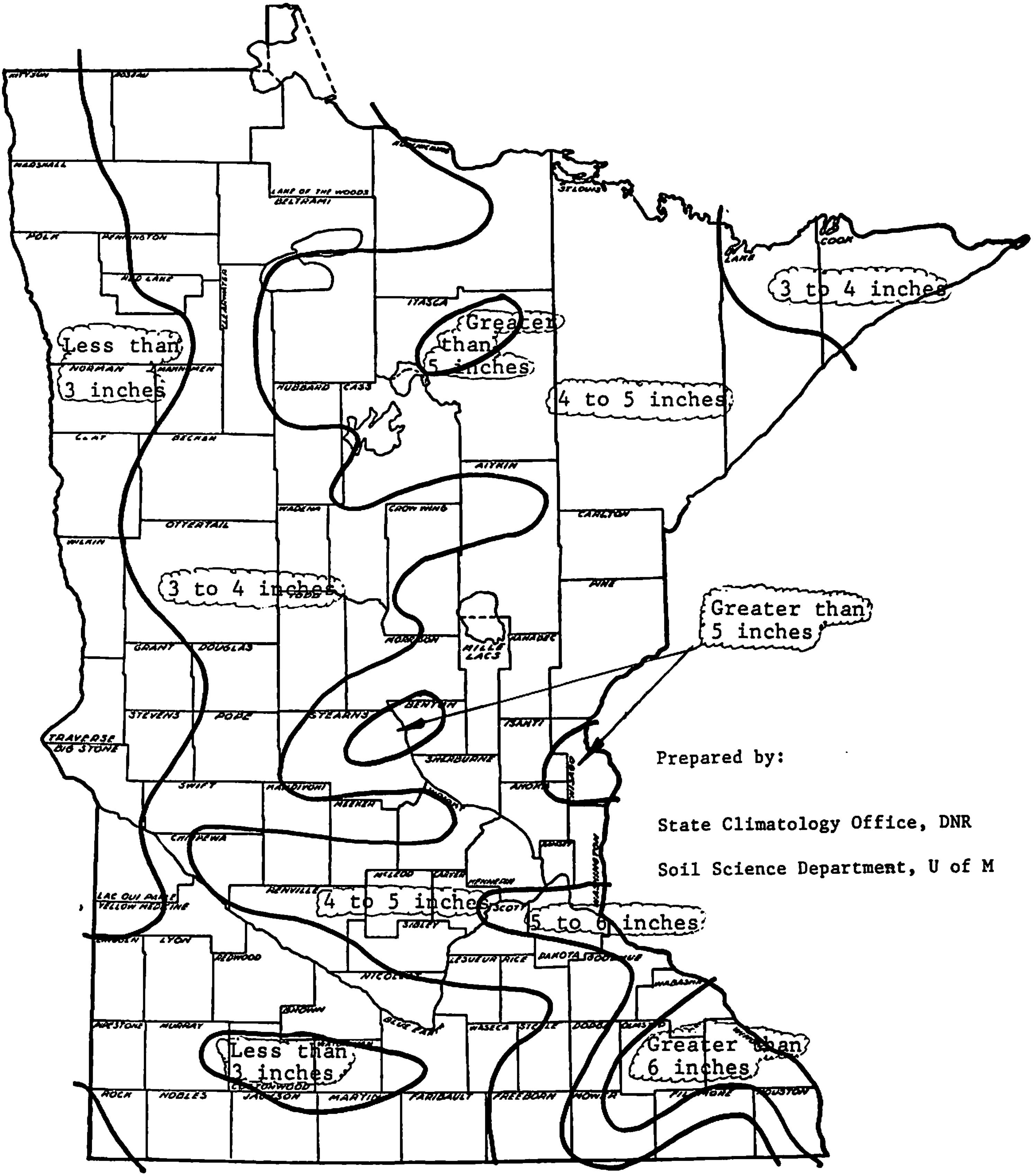
Precipitation across the state during September through Nevember, 1978, was generally below normal, exceptions being the southeastern part of the state and a strip north of the Minnesota River which averaged more than one inch above normal. The greatest September to November precipitation was 11.96 inches at Rochester and the least 1.92, at Halstad (north of Fargo).

SOIL MOISTURE:

Results of combined soil and precipitation measurements are shown in the accompanying figure. Except perhaps for some very localized spots the soils entered the winter of 1978-79 with no areas either excessively wet or dry. The wettest area is centered around Olmsted county in the southeast. Relatively dry soils are found in a 50-mile wide strip along the western border from Canada south to Yellow Medicine County, a small area that is essentially limited to Cottonwood and Watonwan Counties, and the extreme northeast in Lake and Cook Counties.

Top soil moisture was generally short across the state going into winter particularly along the western border. Presently the water content in the snow cover is generally greater than 3 inches, and with continued normal precipitation nearly 5 inches of water can be expected in the snow cover by April.

The dry top soil condition coupled with lots of water in the snow cover means that during the spring snow melt the drier top soils in western Minnesota will absorb more moisture than is ordinarily absorbed under average moisture conditions.



Prepared by:

State Climatology Office, DNR

Soil Science Department, U of M

Estimated soil moisture in inches in the top 5 feet of soil. Based on medium to fine soils. February 1979

CONTROLLING SOIL pH FOR POTATOES UNDER IRRIGATION (LIMY WATER) 1978

C. J. Overdahl and R. P. Schoper 1/

Lowering pH with Nitrogen

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

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

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

Initial Soil tests were made in April 1976 before fertilizer application. The range of these test results were: pH 6.0 to 6.4; P 30 to 42; K60 to 120; soil texture loamy sand.

1/ The efforts of Jerome Lensing, Mike O'Leary, and Glenn Titrud in organizing the field work is gratefully acknowledged.

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

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

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

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

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

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

** Norland received 200# N/A.
Russet Burbank received 300# N/A.

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

Tuber yield in Table 1 shows that ammonium sulfate plots produced significantly higher yield with Norlands in 1977 and 1978. Gypsum at 300 pounds per acre has been added to all plots to prevent compounding of sulfur as a nutrient in ammonium sulfate. It is possible, however, that sulfur has affected yield from the ammonium sulfate treatment. A greater quantity of gypsum will be added in 1979.

Dr. Neal Anderson of the Plant Pathology Department observed no serious scab problem on the tubers in these plots in 1978.

Lowering pH with Elemental Sulfur

Elemental sulfur was added on irrigated land on the Jerry Zimmerman farm in Sherburne County in the spring of 1978. This was broadcast and incorporated at varying rates to observe the effect of sulfur in reducing soil pH where potato scab is a problem. Table 3 shows sulfur rates and related pH measured in the fall of 1978. This trial will be followed-up for potato yield in 1979.

Table 3. The effect of elemental sulfur on soil pH on a Hubbard sandy loam. (Sherburne County, 1978)

Sulfur Treatment lbs/A	Mean Soil pH
0	5.4
500	5.2
1,000	5.0
2,000	4.6
3,000	4.7

Table 4. Elemental analyses of upper mature leaves of 2 varieties of potatoes according to nitrogen forms. Becker Farm, July 7, 1978.

	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	---------	%	----------		-----------		ppm	---------	
Norlands									
None	.35	4.72	2.03	.61	357	146	16	5	32
AN	.31	4.70	1.45	.49	176	169	17	6	39
Urea	.32	4.72	1.49	.51	235	176	19	6	40
AS	.29	4.83	1.35	.45	238	370	20	6	39
Russets									
None	.33	4.23	1.16	.61	406	56	16	8	31
AN	.30	4.50	1.03	.58	221	140	17	6	25
Urea	.32	4.10	.99	.61	201	98	18	7	23
AS	.30	4.28	.77	.45	213	264	19	7	33
Common Ranges for most	.20	4.0	2.0	.50	70	30	20	-	30
research*	.40	8.0	4.0	.80	150	50	40	-	40
Intermediate level**	.20	5.8	---	.40	---	40	17	3	--

* Soil Testing and Plant Anaylsis. SSSA p. 368
** Diagnostic Criteria. H. D. Chapman. University of California

Average of 4 reps for each variety

MICRONUTRIENT TESTS ON ALFALFA

Becker, MN 1978

C. J. Overdahl and Jerome Lensing

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

One rate of each nutrient was compared to none or to a complete mixture of all micronutrients. The nutrients and rates were applied in April 1977 as follows:

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

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

Alfalfa yields at 15 percent moisture in 1978 from the 3 cuttings are shown in Table 1.

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

Table 1. Alfalfa yields from micronutrient treatments in 1977. Becker, MN. non-irrigated plots, 1978.

Micronutrient Treatments per acre	Alfalfa yield Tons/acre 1st cut	2nd cut	3rd cut	Total
None	1.04	1.72	.92	3.68
Mo 4 oz	.94	1.67	.89	3.50
B 2 lbs	1.09	1.60	.88	3.57
Cu 10 lbs	1.08	1.70	.90	3.68
Zn 10 lbs	1.03	1.64	.88	3.56
Fe 0.6 lb	1.07	1.76	.92	3.75
Mn 10 lbs	1.01	1.68	.88	3.56
"shot-gun" all above	.99	1.70	.88	3.57
no-sulfur1/	.98	1.58	.82	3.38
Significance	ns	ns	ns	ns
BLSD (5%)	-	-	-	-

1/ "no sulfur" plot had a significantly lower yield on the second cutting at 5% level compared to no micronutrient treatment yield.

Table 2. Alfalfa yields from micronutrient treatments in 1977. Becker, MN. irrigated1/ plots. 1978.

Micronutrient Treatments per acre	Alfalfa yield Tons/acre 1st cut	2nd cut	3rd cut	Total
None	1.27	1.84	.84	3.95
Mo 4 oz	1.39	1.99	.97	4.35
B 2 lbs	1.38	1.88	.95	4.21
Cu 10 lbs	1.36	1.89	.91	4.16
Zn 10 lbs	1.25	1.80	.90	3.95
Fe 0.6 lb	1.43	2.14	.97	4.54
Mn 10 lbs	1.33	1.96	.88	4.17
"shot-gun" all of above	1.32	1.96	.97	4.25
no-sulfur	1.34	1.84	.94	4.12
Significance	ns	ns	ns	ns

1/ irrigated plot was watered regularly in 1977, but high rainfall (28.5 inches during growing season) permitted omitting of irrigation in 1978.

Micronutrient Fertilization of Potatoes and Corn Under Irrigation

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

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

EXPERIMENTAL PROCEDURES

Seven treatments, including a control, four micronutrient treatments, and two macronutrient treatments were established in a randomized complete block design with four replications. Rates and types of fertilizer applied included: 5 lbs Copper/A as $Cu(NO_3)_2$, 2 lbs Boron/A as Solubor, 25 lbs of Sulfur/A as $CaSO_4$, 75 lbs of Magnesium/A as $MgCl_2$, 10 lbs of Zinc/A as $ZnCl_2$, and 3 lbs of Manganese/A as $MnCl_2$. All treatments were applied as preplant broadcast and incorporated treatments.

The soil was a Hubbard coarse sand with a pH of 6.3, Bray P-1 of 32, exchangeable K, Ca, Mg of 186, 1260, and 250#/A, DTPA extractable Zn, Mn, and Cu of 1.7, 17 and .53 ppm organic matter content of 2.5% and water extractable SO_4-S of 15 ppm. The entire area was spring plowed, and the two experiments with potatoes sprayed with 3½ lbs/A of Eptam (54 gal/A) incorporated for weed control. Fertilizer treatments were applied, incorporated by discing and the potatoes planted on April 27th. Norlands were planted in nine inch spacings utilizing 36 inch rows, while Russet Burbanks were planted in 12" spacings with the same row width. At the time of planting starter was used at 1200 lbs/A of 8-10-30 and an insecticide, Temik 15G banded at 14 lbs/A. Lorox herbicide was applied on May 16th at 1½ lbs/A (54 gal/A spray) for additional weed control. Sidedressing treatments of nitrogen were made on May 30 (170 lbs/A of 34-0-0) and on June 17 (220 lbs/A of 34-0-0), along with hilling at the last sidedressing. Samples of the youngest mature potato leaves were obtained 69 days after planting for nutrient composition. The Norland potatoes were harvested on Aug. 31 and the Russet Burbanks on Sept. 21. Irrigation water was applied during the period of June 6 through August 17th with a total addition of 8.35 inches. Precipitation during the period of May-Aug. was 17.3 inches and May-September was 22.6 inches.

Utilizing the same treatments, a third experimental area was planted to corn. The area had been fertilized with 550 lbs/A of 8-10-30 prior to planting on May 5. A commercial corn variety (Pioneer 3901) was planted in 30 inch rows at a population of 30, 700 seeds/A. Starter fertilizer at the rate of 150 lbs/A of 8-10-30 was utilized at planting time followed by a tank mix (54 gal/A) of Atrazine (1 lb/A a.i.) and Lasso (1½ lbs/A a.i.) for weed control. Sidedressing applications of nitrogen were made on June 1 (230 lbs/A of 34-0-0) and June 23 (320 lbs/A of 34-0-0) for a total addition of 243 lbs of N/A for the season. In addition to the 22.6 inches of precipitation received during the growing season an additional 9.45 inches was added through irrigation during the period of June 6th through September 5th.

General Results

Preliminary soil tests from the experimental area would suggest that large yield response due to addition of the nutrient elements under investigation would not be anticipated. As expected, no significant yield increases were obtained with either the Norland or Russet Burbank potatoes as well as with corn. Yield levels were high in all three experiments. Increased nutrient concentrations in the potato leaves due to direct nutrient application were observed for copper with the Norland potatoes and for Zn, Cu and B with Russet Burbank potatoes. Increased concentrations of Zn and B in the leaf opposite and below the ear at silking as well as increased B levels in the silage stover were obtained due to the treatments. In all cases nutrient concentrations were deemed adequate for good plant growth.

Table 1. Influence of micronutrient fertilization (also Mg and S) on tuber yield and nutrient concentration of youngest mature leaf 69 days following planting for Norland and Russet Burbank potatoes.

	Norland Potatoes													
	Tuber	Leaf Concentration												
Treatment	Yield	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Co
	cwt/A	%					ppm							
Control	402	4.93	.39	4.57	1.48	.82	63	148	49	101	21	7	34	3
Cu	431	4.82	.39	4.55	1.69	.86	63	288	71	114	22	10	36	3
B	420	4.99	.38	4.48	1.41	.76	38	132	28	114	22	7	37	3
S	389	5.08	.38	4.46	1.53	.85	71	153	45	100	21	7	32	3
Mg	378	5.09	.40	4.54	1.26	.77	43	136	44	86	24	7	31	3
Zn	414	4.97	.38	4.40	1.70	.94	82	161	55	115	24	7	33	3
Mn	415	4.89	.38	4.57	1.53	.85	70	151	33	106	22	7	33	3
Signif.	NS	NS	NS	NS	(.10)	NS	NS	NS	NS	NS	NS	**	NS	NS
BLSD(.05)	-	-	-	-	.29	-	-	-	-	-	-	1	-	-
	Russet Burbank Potatoes													
Control	427	5.13	.37	4.01	.81	.64	124	166	39	84	22	6	27	3
Cu	419	5.01	.37	4.19	.86	.67	99	150	64	76	22	7	26	3
B	446	5.04	.37	4.25	.80	.60	109	154	45	85	22	6	30	3
S	435	5.01	.36	4.21	.84	.63	118	160	53	84	22	5	27	3
Mg	407	5.17	.35	4.04	.78	.63	109	155	54	78	22	5	26	3
Zn	437	5.13	.38	4.28	.83	.66	99	150	45	72	25	6	26	3
Mn	424	4.92	.35	4.20	.86	.65	120	160	47	87	21	5	27	3
Signif.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	*	*	NS
BLSD(.05)	-	-	-	-	-	-	-	-	-	-	2	1	3	-

Table 2. Influence of micronutrient fertilization (also Mg and S) on corn grain yield, dry matter production, and elemental composition of the leaf opposite and below the ear at silking.

Treatment	Harvest Grain: Yield 15.5% M	Harvest Grain: Dry Matter	Harvest Grain: N Removal	Dry Matter (Physiological Maturity): Stover	Dry Matter: Grain	Dry Matter: Total	N Removal: Stover	N Removal: Grain	N Removal: Total
	bu/A	%	#/A	T/A	T/A	T/A			
Control	195.5	61.4	143.9	4.52	4.71	9.23	72.5	135.6	208.1
Cu	193.9	65.1	137.2	4.36	4.48	8.84	73.6	124.5	198.2
B	195.2	61.2	127.6	4.18	4.42	8.60	80.3	125.7	206.0
S	194.2	63.7	137.4	4.30	4.64	8.94	63.5	130.7	194.2
Mg	197.3	64.4	134.5	4.25	4.33	8.58	59.7	126.5	186.2
Zn	202.2	63.0	137.8	4.09	4.58	8.67	73.3	133.7	207.0
Mn	195.2	60.8	139.1	4.43	4.55	8.98	65.6	127.0	192.7
Signif.	NS	NS	NS	NS	NS	NS	*	NS	NS
BLSD(.05)							14.4		

Leaf Nutrient Composition

	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	%	%	%	%	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Control	3.05	.33	2.79	.51	.23	59	138	64	98	25	13	8
Cu	3.14	.34	2.95	.48	.21	60	136	61	98	25	14	8
B	2.99	.34	2.65	.49	.23	58	136	64	88	24	13	10
S	3.08	.34	3.02	.50	.19	59	142	59	104	25	14	8
Mg	2.95	.32	2.89	.48	.27	63	180	73	83	24	12	8
Zn	2.88	.30	2.76	.46	.22	71	145	66	72	32	11	8
Mn	2.88	.32	3.00	.47	.23	70	140	70	85	25	12	8
Signif.	*	+	+	NS	NS	NS	NS	NS	NS	**	NS	*
BLSD(.05)	.20	.03 (.10)	.26 (.1[illegible])							4		1

Table 3. Elemental composition of Silage Stover and Harvest grain as influenced by micronutrient (also Mg & S) fertilization

Treatment	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	Silage Stover-Elemental Concentration											
	%					ppm						
Control	.80	.08	1.71	.34	.14	139	148	77	87	17	12	6
Cu	.84	.08	1.77	.36	.15	134	145	78	94	19	13	6
B	.96	.08	1.82	.36	.14	129	130	82	102	15	14	10
S	.74	.07	1.85	.32	.11	129	122	78	87	15	12	8
Mg	.70	.07	1.82	.32	.16	104	109	77	78	16	11	5
Zn	.90	.08	1.74	.36	.14	119	120	78	92	20	14	6
Mn	.74	.07	1.76	.37	.20	121	119	82	77	19	11	6
Signif.	**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**
BLSD(.05)	.08											2
	Corn Grain-Elemental Concentration											
Control	1.56	.31	.46	.04	.13	4	22	52	7	25	4	1
Cu	1.50	.31	.46	.04	.13	4	23	58	6	25	5	1
B	1.38	.29	.43	.04	.12	4	23	31	8	24	5	2
S	1.50	.30	.46	.04	.13	4	24	42	8	24	5	1
Mg	1.44	.30	.45	.05	.12	4	24	42	7	25	5	1
Zn	1.44	.31	.45	.05	.13	5	25	43	8	28	5	2
Mn	1.50	.29	.46	.03	.12	4	21	40	7	24	4	1
Signif.	*	NS	NS	NS	NS	NS	*	NS	NS	NS	NS	NS
BLSD(.05)	.09						2					

Influence of Nitrogen Form, Nitrification Inhibitors, and Treatment Incorporation on Yields, and Nitrogen Utilization of Corn Under Irrigation

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

A number of management alternatives are available for the producer concerned with nitrogen management for corn production under irrigation. The producers must be concerned not only with rates of nitrogen, but must also be prepared to consider timing of application, form of nitrogen, and method of application. The use of nitrification inhibitors under irrigation also presents some new considerations in nitrogen management. The most common method for application of nitrification inhibitors is with simultaneous application of anhydrous ammonia. Under irrigation, nitrogen application may take place in several manners, ranging from one single application at some point during growing season to many small applications which may be facilitated through the irrigation water. With such management systems, a variety of fertilizer nitrogen forms may be utilized. Utilization of nitrification inhibitors under such diverse systems creates a number of questions, such as: Can nitrification inhibitors be applied with the irrigation water? Do they react differently with nitrogen forms other than anhydrous ammonia? Must the products be incorporated to be effective? To investigate some of these concerns a trial was established at the Sand Plains Research Farm near Becker, MN. with the following objectives: 1) to compare the use of urea and 28% nitrogen solutions under irrigation, 2) to evaluate the use of N-Serve (Dow Chemical) and Terrazole (Olin corporation) with different nitrogen forms, and 3) to determine the impact of surface applied and incorporated combinations of the previous treatments.

Experimental Procedures

A total of eight main treatments were replicated four times and arranged in a split block design to generate 16 treatment comparisons. Six of the main treatments consisted of two nitrogen forms (urea and 28% nitrogen solution) with three nitrification inhibitor treatments (none, N-Serve-0.5#ai/A, Terrazole-0.5#ai/A). In the above treatments all nitrification inhibitor applications were made as coatings onto urea prior to application or were mixed into 28% nitrogen solution prior to application. Two additional main treatments were established with urea, where urea was broadcast on the soil prior to a spray application of the nitrification inhibitor treatments. Each main plot was split to provide an incorporated (discing) and a non-incorporated comparison. All treatments received a total of 120#N/A in a spring preplant application. The experimental area had been previously fertilized with 300#/A of K-$MgSO_4$ (0-0-22), 260#/A of 0-0-60, and incorporated by plowing on April 4th. Treatments were applied on April 27, and areas requiring incorporation were disced immediately after application. Corn (Pioneer 3901) was planted into the experimental area on May 5 at a rate of 30,700 seeds/A in 30" rows. Starter fertilizer at 150#/A of 0-18-36 was utilized at planting. A tank mix of Atrazine (1#ai/A) and Lasso (1½#ai/A) was utilized for weed control. The irrigation program was initiated on June 5 and continued through September 6 with a total of 8.75 inches of water being applied through irrigation and 22.31 inches coming through rainfall.

Leaf samples from opposite and below the ear at 50% silking were taken from each plot on July 6, dried, and analyzed for Kjeldahl nitrogen. Dry matter and nitrogen uptake were determined by harvesting one row 15 ft. long from each plot on September 7 and 8 (Physiological maturity). Ears were separated from the stalks, field weights obtained and samples removed for moisture determination and nitrogen analysis. Yields were obtained on September 21 and 22 by hand harvesting two rows 20' long. Field weights were obtained and samples collected for moisture and nitrogen determination. Corn grain yields were adjusted to 15.5% moisture.

General Results

Nitrogen concentration in the leaf opposite and below the ear at 50% silking, yield, and nitrogen removal with the yield grain are reported in Table 1. The general nitrogen status of the corn plant as reflected with the nitrogen content of the leaf at silking and grain yield suggested that the nitrogen availability from the urea treatments was greater than when 28% nitrogen solution. This does not in itself suggest that urea is a superior fertilizer to 28% nitrogen solution, but reflects the timing and initial chemical form of the nitrogen fertilizer. Nitrogen solution (28%) is a mixture of urea and ammonium nitrate (approx. 50-50) fertilizers. As applied, therefore, approximately 25% of the nitrogen fertilizer in the solution will be applied as nitrate nitrogen. This nitrate nitrogen is immediately susceptable for losses through leaching (or denitrification) if the climatic conditions develop. The remaining 75% of the nitrogen in the 28% nitrogen solution as well as 100% of the nitrogen in urea must be transformed from the ammonium form to the nitrate form(nitrification) before leaching or denitrifications can occur. The differences observed between urea and 28% nitrogen solutions are probably due to loss of the nitrate nitrogen from the solution, which were intensified because of the early spring application. The use of both nitrification inhibitors, N-Serve and Terrazole, produced yield responses in excess of 50 bu/A, but only when the treatments were incorporated. No positive yield responses were obtained with either inhibitor unless the treatments were incorporated, and when effective both chemicals produced similar results. Separate applications of fertilizer followed by spraying and incorporation of the chemical produced similar results as when the chemicals were coated onto urea. Both nitrification inhibitors when incorporated were effective and produced yield responses with urea and 28% nitrogen solution. Larger yield responses were obtained with urea than with 28% solutions because of nitrogen losses from the nitrate portion of the fertilizer. Nitrification inhibitors are not effective in minimizing nitrogen losses when the nitrogen initially starts out in the nitrate form.

Dry matter production, nitrogen content and nitrogen removal, in general followed similar trends as to those which were established with yields. As would be expected, those treatments which improved nitrogen availability and higher yields also produced corn grain with a lower moisture content at harvest (higher dry matter). Total nitrogen removal by the stover and grain ranged from 63#N/A with 28% solution to 124#N/A when N-Serve was applied with urea and incorporated, suggesting that nitrification inhibitors when utilized properly can lead to improved nitrogen utilization and yield increases when used in those areas which demonstrate substantial nitrogen losses.

Table 1. Influence of nitrogen form, nitrification inhibitors and treatment incorporation on leaf nitrogen concentration, grain yield and nitrogen utilization by the grain.

Treatments 1/			Leaf	Corn Grain			
N Form	Inhibitor	Incorporation	N	Yield	DM at Harvest	N Content	N Removal
			%	bu/A	%	%	#/A
Urea	-	Yes	1.59	100.7	59.2	.98	47.0
Urea	-	No	1.54	91.8	60.3	1.00	43.6
28%	-	Yes	1.15	77.7	58.1	.92	34.1
28%	-	No	1.30	76.4	55.2	.95	34.8
Urea	Terr.	Yes	2.11	144.5	64.6	1.16	79.2
Urea	Terr.	No	1.50	85.4	57.9	.95	38.3
Urea	N-S	Yes	2.24	154.6	63.6	1.16	84.9
Urea	N-S	No	1.66	93.0	58.0	.95	41.9
28%	Terr.	Yes	1.44	111.8	61.1	1.06	56.2
28%	Terr.	No	1.17	83.1	58.5	1.01	39.6
28%	N-S	Yes	1.34	115.6	59.4	.95	52.7
28%	N-S	No	1.55	91.2	58.7	1.01	43.3
Urea	Terr.(Spray)	Yes	2.12	151.8	64.8	1.14	82.1
Urea	Terr.(Spray)	No	1.32	90.4	58.8	.94	40.1
Urea	N-S(Spray)	Yes	2.05	136.8	65.1	1.07	69.2
Urea	N-S(Spray)	No	1.12	85.0	57.2	.97	39.1
Significance			**	**	**	**	**
BLSD(.05)			.27	16.9	3.0	.07	9.3
N Form x Inhibitor							
Urea	-		1.57	96.2	59.8	.99	45.3
28%	-		1.22	77.1	56.7	.94	34.4
Urea	Terr.		1.80	115.0	61.3	1.05	58.7
Urea	N-S		1.95	123.8	60.8	1.06	63.4
28%	Terr		1.31	97.4	59.8	1.04	47.9
28%	N-S		1.44	103.4	59.1	.98	48.0
Urea	Terr.		1.72	121.1	61.8	1.04	61.1
Urea	N-S		1.58	110.9	61.2	1.02	54.1
Significance			**	**	**	**	**
BLSD(.05)			.13	18.0	2.3	.05	9.6
Incorporation							
Yes			1.76	124.2	62.0	1.06	63.2
No			1.39	87.0	58.1	.97	40.1
Significance			**	**	**	**	**
BLSD(.05)			.27	8.2	1.3	.03	4.7

1/ All treatments received 120#N/A preplant.

Table 2. Influence of nitrogen form, nitrification inhibitors and treatment incorporation on corn forage production and dry matter at physiological maturity.

Treatments[1/]			Corn Forage Production				
			Dry Matter Yield			Dry Matter at Harvest	
N Form	Inhibitor	Incorporation	Stover	Grain	Total	Stover	Grain
			--------T/A------------			---------%-----------	
Urea	-	Yes	2.61	2.10	4.70	28.6	51.0
Urea	-	No	2.67	2.10	4.77	29.2	52.0
28%	-	Yes	2.16	1.65	3.81	28.8	49.6
28%	-	No	2.34	1.83	4.17	28.4	50.5
Urea	Terr.	Yes	3.23	3.04	6.27	30.4	54.3
Urea	Terr.	No	2.75	2.06	4.81	31.2	50.8
Urea	N-S	Yes	3.32	3.11	5.42	30.0	54.0
Urea	N-S	No	2.76	1.94	4.70	29.8	49.3
28%	Terr.	Yes	2.72	1.80	4.53	32.0	50.7
28%	Terr.	No	2.43	1.67	4.09	27.1	49.5
28%	N-S	Yes	2.52	2.12	4.64	26.4	51.0
28%	N-S	No	2.86	2.09	4.95	29.6	53.5
Urea	Terr.(Spray)	Yes	3.63	3.15	6.77	31.8	57.7
Urea	Terr.(Spray)	No	2.68	2.24	4.91	28.3	51.5
Urea	N-S(Spray)	Yes	3.15	2.64	5.78	29.6	54.3
Urea	N-S(Spray)	No	2.45	1.83	4.28	29.0	50.0
Significance			**	**	**	NS	*
BLSD(.05)			.46	.61	.74		4.6
N Form x Inhibitor							
Urea	-		2.64	2.10	4.74	28.9	51.5
28%	-		2.25	1.74	3.99	28.6	50.0
Urea	Terr.		2.99	2.55	5.54	30.8	52.6
Urea	N-S		3.04	2.52	5.56	29.9	51.7
28%	Terr.		2.57	1.74	4.31	29.6	50.1
28%	N-S		2.69	2.10	4.79	28.0	52.3
Urea	Terr.		3.15	2.69	5.84	30.1	54.6
Urea	N-S		2.80	2.23	5.03	29.3	52.2
Significance			*	**	**	+	NS
BLSD(.05)			.57	.54	1.02	3.8	
Incorporation							
Yes			2.92	2.45	5.37	29.7	52.8
No			2.62	1.97	4.58	29.1	50.9
Significance			**	**	**	NS	**
BLSD(.05)			.21	.27	.35		1.9

[1/] All treatment received 120#N/A preplant.

Table 3. Influence of nitrogen form, nitrification inhibitors and treatment incorporation on nitrogen content and nitrogen removal of corn forage at physiological maturity.

Treatments[1/]			Corn Forage				
			N Content		N Removal		
N Form	Inhibitor	Incorporation	Stover	Grain	Stover	Grain	Total
			--------%------		----------#/A------------		
Urea	-	Yes	.46	1.01	43.5	42.7	86.2
Urea	-	No	.42	1.02	38.8	43.2	82.0
28%	-	Yes	.41	.95	31.6	31.8	63.4
28%	-	No	.43	.95	36.0	34.9	70.9
Urea	Terr.	Yes	.44	1.08	55.7	65.5	121.2
Urea	Terr.	No	.45	.97	42.8	39.9	82.7
Urea	N-S	Yes	.44	1.10	55.9	68.9	124.8
Urea	N-S	No	.38	1.05	35.1	41.1	76.2
28%	Terr.	Yes	.39	.94	35.3	34.0	69.3
28%	Terr.	No	.40	.95	32.9	31.8	64.7
28%	N-S	Yes	.52	1.03	48.5	43.6	92.1
28%	N-S	No	.41	.93	40.7	39.2	79.9
Urea	Terr.(Spray)	Yes	.39	1.06	52.8	66.9	119.7
Urea	Terr.(Spray)	No	.45	1.06	44.5	48.1	92.6
Urea	N-S(Spray)	Yes	.38	.98	44.4	51.7	96.1
Urea	N-S(Spray)	No	.42	.96	36.4	35.5	71.9
Significance			**	NS	*	*	**
BLSD(.05)			.05		9.1	16.8	20.9
N Form x Inhibitor							
Urea	-		.44	1.02	41.2	42.9	84.1
28%	-		.42	.95	33.8	33.4	67.2
Urea	Terr.		.44	1.02	49.3	52.7	102.0
Urea	N-S		.41	1.07	45.5	55.0	100.5
28%	Terr.		.39	.94	34.1	32.9	67.0
28%	N-S		.46	.98	44.6	41.4	86.0
Urea	Terr.		.42	1.06	48.6	57.5	106.1
Urea	N-S		.40	.97	40.4	43.6	84.0
Significance			*	**	*	**	**
BLSD(.05)			.04	.05	19.5	12.5	14.7
Incorporation							
Yes			.43	1.02	46.0	50.6	96.6
No			.42	.99	38.4	39.2	77.6
Significance			NS	*	**	**	**
BLSD(.05)				.03	3.9	6.9	9.2

[1/] All treatment received 120#N/A preplant.

Influence of Nitrogen Rate, Timing of Nitrogen Application and Use of Nitrification Inhibitors for Irrigated Spring Wheat and Corn.

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

Nitrogen management on the coarse textured irrigated soils of Minnesota is a primary management decision that all producers must consider if they are to maximize profits from their operations. Efficient nitrogen management along with other inputs should result in high yields at reduced inputs and therefore increased profits for the producer. Because of the high probability that these areas of Minnesota may receive large amounts of precipitation in the spring and early summer, coupled with the water that is added through irrigation, the risk is great that appreciable quantities of nitrate nitrogen may be removed from the rooting zone by leaching prior to the time of plant need. These fertilizer nitrogen losses not only cost the producer money in the investment but may also result in reduced yields, and contamination of shallow aquifers with nitrate nitrogen. Efficient nitrogen management must therefore take many things into consideration including nitrogen rate, nitrogen form, timing of application and method of application.

In most cases the most efficient time to apply nitrogen is just prior to and in proportion to plant demand. Under many management operations this may not be physically possible or economically feasible. When the crop is growing rapidly, plant demands may exceed the rate at which nitrogen can be applied through an irrigation system, thus potentially limiting production. The commercial availability of products known as nitrification inhibitors may provide another tool in nitrogen management for the producer under irrigation. These products are designed to slow the rate at which fertilizer ammonium nitrogen is converted to nitrate nitrogen, thereby minimizing the losses of nitrate nitrogen which may occur during the season. The objective of these experiments were to: 1) evaluate the significance of both rate and timing of nitrogen application for wheat and corn production, and 2) determine the potential that nitrification inhibitors may have in minimizing nitrogen losses under irrigation.

Experimental Procedures

Two separate experiments one with wheat and one with corn were established at the Sand Plains Research Farm near Becker, Mn. Each experiment consisted of twenty-five treatments including a check, four rates of nitrogen, two methods of application, and three nitrification inhibitor treatments. A factorial arrangement 4 x 2 x 3(+1) was set out as four replications in a randomized complete block design. The soil type was a Hubbard coarse sand with approximately 2½% organic matter.

Wheat Experiment

Broadcast applications of Potassium-Magnesium Sulfate (300#/A 0-0-22) and phosphorus (90#/A 0-46-0) were made on April 4, 1978 and incorporated by plowing. Nitrogen experimental variables included a check (0N) and four rates of nitrogen (45, 90, 135 and 180 #N/A) as urea. Nitrogen was applied as single preplant applications on April 11 or as split application with 2/3 as preplant and 1/3 of the nitrogen rate applied at the early boot stage of growth (June 5). Nitrification inhibitor treatments included: fertilizer alone, fertilizer with N-Serve (Dow Chemical - 0.5#ai/A), and fertilizer with Terrazole (Olin Corporation - 0.5 #ai/A) at the preceding rates and times of application. Preplant fertilizer treatments were broadcast over the plot area (12' x 20') and incorporated immediately by discing. (Split application were incorporated by irrigation). All nitrification inhibitor treatments were applied as coatings onto the urea fertilizer. The experimental area was planted with spring wheat (Era) on April 11 at the rate of 2 bu/A in 6" rows. Starter fertilizer was applied as 20# P_2O_5/A with the seed at planting. Brominal plus (0.25#ai/A) was applied on May 16th for weed control.

Forage yields were taken on July 18 (soft dough stage) by harvesting three feet (6 rows) by 15 feet (45 ft^2) from each plot. Field weights were obtained and samples removed for moisture determination and nitrogen analysis. Yield samples were obtained on August 2 by harvesting 45 square feet of plot, and yields determined by thrashing after all samples were air dried(95 ^{o}F).

The first irrigation water was applied on May 26 with the final irrigation on July 25. A total of 5 inches of irrigation was applied in 1978 with an additional 15.63 inches of rainfall received during this period.

Corn Experiment

A similar experiment was conducted with corn. Broadcast applications of potassium-magnesium sulfate (300#/A of 0-0-22) and potassium (260#/A 0-0-60) were made and incorporated by plowing on April 4th. Experimental treatments consisting of a check, nitrogen rates of 60, 180 and 240 #N/A as urea were applied in one preplant and incorporated application on April 27 or in split application. Split applications were applied on April 27 (preplant), June 8 (12" height), June 27 (36" height), and July 17 (early silking) in a ratio of 1/6, 1/6, 3/6, and 1/6 respectively. Treatment combinations either had no coating, N-Serve or Terrazole at 0.5# ai/A with each treatment area being six rows wide and 30 ft. long.

Corn (Pioneer 3901) was planted on May 5, in 30 inch rows at a population of 30,700 seeds/A. Starter fertilizer was applied at a rate of 20# P_2O_5/A and 40 # K_2O/A. Good weed control was obtained with a tank mixture of Lasso (1½ # ai/A) and Atrazine (1 #ai/A) applied on May 6.

Leaf samples from opposite and below the ear at 50% silking were taken from each plot on July 6, dried, and analyzed for Kjeldahl nitrogen. Dry matter and nitrogen uptake were determined by harvesting one row 15 ft. long from each plot on September 7 and 8 (Physiological maturity). Ears were separated from the stalks, field weights obtained and samples removed for moisture determination and nitrogen analysis. Yields were obtained on September 21 and 22 by harvesting two rows 20' long. Field weights were obtained and samples collected for moisture and nitrogen concentration. Corn grain yields were adjusted to 15.5% moisture.

The irrigation program was started on June 5 and continued through Sept. 6 with a total of 8.75 inches of water being applied through irrigation and 22.31 inches coming through rainfall.

General Results

Information obtained from the wheat trial are presented in Tables 1 and 2 and data from the corn experiment in Tables 3, 4 and 5.

Wheat Experiment

Overall wheat yields in 1978 were not as good as 1977 because of poor stooling. No significant yield increases (Table 1) were obtained above 90 #N/A. The highest rate of N application (180#N/A) resulted in a significant yield reduction. Timing of nitrogen application (splitting of applications) had no influence on yield suggesting that fertilizer nitrogen losses from this experiment were not excessive. Although timing of nitrogen application had no influence on yield, nitrogen concentration in the grain (protein) was increased with split applications. Similar to 1977, use of nitrification inhibitors with nitrogen for wheat had no positive influence on yields. Test weights of the grain at harvest were significantly reduced with increasing rates of nitrogen applications.

Dry matter production of the wheat forage was significantly increased with nitrogen rates up to 135#N/A. Timing of nitrogen application tended to lower production suggesting that the second application should have been applied earlier in the growth stage of the plant. The nitrogen content of the forage was significantly increased with increasing nitrogen rate, timing of application and to a lesser extent with nitrification inhibitors. In general, the use of nitrification inhibitors for wheat production under the conditions tested in 1978 were of very little value.

Corn Experiment

Excellent corn yields were obtained in 1978 with treatments ranging from 59 to 196 bu/A(Table 3). Nitrogen management in order to minimize nitrogen losses, was extremely critical in 1978. Yield reductions of up to 55 bu/A were encountered at the recommended nitrogen rates (180#N/A) for these soils under irrigation where nitrogen was applied as a single preplant application versus several applications during the growing season. Highest yields were obtained at 180#N/A when nitrogen was applied during the growing season. Nitrogen rate of 240#/A in a single application was 26 bu/A lower than 180#N/A in split applications, indicating that nitrogen losses with early applications were substantial. Timing of nitrogen application as well as rate of nitrogen application were both important in high yields. The use of nitrification inhibitors appeared to minimize nitrogen losses by 50-60% and as would be expected gave the best results under conditions where nitrogen losses were severe (spring preplant). A significant (.05) yield increase was also obtained when Terrazole was applied with the split applications of N at the 60 lb/A rate suggesting that nitrogen losses may occur under conditions of presumed good nitrogen management. Both N-Serve and Terrazole were effective at minimizing nitrogen losses and therefore increasing yields where nitrogen losses occurred.

Dry matter production increases (Table 4) from the treatments, followed much the same trends as were found with grain yield. When nitrogen was applied in split applications increased production was obtained up to 180#N/A, while responses up to 240#N/A were observed with single nitrogen applications. This again tends to reflect the severe nitrogen losses that were encountered with the early spring nitrogen application on these soils in 1978.

Nitrogen utilization by the corn plant was highly related to nitrogen availability and obtained yield (Table 5). Nitrogen content in the stover did not appear to reflect yield and nitrogen availability to the extent that was found with grain nitrogen. Both yield components were, however, significantly influenced and when combined with yield to evaluate total nitrogen removal produced some large differences. Total nitrogen removal was significantly influenced again by nitrogen rate, timing of nitrogen application, and the use of nitrification inhibitors when nitrogen losses appeared to occur.

Table 1. Influence of Nitrogen Rate, Timing of Nitrogen Application, and Nitrification Inhibitors on ERA Wheat Yield, Nitrogen Utilization, and Test Weight.

Treatment			Wheat Grain			
N Rate	No. of Appl.	Inhibitor	Yield	N. Conc.	N removal	Test Wt.
#/A			bu/A	%	#/A	#/bu
0	-	0	16.2	2.69	26.1	57.0
45	1	0	31.4	2.34	44.0	56.0
45	1	N-S	31.8	2.29	43.6	55.5
45	1	Terr.	31.8	2.29	43.8	56.2
45	2	0	30.4	2.57	46.9	56.0
45	2	N-S	31.1	2.49	46.5	56.0
45	2	Terr.	32.8	2.42	47.7	56.7
90	1	0	42.2	2.59	65.7	55.7
90	1	N-S	42.2	2.60	65.6	56.0
90	1	Terr.	40.4	2.73	66.1	55.0
90	2	0	40.9	2.62	64.4	55.8
90	2	N-S	43.2	2.60	67.0	56.2
90	2	Terr.	36.3	2.78	60.9	54.4
135	1	0	41.0	2.94	72.4	54.3
135	1	N-S	41.4	2.80	69.7	55.1
135	1	Terr.	39.8	3.04	72.4	54.4
135	2	0	42.4	3.01	76.4	54.6
135	2	N-S	41.2	3.12	77.2	54.0
135	2	Terr.	41.6	2.95	73.5	55.6
180	1	0	40.8	2.87	70.2	54.0
180	1	N-S	37.1	3.10	68.6	53.3
180	1	Terr.	39.2	3.05	71.8	54.6
180	2	0	36.0	3.14	67.8	51.9
180	2	N-S	35.9	3.20	68.7	51.9
180	2	Terr.	39.0	3.24	75.8	52.5
Significance			**	**	**	**
BSLD(.05)			5.4	0.15	8.4	1.7
FACTORIAL ARRANGEMENT						
N-Rate - #/A						
45			31.5	2.40	45.4	56.1
90			40.9	2.65	65.0	55.5
135			41.2	2.98	73.6	54.6
180			38.0	3.10	70.5	53.0
Significance			**	**	**	**
BLSD(.05)			2.1	.06	3.4	0.6
No. of Appl.						
One			38.3	2.72	62.8	55.0
Two			37.6	2.84	64.4	54.6
Significance			NS	**	NS	NS
BLSD(.05)				.06		
Inhibitor						
None			38.1	2.76	63.5	54.8
N-Serve			38.0	2.77	63.4	54.7
Terrazole			37.6	2.81	64.0	54.9
Significance			NS	NS	NS	NS
BLSD(.05)						

Table 2. Influence of Nitrogen Rate, Timing of Nitrogen Application, and Nitrification Inhibitors on Dry Matter Production and Nitrogen Utilization by Era Wheat.

Treatments			Wheat Forage			
N Rate	No. of Appl.	Inhibitor	--- Dry Matter---		N. Conc.	N Uptake
#/A			T/A	%	%	#/A
0	-	0	0.92	54.9	1.02	18.6
45	1	0	2.32	59.9	.83	38.5
45	1	N-S	2.38	58.2	.89	42.4
45	1	Terr.	2.54	54.8	1.05	53.0
45	2	0	1.94	54.5	1.02	38.9
45	2	N-S	1.87	57.6	1.01	37.6
45	2	Terr.	2.21	54.7	.98	43.0
90	1	0	3.00	52.9	1.02	72.4
90	1	N-S	2.73	52.3	1.21	65.8
90	1	Terr.	2.62	54.4	1.25	65.6
90	2	0	2.95	50.4	1.17	69.0
90	2	N-S	2.87	51.5	1.36	77.5
90	2	Terr.	2.85	52.4	1.22	69.5
135	1	0	3.48	49.6	1.33	92.7
135	1	N-S	3.27	50.1	1.44	93.1
135	1	Terr.	3.24	50.3	1.26	81.6
135	2	0	3.09	49.7	1.43	88.7
135	2	N-S	3.08	49.3	1.47	90.7
135	2	Terr.	2.86	48.4	1.41	80.3
180	1	0	3.10	48.3	1.35	83.8
180	1	N-S	2.88	48.8	1.44	82.3
180	1	Terr.	2.99	47.9	1.56	93.1
180	2	0	2.94	46.3	1.66	98.1
180	2	N-S	3.40	45.4	1.62	110.8
180	2	Terr.	2.88	48.0	1.63	93.4
Significance			**	**	**	**
BLSD(.05)			0.52	3.9	0.13	14.6

Factorial Arrangement

N-Rate - #/A				
45	2.21	56.5	0.96	42.2
90	2.84	52.3	1.23	70.0
135	3.17	49.6	1.39	87.9
180	3.04	47.5	1.54	93.6
Significance	**	**	**	**
BLSD(.05)	0.20	1.5	0.05	5.9
No. of Appl.				
One	2.88	52.3	1.23	72.0
Two	2.75	50.7	1.33	74.8
Significance	+	**	**	NS
BLSD(.05)	0.14	1.5	0.05	
Inhibitor				
None	2.85	51.4	1.25	72.8
N-Serve	2.81	51.7	1.31	75.0
Terrazole	2.77	51.4	1.30	72.4
Significance	NS	NS	+	NS
BLSD(.05)			0.05	

Table 3. Influence of Nitrogen Rate, Timing of Nitrogen Application, and Nitrification Inhibitors, on Leaf Nitrogen Concentration, Grain Yield, and Nitrogen Utilization of Corn.

Treatments			Leaf	Corn Grain			
N Rate	No. of Appl.	Inhibitor	N	Yield 15.5%M	DM at harvest	N Conc.	N Removal
#/A			%	bu/A	%	%	#/A
0	-	0	1.14	58.8	56.6	1.02	28.5
60	1	0	1.38	89.0	60.3	1.10	46.3
60	1	N-S	1.78	119.3	65.4	1.08	61.0
60	1	Terr.	1.46	98.4	62.1	0.98	46.0
60	4	0	2.14	117.0	61.8	1.09	60.6
60	4	N-S	2.14	126.9	62.5	1.08	64.9
60	4	Terr.	2.12	137.4	63.0	1.09	70.8
120	1	0	1.47	105.4	61.3	1.02	50.8
120	1	N-S	2.20	150.4	67.1	1.20	86.8
120	1	Terr.	2.19	145.3	65.5	1.13	77.8
120	4	0	2.78	167.4	64.4	1.21	95.7
120	4	N-S	2.82	181.4	65.0	1.35	116.1
120	4	Terr.	2.72	179.0	64.6	1.41	119.7
180	1	0	2.07	136.3	62.9	1.04	67.4
180	1	N-S	2.63	169.2	66.6	1.26	101.2
180	1	Terr.	2.38	169.6	64.5	1.28	102.4
180	4	0	2.97	190.8	65.8	1.46	131.4
180	4	N-S	2.93	191.4	65.3	1.45	131.4
180	4	Terr.	2.92	195.5	66.4	1.43	132.7
240	1	0	2.56	169.6	64.3	1.30	104.7
240	1	N-S	2.96	181.0	64.2	1.54	131.3
240	1	Terr.	2.92	186.0	66.7	1.49	130.8
240	4	0	2.97	191.0	62.6	1.46	131.5
240	4	N-S	3.11	189.9	67.2	1.50	134.8
240	4	Terr.	2.96	190.2	64.9	1.53	138.0
Significance			**	**	**	**	**
BLSD(.05)			0.18	14.9	3.2	0.06	10.1
Factorial Arrangement							
N-Rate - #/A							
60			1.84	114.7	62.5	1.07	58.3
120			2.36	154.8	64.6	1.22	91.0
180			2.65	175.5	65.2	1.32	111.1
240			2.91	184.6	65.0	1.47	128.5
Significance			**	**	**	**	**
BLSD(.05)			0.08	5.7	1.2	0.03	4.2
No. of Appl.							
One			2.17	143.3	64.2	1.20	83.8
Four			2.72	171.5	64.5	1.34	110.6
Significance			**	**	NS	**	**
BLSD(.05)			0.08	5.9		0.03	4.3
Inhibitor							
None			2.29	145.8	62.9	1.21	86.0
N-Serve			2.57	163.7	65.4	1.31	103.3
Terrazole			2.46	162.7	64.7	1.29	102.3
Significance			**	**	**	**	**
BLSD(.05)			0.07	5.0	1.0	0.02	3.6

Table 4. Influence of Nitrogen Rate, Timing of Nitrogen Application and Nitrification Inhibitors on Corn Dry Matter Production and Moisture Relations at Physiological Maturity.

Treatments			Corn Forage Production				
			Dry Matter Production			Dry Matter at Harvest	
N Rate	No. of Appl.	Inhibitor	Stover	Grain	Total	Stover	Grain
#/A			------- T/A	-----------		-------- %	----------
0	-	0	1.66	1.31	2.97	25.6	46.2
60	1	0	2.40	2.04	4.43	27.0	51.7
60	1	N-S	2.82	2.11	4.93	29.4	50.8
60	1	Terr.	2.71	2.18	4.88	30.0	53.4
60	4	0	2.81	2.91	5.72	28.2	52.1
60	4	N-S	3.13	3.09	6.23	28.3	52.7
60	4	Terr.	3.35	3.37	6.72	30.1	54.1
120	1	0	3.12	2.81	5.93	29.9	53.2
120	1	N-S	3.40	3.33	6.73	29.3	55.6
120	1	Terr.	3.69	3.34	7.03	33.0	56.0
120	4	0	3.80	4.02	7.82	30.4	53.6
120	4	N-S	3.98	4.35	8.33	29.6	55.6
120	4	Terr.	4.37	4.65	9.02	33.1	56.0
180	1	0	3.26	2.82	6.08	29.0	52.8
180	1	N-S	3.82	3.78	7.61	31.2	55.2
180	1	Terr.	3.73	3.76	7.48	29.9	56.1
180	4	0	4.40	4.40	8.80	32.4	54.8
180	4	N-S	4.12	4.61	8.74	30.4	56.0
180	4	Terr.	4.03	4.58	8.61	30.3	55.1
240	1	0	4.16	4.07	8.22	30.0	55.2
240	1	N-S	3.99	4.26	8.26	28.5	56.1
240	1	Terr.	4.04	4.40	8.44	28.6	56.1
240	4	0	3.88	4.34	8.22	27.4	54.3
240	4	N-S	3.98	4.14	8.11	32.1	55.5
240	4	Terr.	4.24	4.54	8.78	29.6	54.9
Significance			**	**	**	**	**
BLSD(.05)			0.46	0.46	0.82	4.1	2.7
Factorial Arrangement							
N-Rate - #/A							
60			2.87	2.62	5.48	28.8	52.5
120			3.73	3.75	7.48	30.9	55.0
180			3.89	3.99	7.89	30.6	55.0
240			4.05	4.29	8.34	29.3	55.4
Significance			**	**	**	**	**
BLSD(.05)			0.19	0.19	0.33	1.4	1.1
No. of Appl.							
One			3.43	3.24	6.67	29.7	54.4
Four			3.84	4.08	7.92	30.1	54.5
Significance			**	**	**	NS	NS
BLSD(.05)			0.19	0.19	0.34		
Inhibitor							
None			3.48	3.43	6.90	29.3	53.4
N-Serve			3.66	3.71	7.37	29.4	54.7
Terrazole			3.77	3.85	7.62	30.5	55.2
Significance			**	**	**	NS	**
BLSD(.05)			0.18	0.17	0.31		1.0

Table 5. Influence of Nitrogen Rate, Timing of Nitrogen Application, and Nitrification Inhibitors, on Nitrogen Utilization of Corn at Physiological Maturity.

Treatments			Corn Forage				
			N Content		N Removal		
N Rate	No. of Appl.	Inhibitor	Stover	Grain	Stover	Grain	Total
#/A			------- %	--------	------- #/A	---------	
0	-	0	.46	1.08	27.7	28.3	56.0
60	1	0	.40	1.02	35.4	41.7	77.1
60	1	N-S	.42	1.05	41.3	44.7	86.0
60	1	Terr.	.39	1.09	38.3	47.6	85.9
60	4	0	.50	1.07	57.0	62.6	119.6
60	4	N-S	.51	1.09	63.7	67.4	131.1
60	4	Terr.	.49	1.16	65.8	78.3	144.1
120	1	0	.54	1.05	64.7	59.4	124.1
120	1	N-S	.42	1.12	57.5	74.7	132.2
120	1	Terr.	.44	1.12	61.9	74.8	136.7
120	4	0	.57	1.16	88.9	93.5	182.4
120	4	N-S	.55	1.32	91.2	115.3	206.5
120	4	Terr.	.66	1.46	118.8	136.2	255.0
180	1	0	.44	1.06	54.0	60.1	114.1
180	1	N-S	.46	1.22	71.2	92.8	164.0
180	1	Terr.	.49	1.27	73.8	96.1	169.9
180	4	0	.63	1.50	111.2	132.0	243.2
180	4	N-S	.70	1.50	121.9	138.8	260.7
180	4	Terr.	.67	1.47	115.9	134.5	250.4
240	1	0	.53	1.19	87.4	96.8	184.2
240	1	N-S	.67	1.41	110.3	119.8	230.1
240	1	Terr.	.61	1.33	102.6	116.7	219.3
240	4	0	.76	1.50	124.9	130.3	255.2
240	4	N-S	.74	1.50	120.9	124.2	245.1
240	4	Terr.	.80	1.48	140.5	134.0	274.5
Significance			**	**	**	**	**
BLSD(.05)			.06	0.08	13.6	12.7	24.3
Factorial Arrangement							
N-Rate-#/A							
60			.45	1.08	50.2	57.0	107.2
120			.53	1.21	80.5	92.3	172.8
180			.57	1.34	91.3	109.0	200.3
240			.69	1.40	114.4	120.3	234.7
Significance			**	**	**	**	**
BLSD(.05)			.02	.03	5.6	5.2	10.0
No. of Appl.							
One			.49	1.16	66.5	77.1	143.6
Four			.63	1.35	101.7	112.3	214.0
Significance			**	**	**	**	**
BLSD(.05)			.02	.03	5.8	5.4	10.4
Inhibitor							
None			.55	1.20	77.9	84.6	162.5
N-Serve			.56	1.28	84.7	97.2	181.9
Terrazole			.57	1.30	89.7	102.3	192.0
Significance			NS	**	**	**	**
BLSD(.05)				.30	5.2	4.6	8.9

Influence of Nitrification Inhibitors and Nitrification Inhibitor Rates on the Production of Spring Wheat and Corn Under Irrigation.

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

The use of nitrification inhibitors for minimizing nitrogen losses from soils, generates many concerns regarding management of the products themselves in order to obtain the desired results. At the present time, recommended rates of application for commercially available nitrification inhibitors (N-Serve) suggest optimum rates of ¼-½ # active ingredient/acre. To investigate the importance of rate of application for nitrification inhibitors, a field trial was conducted in 1978 at the Sand Plains Research Farm near Becker, MN. The objectives of the trial were to evaluate the influence of two nitrification inhibitors (N-Serve-Dow Chemical company and Terrazole-Olin corporation) at five different rates of application on the yield, and nitrogen utilization characteristics of spring wheat and corn grown under irrigation.

Experimental Procedures

Two separate experiments each consisting of ten experimental treatments including two nitrification inhibitors (N-Serve and Terrazole) at five rates of application (0, 1/8, 1/4, 1/2 and 1 #active ingredient/A) were applied to a Hubbard coarse sand. The treatments within each experiment were replicated four times and arranged in a randomized complete block design. In the first experiment the above treatments were applied with 45 #N/A as urea in a spring application. After immediate incorporation of the fertilizer coated material the area was seeded to spring wheat (Era-2bu/A). The second experimental area had the same nitrification inhibitor treatments and experimental design but was applied with 120 #N/A and was planted to corn (Pioneer 3901 - 30,700 seeds/A). Both experimental areas had been previously fertilized according to soil test recommendations (Wheat - 300 #/A 0-0-22 $K \cdot MgSO_4$, 90#/A 0-46-0 with 20# P_2O_5 applied with starter and corn 300#/A -0-0-22, 250#/A 0-0-60 and 150#/A of 0-18-36 as a starter at planting.) Weed control was accomplished with an application of Brominal plus (0.25#ai/A) on May 16 for wheat and mixture of Lasso (1½#ai/A) and Atrazine (1#ai/A) on May 6 for corn.

Wheat was harvested for grain on August 2 by removing 45 ft^2 from each experimental plot and yields determined after drying and thrashing. Grain was analyzed for kjeldahl nitrogen. To characterize nitrogen utilization and production on the area planted in corn the following samples were taken: 1) The leaf opposite and below the ear at silking (July 12) for N content 2) Total corn forage production at physiological maturity (September 7 and 8); stover and grain components for dry matter production and nitrogen utilization and 3) Final grain yields (September 21 and 22) and nitrogen analyses. Soil samples were obtained from the corn experimental area at three different times to characterize the influence of the treatments on nitrification (disappearance of ammonium N) within the soil.

The experimental area in wheat received a total of 20.63 inches of rainfall plus irrigation while the corn area received a total of 31.06 inches during the growing season.

General Results

The information obtained from the wheat trial is presented in Table 1, and data from the corn experiment is in Tables 2 and 3.

Wheat Experiment - Similar to the results that were obtained from the experiment with nitrogen rates and timing of nitrogen application, very little positive response to the use of nitrification inhibitors were obtained. Increasing nitrification inhibitor rates had no significant (.05) influence on wheat yield test weight or nitrogen utilization. The significant difference (.10) that was obtained because of a low grain N content with N-Serve at the ½#ai/A rate established no trends.

Corn Experiment - Considerable nitrogen losses from the corn experimental area are evident from the yield increases that were obtained with both nitrification inhibitors as rates of application were increased. Yield responses in excess of 50 bu/A were obtained with both inhibitors. As a general rule a trend for increased yield was observed with increasing inhibitor rates. Statistically there was no yield advantage to application rates of either inhibitor over ½#ai/A. Although not significant with the yield grain, leaf nitrogen concentrations suggest that N-Serve was more effective at the lower application rates than was Terrazole. Total nitrogen removal by the corn forage at physiological maturity summarizes the potential advantages and importance of nitrification inhibitor rate on nitrogen utilization. Both inhibitors resulted in increased uptakes of 55-65 pounds of additional N/A under the conditions encountered, however, the rates of application that were the most efficient were not the same rates for each inhibitor. The soil ammonium concentrations (Table 3) would suggest that N-Serve may have delayed nitrification longer into the growing season than Terrazole.

Table 1. Influence of nitrification inhibitors and nitrification inhibitor rates on spring wheat yields and nitrogen utilization.

Treatment 1/		Wheat Grain			
Inhibitor	Inhibitor Rate	Yield	Test Wt.	N Content	N Removal
	#/A	bu/A	#/bu	%	#/A
N-Serve	0	31.8	55.7	2.48	47.1
N-Serve	1/8	35.8	54.8	2.42	51.9
N-Serve	1/4	34.3	56.3	2.52	52.0
N-Serve	1/2	34.0	56.3	2.36	48.2
N-Serve	1	30.6	56.2	2.57	47.1
Terrazole	0	34.6	56.7	2.39	49.5
Terrazole	1/8	34.1	56.3	2.42	49.5
Terrazole	1/4	36.7	56.2	2.36	51.9
Terrazole	1/2	35.1	56.4	2.44	51.2
Terrazole	1	33.4	56.1	2.40	48.0
Significance		NS	NS	NS	NS
BLSD(.05)					
Inhibitor x Inhibitor Rate					
N-Serve alone					
Significance		NS	NS	+	NS
BLSD(.05)				.15	
Terrazole alone					
Significance		NS	NS	NS	NS
BLSD(.05)					

1/ All treatments received 45#N/A as urea in a preplant application.

Table 2. Influence of Nitrification Inhibitors and Nitrification Inhibitor Rates on Corn Grain Yield, Nitrogen Utilization and Total Dry Matter Production.

Treatment [1/]		Corn Grain				Leaf	Corn Forage-Physiological Maturity							
							Stover			Grain			Total	
Inhibitor	Inhibitor Rate	Yield	N	D.M.	N Removal	N	Yield	N	N Removal	Yield	N	N Removal	Yield	N Removal
	#/A	bu/A	%	%	#/A	%	T/A	%	%/A	T/A	%	#/A	T/A	#/A
N-Serve	0	108.2	1.02	60.0	52.2	1.44	2.95	.39	43.3	2.56	.97	49.5	5.51	92.8
N-Serve	1/8	135.8	1.11	62.3	71.2	2.28	3.01	.43	50.2	2.83	1.01	57.4	5.84	107.6
N-Serve	1/4	149.2	1.21	66.1	85.5	2.27	3.20	.46	59.1	3.17	.99	62.9	6.37	122.0
N-Serve	1/2	140.8	1.02	61.8	68.6	2.20	3.52	.49	68.5	3.49	1.14	79.6	7.01	148.1
N-Serve	1	158.4	1.17	67.7	87.6	2.22	3.42	.42	58.0	3.54	1.09	77.2	6.96	135.1
Terrazole	0	100.2	1.06	61.0	50.8	1.36	2.93	.41	44.6	2.57	.94	48.7	5.50	93.3
Terrazole	1/8	115.7	1.12	61.6	62.8	1.94	3.12	.41	48.8	2.85	.97	55.9	5.97	104.7
Terrazole	1/4	123.6	1.03	62.4	60.4	1.65	3.14	.41	50.1	2.97	.99	58.9	6.11	109.0
Terrazole	1/2	137.2	1.16	64.0	75.1	2.26	3.22	.43	53.8	3.04	1.09	66.6	6.26	120.4
Terrazole	1	151.6	1.19	63.4	85.2	2.45	3.61	.47	68.7	3.65	1.18	86.8	7.26	155.5
Significance		**	**	**	**	**	*	*	**	**	**	**	**	**
BLSD(.05)		24.7	.10	4.4	16.4	.26	.44	.06	9.2	.42	.10	12.2	.76	18.9
Inhibitor x Inhibitor Rate														
N-Serve Alone														
Significance		**	**	**	**	**	**	**	**	**	**	**	**	**
BLSD(.05)		23.2	.07	5.8	13.4	.28	.38	.06	8.7	.28	.08	8.2	.55	14.0
Terrazole Alone														
Significance		*	+	NS	*	**	+	*	**	*	*	**	*	**
BLSD(.05)		28.6	.12		20.2	.24	.46	.05	10.2	.65	.14	18.0	1.10	25.6

1/ All treatments received 120#N/A as urea in a spring preplant application.

Table 3. Influence of Nitrification Inhibitors and Nitrification Inhibitor Rates on Soil Ammonium Concentration in the 0-6" depth three times after application.

Treatment 1/		Soil Ammonium Conc. (0-6")		
Inhibitor	Inhibitor Rate	June 5	June 20	July 6
	#/A	ppm-NH_4-N		
N-Serve	0	11.1	7.2	8.6
N-Serve	1/8	14.6	9.4	8.4
N-Serve	1/4	19.6	7.4	9.4
N-Serve	1/2	28.6	10.8	12.0
N-Serve	1	34.0	29.6	16.5
Terrazole	0	6.6	3.9	10.8
Terrazole	1/8	12.0	6.2	10.3
Terrazole	1/4	19.0	5.9	10.8
Terrazole	1/2	19.6	5.2	7.4
Terrazole	1	30.6	18.4	11.1
Significance		+	**	+
BLSD(.05)		20.1	5.2	5.3
Inhibitor x Inhibitor Rate				
N-Serve Alone				
Significance		NS	**	*
BLSD(.05)			7.1	6.3
Terrazole Alone				
Significance		+	**	NS
BLSD(.05)		16.7	4.3	

1/ All treatments received 120#N/A as urea in a spring preplant operation.

Navy Bean Inoculation Trials - 1978

M.C. Severson, S. Sparrow and G.E. Ham

More efficient nitrogen fixing bacteria (Rhizobium phaseoli) seem to be one of the means of obtaining efficiency and stability of navy bean yields. Many different strains of nodule bacteria for navy beans (Rhizobium phaseoli) exist and their nitrogen fixing ability varies depending on a number of factors including the host plant. Some rhizobia induce nodule formation but then fail to fix nitrogen while other rhizobia provide sufficient nitrogen for excellent plant growth. A randomized complete block design was used with 6 replications. All plots received 36 pounds of nitrogen per acre from fertilizer before planting and the plots were irrigated when necessary. The plots were planted on May 21-23 in 14 inch rows.

As shown in Table 1, CIAT strain 404 produced the maximum grain yield increase at Becker compared to the uninoculated control (102% or 840 pounds per acre for Seafarer variety and 76% or 813 pounds per acre for Upland variety). Table 2 shows that seed yield decreased as the number of rhizobia per inch of row was decreased. These results indicate that inoculation with extremely large numbers of rhizobia is necessary for maximum yields and these results indicate considerable variation among the rhizobia strains for nitrogen fixation and seed yield.

Table 1. Influence of Rhizobium phaseoli strains on navy bean yields at Becker in 1978.

Rhizobium phaseoli strain	Navy Bean Variety: Becker Seafarer	Becker Upland	Rosemount Seafarer	Rosemount Upland
	lbs/acre			
Check	822abc*	1066ab*	2522a*	2740a*
CIAT 57	1179d	1680c	2600a	2821a
CIAT 75	851abc	968a	2439a	2795a
CIAT 255	918bc	901a	2862a	2667a
CIAT 404	1662e	1879d	2839a	2795a
CIAT 676	1520e	1782cd	2837a	2870a
IP736A1	679a	1093ab	2839a	2939a
Nit127K51	857abc	881a	2451a	2769a
Nit127K54	701ab	919a	2597a	2783a
3644	847abc	1084ab	2846a	2861a
Allen 413-2	924bc	1245b	2807a	2810a
1Q423	740ab	872a	2885a	2575a
QA1062	1001cd	1088ab	2562a	2950a

*Seed yields within a variety followed by the same letter(s) are not significantly different at the 95% level. Do not compare yields between the two varieties.

Table 2. Influence of *Rhizobium phaseoli* inoculation rate on navy bean yields at Becker in 1978.

Rhizobium phaseoli strain	Number rhizobia per inch of row	Navy Bean Variety			
		Becker		Rosemount	
		Seafarer	Upland	Seafarer	Upland
		lbs/acre			
Control	0	753a*	871a*	2635a	2292a
CIAT 75	10^6	974ab	1108b	2831ab	2763b
	10^4	875a	984ab	2786ab	2750b
	10^2	845a	973ab	2753ab	2426ab
	10	645a	869a	2652ab	2515ab
	1	762a	964ab	2794ab	2256ab
650R	10^7	1208b	1071ab	2963b	2830b
	10^5	760a	967ab	2866ab	2419ab
	10^3	764a	958ab	2626a	2344ab
	10	682a	865a	2888ab	2209ab
	1	843a	910ab	2682ab	2415ab
3644	10^6	790a	948ab	2781ab	2691b
	10^7	926a	1138b	2768ab	2398ab
	10^2	825a	998ab	2904ab	2429ab
	10	587a	984ab	2788ab	2147ab
	1	718a	785a	2849ab	2233ab

*Seed yields within a variety followed by the same letter(s) are not significantly different at the 95% level. Do not compare yields between the two varieties.

1978 Weather Summary - Crookston, Minnesota

The 1978 weather reflects average temperature and is highlighted by well below normal precipitation. There have only been 10 years previously since 1890 that 15 inches or less precipitation were recorded at the Crookston station. Two all-time high temperature records were also broken in 1978.

The first 3 months of 1978 were below normal in regard to temperature, and precipitation was well below normal through June recording a 5 inch departure from normal for the first 6 months of the year.

July and August were the only two months in 1978 which recorded above normal precipitation. We received 2.77 inches of rain on July 18 and 19 bringing the total for the month .60 inch above average. August was 1.32 inches above normal with 2.44 inches of rain recorded on the 15th.

Two record high temperatures were recorded in August and September. On August 12 the mercury climbed to 95°F. surpassing the old record of 94°F. set in 1970. September 8 also recorded a high of 95°F. which was 2°F. higher than the previous record of 93°F. set in 1931.

September, October and November also followed the 1978 trend of below normal precipitation recording 2 inches below normal for the three month period. Cold temperatures also prevailed in November with a -25°F. reading on November 30 being the second coldest day in the history of the station next to -29°F. recorded in 1896.

The last frost in 1978 was on May 1 and the first frost occurred September 27 setting the growing season of 149 days in 1978 which is 24 days longer than normal for Northwest Minnesota.

Table 1. Weather Summary for 1978 with Averages for Precipitation and Mean Temperatures for 1890-1973.

	Precipitation Snow	Precip.				Mean Temperature degrees	
	Inches	Inches	Rain	Total	1890-1973	1978	1890-1973
Jan.	3.0	.14	-	.14	.56	-2.4	3.9
Feb.	1.3	.07	-	.07	.54	2.8	8.2
Mar.	2.0	.15	-	.15	.85	21.1	23.0
Apr.	2.5	.13	.52	.65	1.53	42.0	41.4
May	-	-	1.49	1.49	2.61	60.0	54.5
June	-	-	2.24	2.24	3.61	64.5	64.5
July	-	-	3.73	3.73	3.13	69.3	69.4
Aug.	-	-	4.20	4.20	2.88	69.2	67.5
Sept.	-	-	1.66	1.66	2.26	63.2	57.4
Oct.	-	-	.11	.11	1.39	47.7	45.4
Nov.	10.2	.60	.02	.62	.76	20.5	26.9
Dec.	10.5	.91	-	.91	.61	5.8	11.5
Total	29.5	2.00	13.97	15.97	20.73	38.6	39.5

Copper Sulfate Carrier x Method of Application Study

G. E. Varvel and R. K. Severson

Copper deficiency in small grains has been a problem on some of the organic soils in northern Minnesota. This deficiency has been corrected with the addition of copper to the soil. However, recent information has shown that problems may occur if the copper is applied as copper sulfate in the granular form. The experimentation with copper sulfate has involved dissolving it in water and then applying it. For this reason it was felt that a comparison of the two methods was needed.

Experimental Methods:
A completely random design with 5 replications was used. The experiment was located at the Kveen farm in Roseau County. The plots were fertilized and Era wheat was planted on May 9, 1978 and harvested on August 31, 1978.

Results:
Results shown in the table below are an indication of the severe copper deficiency that was present at the location. Significant differences in yield were obtained between carriers and application methods. No differences were obtained between the treatments with starter and those without starter fertilizer or between the different granule sizes of copper sulfate.

$CuSO_4$ Carrier	Method	Starter (15-30-15)	Yield
		lbs/A	Bu/A
Control	---	0	0.2
Control	---	100	0.2
Small Granule	Band	0	4.7
" "	"	100	0.1
" "	Brdcst.	0	0.7
" "	"	100	2.7
Large Granule	Band	0	2.2
" "	"	100	1.9
" "	Brdcst.	0	1.0
" "	"	100	1.0
Liquid	Band	0	5.9
"	"	100	5.8
"	Brdcst.	0	12.4
"	"	100	16.9
Significance			**
B.L.S.D.			2.0
C.V.			46.4

Wheat Production as Affected by Copper on Organic Soils

G. E. Varvel, G. L. Malzer, R. K. Severson

The organic soils of northwestern Minnesota are being developed into productive agricultural land through land clearing and drainage. Most of these soils have been in grass seed or wild rice production, but as more acres have been cleared, interest in growing other crops has developed. Problems, especially with spring wheat, were encountered. Preliminary studies with the addition of the macro nutrients and also the micro nutrients isolated copper as being the major limiting nutrient for wheat production on these soils. Based on this discovery, experimental locations were established in both Roseau and East Polk counties in 1977. Three separate experiments were conducted at each location.

Experiment number one was established to determine the affect of copper rate, carrier and method of application on wheat yield and pounds of dry matter production. Results are presented in Table 1 for the Roseau location and in Table 2 for the East Polk location.

Experiment number two was established to determine the affect of copper by itself and in combination with iron, zinc and manganese on wheat yield and dry matter production. Results are presented in Table 3 for the Roseau location and in Table 4 for the East Polk location.

Experiment number three involves the residual affect of copper applied in 1977 on wheat yield. Results are presented in Table 5 for the Roseau location. The East Polk location was lost due to the severe infestation of Canadian thistle.

Table 1. Wheat yield and dry matter production as affected by copper rate, carrier and application method at the Roseau County location.

Carrier	Rate	Application Method			
		Broadcast		Band	
		Yield	Dry Matter	Yield	Dry Matter
	lbs Cu/A	Bu/A	lbs/A	Bu/A	lbs/A
Control	0	0.5	700	0.5	700
$CuSO_4$	0.75	---	---	1.3	1754
	1.5	8.4	3410	1.6	2168
	3.0	15.1	4445	3.7	2766
	6.0	17.9	4241	4.0	2722
	12.0	17.3	5390	4.5	3531
	24.0	13.6	3044	2.3	1558
Cu Chelate	0.375	3.8	2321	19.0	5337
	0.75	10.0	3281	25.8	5839
	1.5	24.4	5219	38.2	7746
	3.0	35.8	6619	---	---
	6.0	40.3	7147	---	---
Significance		**	**	**	**
B.L.S.D. (.05)		3.2	930	3.2	930
C.V.		17.9	18.4	17.9	18.4

Table 2. Wheat yield and dry matter production as affected by copper rate, carrier and application method at the East Polk County location.

Carrier	Rate	Application Method			
		Broadcast		Band	
		Yield	Dry Matter	Yield	Dry Matter
	lbs Cu/A	Bu/A	lbs/A	Bu/A	lbs/A
Control	0	2.3	---	2.3	---
$CuSO_4$	0.75	---	---	1.3	1821
	1.5	22.4	5403	2.2	1712
	3.0	33.6	5594	3.2	3132
	6.0	39.2	6072	4.0	2940
	12.0	42.1	6665	9.1	2697
	24.0	43.4	7321	10.4	4367
Cu Chelate	0.375	8.0	2956	10.0	3923
	0.75	19.7	4045	19.2	5043
	1.5	28.5	5295	30.5	5036
	3.0	45.1	6490	---	---
	6.0	44.8	6831	---	---
Significance		**	**	**	**
B.L.S.D. (.05)		8.2	1307	8.2	1307
C.V.		30.6	23.1	30.6	23.1

Table 3. Wheat yield and dry matter production as affected by micronutrients in combination with copper at the Roseau County location.

Material	Rate	Yield	Dry Matter
	lbs/A	Bu/A	lbs/A
Cu	12	11.8	5832
Cu + Fe	12 + 10	27.9	6348
Cu + Zn	12 + 5	25.7	6087
Cu + Mn	12 + 10	30.4	8296
Cu + Fe + Zn + Mn	12 + 10 + 5 + 10	31.1	86.47
Significance		**	*
B.L.S.D. (.05)		3.3	2388
C.V.		9.1	20.1

Table 4. Wheat yield and dry matter production as affected by micronutrients in combination with copper at the East Polk County location.

Material	Rate	Yield	Dry Matter
	lbs/A	Bu/A	lbs/A
Cu	12	56.2	9686
Cu - Fe	12 + 10	56.5	8878
Cu + Zn	12 + 5	49.5	9006
Cu + Mn	12 + 10	56.0	9814
Cu + Fe + Zn + Mn	12 + 10 + 5 + 10	53.4	9140
Significance		N.S.	N.S.
C.V.		10.7	8.9

Table 5. Wheat yield as affected by residual copper from copper applied in 1977 at the Roseau County location.

1977 Applied Copper	Yield
lbs/A	Bu/A
0	0
3	34.6
6	34.2
12	34.4
24	32.9
48	35.1
96	34.9
192	31.1
Significance	N.S.
B.L.S.D.	3.6
C.V.	9.2

Nitrogen Carrier x Rate x Application Time Study for Wheat - 1978

G. E. Varvel and R. K. Severson

This is a continuation of a study initiated in 1976 and continued in 1977. Results from 1976 and 1977 were inconclusive due to high nitrate-nitrogen soil tests. Those results are presented in the 1978 Bluebook.

Experimental Procedures:

The treatments included in this study were the same as the previous two years. A randomized complete block design with four replications was used. Fall applications were made on October 25, 1977 and spring applications on April 27, 1978. Era wheat was planted on April 28, 1978 and the study was harvested on August 1, 1978. The study was located at the Northwest Experiment Station on a Hegne silty clay. Soil test results for the site were: pH - 8.3, nitrate-nitrogen (0-2') - 50 lbs/A, available phosphorus (10:1) - 20 lbs/A and extractable potassium - 225 lbs/A.

Results:

Protein content and grain yields as affected by the treatments are shown in Table 1. Significant increases in both protein content and yield were obtained with increasing amounts of nitrogen. Significant differences in protein content and yield were also obtained between nitrogen carriers when compared at the different dates of application.

Table 1. The effects of nitrogen carriers, rates and application times on yield and protein content of Era wheat.

		Application Time			
		Fall		Spring	
Carrier	N Rate	Yield	Protein	Yield	Protein
	lbs./A	Bu./A	-%-	Bu./A	-%-
Control	0	28.5	11.7	28.5	11.7
Ammonium	30	44.0	13.2	35.1	11.0
Nitrate	60	46.2	13.3	45.6	13.1
(34-0-0)	90	52.6	13.9	52.8	13.1
Urea	30	36.9	12.3	42.0	12.4
(46-0-0)	60	42.6	12.9	47.3	13.9
	90	48.6	13.0	55.2	13.8
UAN	30	33.2	11.7	43.0	13.2
Solution	60	40.2	12.9	47.5	13.3
(28-0-0)	90	43.2	12.3	56.3	14.3
Anhydrous	30	43.7	13.3	44.1	13.9
Ammonia	60	51.2	13.8	52.5	13.1
(82-0-0)	90	56.3	13.7	52.2	15.1
Significance		**	*	**	*
B.L.S.D. (.05)		8.1	0.4	8.1	0.4
C.V.		13.0	10.4	13.0	10.4

	Application Time			
	Fall		Spring	
Carrier	Yield	Protein	Yield	Protein
	Bu./A	-%-	Bu./A	-%-
Ammonium Nitrate	47.6	13.4	44.5	12.4
Urea	42.7	12.7	48.1	13.4
UAN	38.8	12.3	48.9	13.6
Anhydrous Ammonia	50.4	13.6	49.6	14.0
Significance	**	*	**	*
B.L.S.D. (.05)	4.4	1.1	4.4	1.1

Nitrogen Rate	Yield	Protein
lbs./A	Bu./A	-%-
30	40.2	12.6
60	46.6	13.3
90	52.1	13.6
Significance	**	**
B.L.S.D. (.05)	2.4	0.7

Nineteen Years of Field Experimentation with Nitrogen Source, Placement, and Time of Application to a Webster Loam Near Lamberton.

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

(Annual reports of this experiment have been reported in Soil Series 74 through 103 and some of this information will not be included here).

The fertilizer treatments have now been annually applied to the same plot areas for 19 years. After ear corn removal and stalk cutting, the fall plowdown N treatments are broadcast on their respective plots and the entire area is then plowed to an approximate 12 inch depth. The fall surface N treatments are then broadcast, with no further working of the plowed area. Each plot is 20' x 77.5' and the 4 treatment replications are arranged in a randomized block.

Spring N treatments are broadcast before seedbed preparation late in April or in early May. The corn is drilled in 30" rows to produce approximately 20,000 plants/A, using a banded starter fertilizer of 8-24-12 at the rate of 180 lbs. over the entire experimental area, thus supplying an additional 14 lbs. N/acre to all plots. Herbicides and insecticides are also annually applied. Nitrogen sidedressing treatments are broadcast in June. Nitrogen concentrations present in the sixth or "index" leaf at silking were determined and are reported along with individual plot yields in table 1. Nitrogen concentration and nitrogen removal with the yield grain and total dry matter production are presented in table 3.

The yields obtained in 1978 were above average when considering the long term previous average for this experiment. Treatment averages in 1978 appeared to follow the trends which had been established with the long term average yields. This suggests that the residual influence from the 1976 drought which was obvious in the 1977 information had not carried over into the 1978 growing season.

EIGHTEEN YEAR AVERAGE

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

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

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

GENERAL CONCLUSIONS

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

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

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

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

N applied annually in lbs/A[1]	% N 6th Leaf	Bu/A @ 15.5% Moisture				
		I	II	III	IV	Ave.
Check	1.65	84.7	59.8	64.2	51.4	64.6
40-NH_4NO_3-fpd[2]	2.23	98.6	120.6	83.9	89.3	98.1
40-urea-fpd	2.38	118.6	125.2	91.5	105.5	110.2
40-NH_4NO_3-fpd[3]	1.88	113.7	115.5	84.6	91.6	101.4
40-urea-fps	2.15	100.5	92.6	94.2	118.3	101.4
80-NH_4NO_3-fpd	2.69	130.7	138.2	125.4	119.3	128.4
80-urea-fpd	2.66	132.6	130.4	108.1	123.1	123.6
160-NH_4NO_3-fpd	2.93	126.5	135.7	118.6	136.3	129.3
160-urea-fpd	2.86	136.2	114.8	118.9	127.8	124.4
40-NH_4NO_3-std[4]	2.32	74.8	122.0	86.6	106.1	97.4
40-urea-std	2.28	125.9	101.2	94.4	94.2	103.9
80-NH_4NO_3-std	2.53	120.2	133.6	119.6	94.9	117.1
80-urea-std	2.66	127.8	134.8	123.6	123.3	127.4
40-NH_4NO_3-sd[5]	2.54	111.1	107.6	104.6	103.7	106.8
40-urea-sd	2.12	113.8	90.2	108.8	106.3	104.8
80-NH_4NO_3-sd	2.64	121.8	106.4	94.1	120.0	110.6
80-urea-sd	2.98	125.1	128.4	118.0	135.3	126.7
160-NH_4NO_3-sd	2.92	135.5	139.3	122.2	107.1	126.0
Significance	**					**
C.V. (%)	6.4					10.6
BLSD (0.05)	.20					15.2

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

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

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

Table 2. Yields of ear corn during 18 years on a tiled Webster loam near Lamberton with annual applications of NH_4NO_3 or urea nitrogen at different rates, times, and placement. (Average of 4 replications)

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

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

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

Table 2 (continued). Yields of ear corn during 18 years on a tilled Webster loam near Lamberton with annual applications of NH_4NO_3 or urea nitrogen at different rates, times, and placement. (Average of 4 replications).

N applied annually in lbs/A[1]	1970	1971	1972	1973	1974	1975	1976	1977	1978	18 year average
	Ear corn yield in bushels per acre									
Check	85.7	40.8	75.6	69.2	53.4	58.3	No	141.2	64.6	69.6
40 NH_4NO_3-fpd[2]	96.3	88.7	113.6	92.0	80.5	88.6		145.1	98.1	87.7
40 Urea-fpd	120.4	100.7	113.9	101.5	96.9	96.6	Yields	165.2	110.2	95.5
40 NH_4NO_3-fps[3]	122.5	81.5	109.9	93.0	88.3	78.2		149.4	101.3	91.5
40 Urea-fps	121.2	82.4	106.7	97.8	85.0	78.9	Taken	156.8	101.4	94.5
80 NH_4NO_3-fpd	134.7	108.0	143.1	121.7	103.6	89.2		156.9	128.4	108.6
80 Urea-fpd	141.4	107.8	140.1	117.9	107.2	96.9		146.0	123.6	107.2
160 NH_4-NO_3-fpd	141.7	120.2	147.6	121.0	113.1	90.4		149.8	129.3	111.8
160 Urea-fpd	140.4	110.6	151.7	114.9	105.1	82.4		163.0	124.4	113.1
40 NH_4NO_3-std[4]	125.6	84.0	117.0	104.0	82.8	88.0		160.0	97.4	98.4
40 Urea-std	118.9	94.6	116.5	97.1	94.5	89.0		165.2	103.9	98.3
80 NH_4NO_3-std	140.4	122.7	142.7	118.0	92.9	97.6		162.9	117.1	110.7
80 Urea-std	146.2	116.0	142.1	117.6	108.5	93.6		162.2	127.4	112.5
40 NH_4NO_3-sd[5]	127.1	104.5	136.0	99.1	82.7	91.8		153.8	106.8	99.9
40 Urea-sd	117.7	100.5	133.9	103.9	80.4	92.6		165.4	104.8	98.5
80 NH_4NO_3-sd	127.7	97.6	124.7	109.4	87.6	95.3		163.2	110.6	103.2
80 Urea-sd	140.5	124.4	149.8	124.0	95.6	90.1		162.8	126.7	113.0
160 NH_4NO_3-sd	136.9	104.2	150.0	117.1	105.5	91.3		160.3	126.0	111.5
Ave. annual corn yield in bu/A	127.0	99.4	128.6	106.6	92.4	88.3		157.2	111.2	101.4
Significance									**	**
C.V. (%)									10.6	8.8
BLSD (.05)									15.2	5.2

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

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

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

Table 3. Nitrogen content and removal with yield grain and total dry matter production - continuous corn - 1978.

	Yield Grain		Dry Matter Production		
Treatment	N Content	N Removal	Yield	Stover N	Total N Removal
#N/A	%	#/A	T/A	%	#/A
Control	1.12	34.6	4.64	.40	59.4
40 NH_4NO_3-fpd[2]	1.21	56.1	5.91	.44	88.0
40 Urea-fpd	1.26	65.6	6.39	.49	102.4
40 NH_4NO_3-fps[3]	1.20	57.5	5.88	.40	84.9
40 Urea-fps	1.40	67.4	6.36	.48	105.3
80 NH_4NO_3-fpd	1.56	94.8	7.22	.57	142.7
80 Urea-fpd	1.40	81.9	6.90	.58	127.7
160 NH_4NO_3-fpd	1.68	102.6	7.91	.77	177.0
160 Urea-fpd	1.71	100.4	7.90	.78	175.7
40 NH_4NO_3-std[4]	1.18	53.7	5.92	.48	88.1
40 Urea-std	1.33	65.7	6.82	.41	101.3
80 NH_4NO_3-std	1.42	82.4	6.77	.50	122.7
80 Urea-std	1.50	90.2	7.31	.59	141.1
40 NH_4NO_3-sd[5]	1.26	63.8	6.36	.48	100.4
40 Urea-sd	1.38	68.8	5.99	.44	100.2
80 NH_4NO_3-sd	1.56	81.4	6.22	.60	125.4
80 Urea-sd	1.53	91.7	7.02	.59	138.8
160 NH_4NO_3-sd	1.68	100.1	7.04	.70	157.0
Significance	**	**	**	**	**
BLSD(.05)	0.10	11.3	1.22	.07	18.6
CV (%)	12.7	11.6	10.1	10.6	12.2

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

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

WEST CENTRAL EXPERIMENT STATION - MORRIS

WEATHER SUMMARY - 1978

Month	Period	Precipitation 1978	Precipitation 91-yr. av.	Precipitation Dev. from av.	Air Temperature 1978	Air Temperature 91-yr. av.	Air Temperature Dev. from av.	Soil (10 cm) Temperature 1978	Soil (10 cm) Temperature 10-yr. av.
January	1-31	.37	.67	- .30	- 0.3	8.4	-8.9	6.6	20.7
February	1-28	.38	.66	- .28	5.8	12.8	-7.0	10.9	23.9
March	1-31	.78	1.05	- .27	24.8	26.7	-1.9	27.0	29.2
April	1-10	1.55	.57	+ .98	38.4	38.0	+0.4	36.0	
	11-20	.72	.64	+ .08	38.9	44.3	-5.5	37.9	
	21-30	.53	1.10	- .57	47.6	48.2	-0.6	42.9	
Total or av.		2.80	2.31	+ .49	41.6	43.5	-1.9	39.0	41.4
May	1-10	.78	.78	0	49.9	52.0	-2.1	49.4	
	11-20	.33	.96	- .63	59.1	55.6	+3.5	58.2	
	21-31	1.37	1.22	+ .15	65.6	59.9	+5.7	66.0	
Total or av.		2.48	2.96	- .48	58.5	56.0	+2.5	58.1	57.1
June	1-10	.36	1.29	- .93	58.4	63.2	-4.8	62.4	
	11-20	1.20	1.24	- .04	66.4	66.5	-0.1	71.1	
	21-30	3.96	1.36	+2.60	68.7	68.3	+0.4	72.6	
Total or av.		5.52	3.89	+1.63	64.5	66.0	-1.5	68.7	69.3
July	1-10	.99	1.50	- .51	69.2	70.0	-0.8	73.6	
	11-20	.58	1.04	- .46	70.9	71.4	-0.5	79.1	
	21-31	.51	1.03	- .52	67.5	71.6	-4.1	75.6	
Total or av.		2.08	3.57	-1.49	69.1	71.0	-1.9	76.1	76.7
August	1-10	1.12	1.06	+ .06	65.5	70.4	-4.9	74.0	
	11-20	.40	.92	- .52	71.4	69.3	+2.1	70.6	
	21-31	1.11	.97	+ .14	69.5	66.9	+2.6	74.8	
Total or av.		2.63	2.95	- .32	68.8	68.8	0	75.3	73.9
September	1-30	3.03	2.19	+ .82	63.3	59.1	+4.2	66.9	61.5
October	1-31	.08	1.59	-1.51	45.8	47.4	-1.6	49.6	47.8
November	1-30	1.25	.94	+ .31	26.7	29.8	-3.1	34.3	33.6
December	1-31	.46	.67	- .21	10.4	15.5	-5.1	22.2	23.4
April-August Growing Season		15.51	15.68	- .17	60.6	61.1	-0.5	63.6	63.8
January-December Annual		21.86	23.45	-1.59	40.1	42.1	-2.0	44.8	46.7

CONTINUOUS CORN SILAGE

West Central Experiment Station - Morris

S. D. Evans

I. Experimental Description

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

II. 1978 Operations

In 1978 the variety was Trojan TXS99. Counter was applied at 1 lb./acre (active ingredient) at planting on May 18. Lasso @ 2 lbs./acre plus Bladex @ 2.2 lbs./acre were applied broadcast on May 19. Silage yields were taken on September 20 and grain yields on October 7.

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

Treatment	1978 yield	1966-78 yield
Silage, low fertility	6.55	5.47
Silage, high fertility	6.84	5.89
Grain, low fretility	7.26	5.40
Grain, high fertility	6.67	5.70

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

	1978 yield	1966-78 yield
Grain, low fertility	128.28	89.57
Grain, high fertility	116.37	92.36

V. Check Yields

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

	1978 yield	1966-78 yield
Grain (0 + 0 + 0)	84.87 Bu/A	53.75 Bu/A
Silage (0 + 0 + 0)	4.54 tons/A	3.81 Tons/A

VI. Discussion

A. In 1978 the silage yield on the low fertility grain plots was significantly higher (10% level) than the high fertility grain plots and the low fertility silage plots.

B. The 13-year average yields show very little difference between silage and grain plots, but there is still a slight advantage for the higher fertility level.

ECO-GRO STUDIES ON CORN

Lamberton and Morris, 1978

S. D. Evans and W. W. Nelson

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

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

Treatment Description - Lamberton

1. Check - No fertilizer material of any kind added.
2. 1 qt/A of Eco-Gro (8-4-4) applied as a foliar spray on July 10 (corn 40-48 in. tall, tassel 12 in. long but still wrapped inside plant) and 1 qt/A of Eco-Gro on August 3 after tasseling--both applied with Wex, a wetting agent. Total plant food = 0.39 + 0.19 + 0.19.
3. 65.6 lbs/A of N as urea prior to planting plus 100 lbs/A of 12-32-18 starter. Total plant food = 77.60 + 32.00 + 18.00.
4. Combination of treatments 2 and 3.
   Total plant food = 77.99 + 32.19 + 18.19.
5. 90.9 gal/A of Eco-Gro applied prior to planting and worked into the soil. Total plant food = 70.39 + 35.20 + 35.20.

Treatment Description - Morris

1. Check - No fertilizer material of any kind added.
2. 1 qt/A of Eco-Gro (8-4-4) applied as a foliar spray when the corn was 30 inches tall (July 3) plus 1 qt/A of Eco-Gro on July 13 (no tassels showing)--both applied with Wex, a wetting agent.
   Total plant food ($N + P_2O_5 + K_2O$) = 0.39 + 0.19 + 0.19.
3. 65.6 lbs/A of N as ammonium nitrate prior to planting plus 150 lbs/A of 10-26-26 starter. Total plant food = 80.60 + 39.00 + 39.00.
4. Combination of treatments 2 and 3.
   Total plant food = 80.99 + 39.19 + 39.19.
5. 90.9 gal/A of Eco-Gro applied prior to planting and worked into the soil. Total plant food = 70.39 + 35.20 + 35.20.

Table 1. Silage and Grain Yields in 1978.

Treatment	Silage Yield (Tons/A)		Grain Yield (Bu/A)	
	Lamberton	Morris	Lamberton	Morris
1. Check	7.42	5.51	137.9	100.7
2. Eco-Gro (foliar)	6.95	5.44	133.3	103.8
3. Conventional	7.14	6.54	136.9	119.0
4. Conventional + Eco-Gro (foliar)	7.51	6.70	130.4	117.5
5. Eco-Gro (Soil)	7.64	6.55	136.2	118.9
Significance	NS	**	NS	**
Bayes LSD (5%)	-	0.54	-	9.8

The yield data for the trials at Lamberton and Morris are given in Table 1. At Lamberton, there were no significant differences (NS) in either silage or grain yields. The grain yield on the check plot at Lamberton was 137.9. The fact that a yield this high was obtained is due to sufficient nitrogen in the soil for maximum yield. This is probably due to two reasons-- (1) high levels of nitrate nitrogen built up in the soil with dry years of 1975 and 1976 and (2) the experimental area was cropped to soybeans in 1977 and nitrogen fixation in the soybean root nodules supplied nitrogen to the soybeans. Therefore, the soybeans did not deplete the already high nitrogen reserves.

At Morris the soil nitrogen levels were somewhat lower with a check yield of 100.7 bu/A. (This site was cropped to corn in 1977.) There were highly significant (**) yield differences of both silage and grain. Statistical analysis shows that treatments 1 and 2 are not significantly different and that treatments 3, 4, and 5 are not significantly different. The Eco-Gro foliar treatments, 2 and 4, did not increase yields over treatments 1 and 3, respectively, apparently because the amount of plant food added-- 0.39 lb/A of N, 0.19 lb/A of P_2O_5 and 0.19 lb/A of K_2O--was so small compared to the actual needs for corn. Treatment 5, where Eco-Gro was applied at a rate to give the approximate plant food needs of corn, yielded the same as the conventional treatment.

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

Treatment	Extra Corn over Check (Bu/A)	Value of Corn ($)	Total Fertilizer Cost ($/A)	Plant Food Cost ($/lb)	Return over Check ($/A)
2. Eco-Gro (foliar)					
Lamberton	-4.6	-8.65	12.70	16.49	-21.35
Morris	+3.1	+5.83	12.70	16.49	-6.87
3. Conventional					
Lamberton	-1.0	-1.88	18.75	.15	-20.63
Morris	+18.3	+34.40	20.73	.13	+13.67
4. Conventional + Eco-Gro (foliar)					
Lamberton	-7.5	-14.10	31.45	.24	-45.55
Morris	+16.8	+31.58	33.43	.21	-1.85
5. Eco-Gro (soil)					
Lamberton	-1.7	-3.20	2309.75	16.41	-2312.95
Morris	+18.2	+34.22	2309.75	16.41	-2275.53

* Prices used: Eco-Gro - $25.39/gallon, urea - 17¢/lb of N, ammonium nitrate - 19.5¢/lb of N, 10-26-26 - $127/ton, 12-32-18 - $152/ton, and corn - $1.88/bu.

The economic analyses (Table 2) shows that all treatments at Lamberton resulted in a negative return (or loss) compared to the return from the check. This is due to the fact that the check treatment was the highest yielding and any other treatment not only resulted in a higher cost but also a lower yield.

The results at Morris show that the conventional treatment resulted in the highest return over check (+$13.67/A). In fact, this was the only treatment that did not result in a loss. Treatment 3, where the Eco-Gro was used as a supplemental foliar treatment, resulted in a loss of $1.85/A. Treatment 5, the Eco-Gro soil treatment, resulted in a loss of over $2000/A because of the high cost of the Eco-Gro needed to provide sufficient nutrients for the corn. At both Lamberton and Morris, the lowest plant food cost was with the conventional treatment.

MANURE RATE STUDY

West Central Experiment Station - Morris

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

The experiment initiated in 1972 was continued. Manure was not applied in the fall of 1977 in order to partially compensate for the low nutrient removal in 1976 due to the drouth in 1976 and subsequent low yields. The check and fertilized treatments were continued as in the past. Treatments and results from previous years are given in Soil Series 91, 95, 97, 99, and 103.

I. Planting Information

The plots were planted to Dekalb XL12 on May 10, 1978. Counter @ 10 lbs./acre (1 lb./acre active ingredient) was applied in the row at planting to the entire area. Starter fertilizer consisting of 154 lbs./acre of 10-26-26 was applied to the fertilized treatment. Nitrogen in the form of ammonium nitrate had been applied on November 3, 1977, prior to plowing to provide 110 lbs./acre of N. Lasso (2 lbs./acre) and Bladex (2.2 lbs./acre) were applied broadcast on May 11, 1978.

II. Soil Sampling and Analysis

A. 1977 Measurements

The results of the analyses of the soil samples collected to a depth of 10 feet are given in Tables 1 and 2.

1. $(NO_3 + NO_2)$-N - There are large increases in the top 3 feet of the manure treated plots as compared to the fertilized plots. At the higher rates of manure (SB2, SB3, LB2, and LB3), the increase is seen at progressively lower depths.

2. Chloride - The manure caused increases in chloride in a manner very similar to that with nitrate-nitrogen.

3. Conductivity - Increases are seen to a depth of 3 feet with SB1 and SB2 and to 4 feet with higher rates of manure.

4. Available P - All manure treatments have increased P levels significantly.

5. Extractable K - The manure treatments greatly increased the K levels in the top foot. In the second foot there is an indication of some increase in K, particularly at the highest rate of solid beef manure.

6. Extractable Ca and Mg - There appears to be no effect of treatment on levels of these two elements.

7. Extractable Na - Manure greatly increased the Na levels in the top 3 feet of the soil profile.

8. Extractable Mn - There is a possible increase of Mn in the top 2 feet of the soil profile due to manure application.

B. 1978 Measurements

The soils were sampled to a depth of 10 feet in the fall of 1978 but the results are not yet available.

III. Plant Tissue Analysis

A. 1977 Harvest Samples

1. Stover

All manure treatments were significantly higher than the fertilized treatment in P and K. The heavier manure treatments tended to have higher N and Mn levels and lower Mg and Cu levels than the fertilized treatment.

2. Grain

All the manure treatments except LB1 had significantly higher N levels than the fertilized treatments.

B. 1978 Samples

1. Early whole corn plants (Table 4)

The only hghly significant effect was at Zn levels where SB1 and all levels of liquid beef manure had significantly lower levels than FE.

2. Corn leaves at silking (Table 5)

a. Nitrogen and Potassium - The level in CK was significantly lower than all other treatments.

b. Phosphorus - The levels in FE were significantly lower than in all solid beef treatments and LB2 and LB3 treatments.

c. Calcium - Solid beef manure significantly reduced calcium levels.

d. Magnesium and Zinc - All manure treatments significantly reduced magnesium and zinc levels.

e. Copper - All levels of solid beef manure and the LB3 reduced the copper levels.

f. Manganese - The CK had lower levels than all other treatments.

g. Boron - Treatment SB1 had a significantly lower boron level than CK.

IV. <u>Yield and Plant Measurements</u> (Table 6)

A. Early Plant Height - The two highest levels of each manure were significantly taller than FE.

B. Broken Stalks - Each increase in rate of solid beef manure increased stalk breakage.

C. Ear Moisture - The application of fertilizer or manure tended to result in drier corn.

D. Grain Yield - Treatment SB1 and LB2 were significantly higher yielding than CK and SB2.

E. Silage Dry Matter - The CK treatment had significantly lower dry matter than most other treatments.

Table 1. Effect of two types of beef cattle manure and commercial fertilizer on the $(NO_3 + NO_2)$-N content, chloride content, and conductivity - fall 1977.

Depth	CK	FE	SB1	SB2	SB3	LB1	LB2	LB3
				$(NO_3 + NO_2)$-N, ppm				
0-1'	7.7	8.2	83.1	108.6	65.6	13.7	36.5	77.3
1'-2'	6.4	33.0	158.9	246.6	153.0	38.9	112.8	185.0
2'-3'	12.1	82.3	125.1	239.7	227.0	107.9	191.7	204.3
3'-4'	13.5	20.6	27.0	63.3	142.0	35.0	72.7	69.2
4'-5'	8.4	8.6	11.7	17.6	79.2	8.9	18.5	18.4
5'-6'	7.0	7.8	7.5	10.1	38.1	7.4	9.9	12.2
6'-7'	6.2	6.3	7.1	8.1	22.1	7.1	8.1	8.6
7'-8'	6.5	5.2	7.2	6.1	15.3	5.7	6.1	10.0
8'-9'	6.4	4.8	6.1	5.0	12.0	4.8	5.4	7.5
9'-10'	5.4	4.6	5.5	4.2	9.4	4.3	4.7	6.1
				Chloride, ppm				
0-1'	2.0	5.7	26.2	33.0	10.1	5.1	5.8	17.0
1'-2'	5.3	9.3	106.1	136.5	85.1	16.5	23.2	52.1
2'-3'	26.0	35.7	203.4	239.5	208.5	77.4	133.6	136.8
3'-4'	14.9	14.1	32.9	104.4	177.5	33.2	63.1	54.7
4'-5'	6.4	6.6	12.4	23.6	106.6	9.6	17.4	14.6
5'-6'	7.5	6.9	6.1	7.8	58.3	8.9	11.5	9.7
6'-7'	7.4	5.3	7.2	6.3	30.2	8.6	8.9	9.3
7'-8'	8.5	10.0	7.5	4.4	17.1	5.6	9.0	10.6
8'-9'	8.0	4.2	6.9	5.4	14.1	5.2	5.3	7.5
9'-10'	7.2	3.1	6.7	5.8	10.0	4.7	5.1	7.0
				Conductivity, mmhos/cm				
0-1'	.135	.148	.528	.685	.507	.193	.289	.429
1'-2'	.241	.288	.836	1.103	.858	.290	.605	.868
2'-3'	.411	.490	.817	1.024	1.128	.592	.964	1.007
3'-4'	.268	.239	.270	.407	.834	.296	.457	.443

Table 2. Effect of two types of beef cattle manure and commercial fertilizer on the available P content, and extractable K, Ca, Mg, Na, and Mn contents - fall 1977.

Depth	CK	FE	SB1	SB2	SB3	LB1	LB2	LB3
				Available P, ppm				
0-1'	9.9	9.3	66.2	81.3	80.0	31.6	56.0	74.2
				Extractable K, ppm				
0-1'	158	153	544	868	1184	211	288	337
1'-2'	125	101	108	128	181	107	100	115
2'-3'	97	88	84	105	98	97	87	92
3'-4'	92	99	97	104	107	103	94	101
				Extractable Ca, ppm				
0-1'	3378	3863	3357	3619	3391	4134	3891	2981
1'-2'	4783	4782	4881	4041	4479	3919	4570	3980
2'-3'	4189	4194	4273	4586	3845	4399	4143	4266
3'-4'	3983	4007	3959	4219	4441	4056	3871	4048
				Extractable Mg, ppm				
0-1'	780	606	800	798	816	647	852	728
1'-2'	1062	711	895	916	773	676	897	966
2'-3'	1268	986	1119	1110	879	890	1184	1130
3'-4'	1072	1013	868	1108	956	861	1076	1055
				Extractable Na, ppm				
0-1'	8.5	4.6	74.6	100.6	85.8	30.3	48.2	62.9
1'-2'	23.3	11.7	67.6	151.9	128.7	38.7	61.2	93.2
2'-3'	44.7	28.1	36.9	42.4	69.1	33.5	42.2	42.1
3'-4'	45.3	37.0	35.6	41.9	41.3	38.6	47.0	44.8
				Extractable Mn, ppm				
0-1'	3.83	2.78	4.37	7.18	5.30	3.34	2.64	8.58
1'-2'	.68	.54	.83	1.32	1.33	1.01	.45	1.20
2'-3'	.69	.26	.38	.68	.96	.97	.19	.58
3'-4'	.54	.36	.79	.40	.45	.50	.39	.30

Table 3. Summary of analysis of stover and grain samples - 1977.

Treatment	Stover											Grain
	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B	Cl	N
	%					ppm						-%-
CK	.82	.06	1.16	.42	.64	194	13.9	6.9	58	10.0	4550	1.37
FE	.89	.06	1.42	.44	.63	186	19.5	6.1	81	7.1	5439	1.44
SB1	.98	.14	2.31	.41	.43	168	9.5	5.5	76	6.0	6694	1.66
SB2	1.13	.24	2.65	.49	.39	205	12.3	4.3	100	8.4	6406	1.73
SB3	1.06	.26	2.65	.45	.29	166	17.3	4.2	101	6.4	6437	1.67
LB1	.87	.08	2.87	.47	.54	387	20.5	6.7	95	6.2	4724	1.58
LB2	1.07	.15	1.99	.62	.48	158	11.8	5.5	125	8.6	4943	1.64
LB3	1.12	.20	2.17	.62	.40	163	17.3	4.9	148	8.3	4783	1.70
Signif.:	*	**	**	+	**	NS	NS	*	**	NS	+	**
BLSD(.05)	.24	.09	.46	-	.12	-	-	2.0	42	-	-	.15

Table 4. Summary of analysis of early corn plant samples - 1978.

Treatment	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%				ppm				
CK	.41	3.79	.59	.46	1280	34.1	7.3	94	4.1
FE	.33	3.52	.63	.41	1599	40.3	7.2	104	4.1
SB1	.49	4.37	.56	.38	1638	30.3	6.6	92	3.3
SB2	.55	4.19	.52	.44	1251	38.1	6.0	83	4.3
SB3	.62	4.78	.41	.31	1536	46.6	6.0	76	4.4
LB1	.36	3.94	.64	.40	1633	29.9	7.3	92	3.6
LB2	.45	4.19	.56	.39	1549	29.9	7.1	96	3.8
LB3	.53	4.27	.50	.35	1596	30.9	5.8	88	3.8
Significance:	NS	NS	+	NS	+	**	+	+	NS
BLSD(.05)	-	-	-	-	-	7.0	-	-	-

Table 5. Summary of analysis of corn leaves at silking - 1978.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	2.23	.21	1.84	.60	.45	106	12.5	6.2	55	5.7
FE	3.36	.28	2.24	.64	.46	119	21.2	8.9	87	5.4
SB1	3.15	.47	2.44	.44	.25	112	10.3	5.3	64	3.3
SB2	3.35	.52	2.83	.46	.21	127	14.9	5.1	66	4.4
SB3	3.33	.49	2.85	.40	.19	114	16.4	4.9	60	3.8
LB1	3.10	.33	2.48	.60	.37	121	14.4	8.4	80	4.9
LB2	3.16	.47	2.69	.57	.30	130	12.3	7.1	93	4.4
LB3	3.21	.51	2.98	.55	.27	145	14.1	5.8	87	4.4
Significance:	**	**	**	*	**	NS	**	*	*	*
BLSD(.05)	.64	.16	.52	.15	.08	-	4.6	2.7	28	1.4

Table 6. Summary of plant measurements - 1978.

			Harvest measurements		Grain		Silage		
Trt.	Early plant height inches	Early plants (10) dry wt. grams	Root lodged 30° or more %	Stalks broken below ear %	Ear moisture at harvest %	Yield @ 15.5% M bu/A	Dry matter at harvest %	Silage yield (D.M.) lb/A	Ear wt. ÷ silage wt. %
CH	18.4	41.9	2.4	5.7	31.8	101.4	42.8	12520	55.2
FE	14.0	36.4	1.0	7.2	26.8	110.2	49.3	13582	54.2
SB1	19.8	58.5	0	10.0	21.1	124.2	50.8	14917	56.4
SB2	18.7	50.6	0	24.3	18.3	101.1	50.4	12190	51.6
SB3	22.9	58.2	0	27.6	19.6	119.8	46.0	13514	54.0
LB1	14.2	42.6	0	10.0	23.7	117.8	52.1	12667	56.1
LB2	17.5	53.2	0	7.1	20.7	130.9	54.2	12810	56.2
LB3	21.1	64.2	0	16.7	19.8	120.4	49.9	13612	55.8
Signif.:	*	NS	NS	**	**	*	*	NS	NS
BLSD(.05)	6.0	-	-	7.2	3.1	22.2	5.7	-	-

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

West Central Experiment Station - Morris

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

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

I. Planting Information

Twenty-four rows of corn (var. Dekalb XL12) were planted in each plot on May 10, 1978. Counter @ 10 lbs./acre (1 lb./acre active ingredient) was applied to the entire area. Starter fertilizer consisting of 154 lbs./acre of 10-26-26 was applied to the fertilized treatment only. Nitrogen in the form of ammonium nitrate was applied to the fertilized plots to provide 110 lbs./acre of N on November 3, 1977. Lasso (2 lbs./acre) and Bladex (2.2 lbs./acre) were applied broadcast on May 11, 1978.

II. Soil Sampling and Analysis

A. 1977 Measurements

The results of the analyses of the soil samples collected to a depth of 4 feet are given in Tables 1 and 2.

1. NO_3-N - The SB and LB treatments continued to have higher levels than FE. The LH treatment has essentially the same levels as FE in the top 3 feet, but higher levels in the 3- to 4-foot zone.

2. Available P - Levels in the manure treated plots are much higher than in FE.

3. Extractable K - Levels in the 0 to 1-foot layer are much higher in the manure treated plots than in FE. Below 1 foot the levels are not different.

4. Extractable Na - The manure treated plots have higher levels of Na at all depths than FE. The total Na in the top 4 feet is essentially equal to that one year earlier.

5. Chloride - Levels of chloride in the top foot of the manure treated plots are equal to those of CK and FE. In the second foot SB and LB still have much higher levels than FE. In the third and fourth foot all manure treatments have higher levels than FE. The total chloride in the top 4 feet has increased in all treatments over levels one year earlier indicating some upward movement of chloride.

6. Electrical conductivity - The manure treated plots have higher EC than FE. There has been an increase in EC in the past year in the 2- to 3-foot zone of all treatments except for CK.

7. Extractable Ca - The levels of Ca are higher than FE in the 0 to 1-foot zone of LB and the 1- to 2-foot zone of SB and LH.

8. Extractable Mg - There are no consistent effects of manure on the Mg levels.

9. Extractable Mn - There are no significant effects of manure on the Mn levels.

10. Soil pH - There are no effects of manure on the pH levels.

B. 1978 Measurements

The soils were sampled to a depth of 16 feet in the fall of 1978 but the results are not yet available.

III. <u>Plant Tissue Analysis</u>

A. 1977 Harvest Samples (Table 3).

1. Stover

All manure treatments were significantly higher than the FE treatment in P and K and significantly lower in Mg and Zn. SB was significantly higher than all other treatments in iron.

2. Grain

The SB treatment was significantly higher in N than CK and LH.

B. 1978 Samples

1. Early whole corn plants (Table 4)

The only significant effect was on iron with LH higher than all other treatments.

2. Corn leaves at silking (Table 5)

All manure treatments were significantly higher than FE in K and significantly lower in Mg. The LB treatment was significantly higher than FE in P. The Ca levels in SB were significantly lower than in FE. The Zn levels in SB and LB were significantly lower than in FE.

IV. Field and Plant Measurements (Table 6)

A. Early plant height and dry weight - The manure treated plots were significantly taller and heavier than CK and FE.

B. Root lodging - The FE treatment had more root lodging than all other treatments.

C. Ear moisture at harvest - The CK treatment was significantly wetter than all other treatments and FE was significantly wetter than SB.

D. Grain yield - The CK treatment was significantly lower yielding than all other treatments, but there was no difference between FE and any manure treatment.

E. Silage dry matter - The CK treatment was lower in dry matter than all other treatments.

F. Silage yield - The CK treatment was lower yielding than all other treatments. There was no significant difference between FE and any manure treatments.

V. Summary

The effects of the manure treatments applied in 1970 and 1971 are still quite apparent in most soil and plant measurements. The soil levels of nutrients are as high or higher than a year earlier. Plant analysis in 1978 still shows large effects of the manure treatments, particularly in the leaves.

In 1978 there were no significant differences in either grain or silage yields between the fertilized treatment and the manure treatments.

Table 1. Effects of high rates of manure and commercial fertilizer seven years (fall 1977) after application on the (NO_3+NO_2)-N, available P, extractable K, and Na, Cl, and electrical conductivity of a Tara soil profile.

Depth	CK	FE	SB	LB	LH
			- NO_3 + NO_2)-N, ppm -		
0-1'	6.3	6.8	13.1	23.3	9.7
1'-2'	5.0	19.2	83.9	101.5	18.2
2'-3'	5.4	97.7	160.7	213.3	113.4
3'-4'	6.9	36.4	93.3	129.0	74.4
			- Available P, ppm -		
0-1'	3.6	25.6	63.0	62.2	59.6
			- Extractable K, ppm -		
0-1'	133	157	558	422	256
1'-2'	108	126	118	125	103
2'-3'	94	92	78	88	99
3'-4'	91	92	84	77	89
			- Extractable Na, ppm -		
0-1'	8.0	15.4	40.8	54.2	26.3
1'-2'	17.0	27.9	108.5	153.7	55.7
2'-3'	27.3	32.3	99.2	127.3	58.3
3'-4'	36.8	40.4	62.8	62.6	38.6
			- Cl^-, ppm -		
0-1'	4.8	5.2	5.4	5.1	3.9
1'-2'	4.4	8.2	46.9	43.5	8.0
2'-3'	6.4	58.9	196.7	173.0	77.6
3'-4'	8.1	31.7	147.0	124.3	59.7
			- Electrical conductivity, mmhos/cm -		
0-1'	.171	.104	.214	.250	.147
1'-2'	.183	.264	.556	.642	.250
2'-3'	.203	.598	.984	1.094	.664
3'-4'	.191	.332	.623	.729	.458

Table 2. Effects of high rates of manure and commercial fertilizer seven years (fall 1977) after application on the extractables Ca, Mg, and Mn levels and pH of a Tara soil profile.

Depth	CK	FE	SB	LB	LH
			- Extractable Ca, ppm -		
0-1'	4457	3115	3195	3743	2972
1'-2'	3902	4220	4738	4195	4606
2'-3'	4115	4370	4296	4369	4489
3'-4'	4040	4263	3949	3817	4143
			- Extractable Mg, ppm -		
0-1'	644	727	646	659	591
1'-2'	780	839	628	789	582
2'-3'	894	805	745	839	800
3'-4'	906	772	839	721	787
			- Extractable Mn, ppm -		
0-1'	2.03	3.32	2.73	2.91	3.15
1'-2'	.58	.55	.41	.48	.32
2'-3'	.15	.16	.18	.23	.26
3'-4'	.19	.23	.23	.22	.14
			- pH -		
0-1'	7.5	7.0	7.3	7.2	7.3

Table 3. Summary of analysis of stover and grain samples - 1977.

	Stover											Grain
Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B	Cl	N
	%					ppm						-%-
CK	.88	.07	1.38	.49	.60	237	14.7	6.8	64	6.8	3693	1.25
FE	.97	.09	1.55	.47	.57	217	19.5	6.7	66	7.0	4609	1.69
SB	1.02	.23	2.55	.38	.35	389	9.6	5.5	75	6.2	3362	1.80
LB	1.01	.36	2.77	.43	.32	281	9.0	4.3	68	6.2	3715	1.56
LH	.87	.12	2.11	.41	.38	215	12.4	4.7	61	6.3	3811	1.37
Signif.:	NS	**	**	NS	**	**	+	+	NS	NS	NS	*
BLSD(.05)	-	.15	.36	-	.10	62	-	-	-	-	-	.38

Table 4. Summary of analysis of early corn plant samples - 1978.

Treatment	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%				ppm				
CK	.34	3.07	.66	.48	1165	32.7	7.2	86	5.7
FE	.37	3.24	.61	.44	1381	37.5	6.8	87	4.9
SB	.47	3.91	.54	.39	1306	33.0	6.9	82	4.8
LB	.55	4.21	.49	.34	1284	40.8	5.9	70	5.4
LH	.41	3.75	.54	.31	1650	44.4	6.1	80	5.3
Significance:	NS	NS	NS	NS	+	NS	NS	NS	NS
BLSD(.05)	-	-	-	-	-	-	-	-	-

Table 5. Summary of analysis of corn leaves at silking - 1978.

	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	1.85	.17	1.66	.63	.49	87	11.4	5.6	54	5.3
FE	3.26	.30	1.99	.54	.44	113	21.9	7.3	71	4.5
SB	3.02	.39	2.51	.41	.20	106	12.9	5.7	56	3.7
LB	3.11	.48	2.76	.50	.22	131	16.3	5.7	62	4.1
LH	2.82	.33	2.48	.53	.25	113	18.4	6.4	55	4.5
Significance:	**	**	**	*	**	*	**	NS	NS	NS
BLSD(.05)	1.04	.06	.39	.11	.09	23	3.2	-	-	-

Table 6. Summary of plant measurements - 1978.

			Harvest measurements		Grain		Silage		
Trt.	Early plant height inches	Early plants (10) dry wt. grams	Root lodged 30° or more %	Stalks broken below ear %	Ear moisture at harvest %	Yield @ 15.5% M. bu/A	Dry matter at harvest %	Silage yield (D.M.) lb/A	Ear wt. ÷ silage wt. %
CK	12.2	15.0	0	1.4	32.5	79.7	41.9	9968	50.3
FE	14.7	40.2	2.9	5.5	26.0	111.2	47.6	14200	51.5
SB	19.9	59.3	0	7.6	18.5	119.6	52.4	14148	56.6
LB	22.2	68.1	0	12.9	20.3	117.5	49.1	14716	54.3
LH	19.2	54.7	0	5.2	22.9	119.7	51.5	13958	60.2
Signif:	**	**	**	+	**	**	*	**	+
BLSD(.05)	3.4	10.9	1.0	-	5.5	14.8	6.1	1175	-

Influence of Nitrogen on Forage Production Nitrogen Utilization by Three Small Grain Varities

G.L. Malzer and S. Evans

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

Experimental Procedures

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

Dry matter production was determined at three different times during plant growth and analyzed for nutrient composition. Grain was harvested on August 9 by hand harvesting known areas from each plot. Soil samples were obtained at the four samplings above (June 13, June 28, July 11, and August 9) for determination of rooting density, soil moisture and soil nitrate nitrogen. Root samples were obtained utilizing a coring technique. For root analysis samples were collected over the row and between the row to a depth of four feet. Each core (2 5/8" diameter) was divided into eight 6" increments and each sample consisted of a composite of two cores. The root samples at this time are in the process of being analyzed. Soil samples for moisture and nitrate analysis were taken in a similar manner by obtaining one core in the immediate area from which the roots samples were obtained.

General Results

Preliminary nitrate soil tests indicated a very low nitrate nitrogen content in the 0-2' depth. Appreciable quantities of nitrate nitrogen were present in the 2-4' depth in 1978. Significant dry matter production increases were obtained due to nitrogen application with both Chris and Era wheat with the first two samplings while MN 7125 was increased only at the second sampling. No significant (.10) dry matter response was obtained with nitrogen rate or variety at the third sampling. Nitrogen removal with the forage (both concentration and total removal) was significantly influenced by both nitrogen rate as well as variety at all three forage harvests. The nitrogen content of the forage was increased due to nitrogen application at all three harvest dates but was increased only with the first sampling with MN 7125 and only on the first and third sampling with Chris. Total nitrogen removal with each sampling was the same at all three harvest when no nitrogen was applied. At the first sampling Chris had taken up more nitrogen than MN 7125 when fertilizer was applied. No differences were obtained with total nitrogen removal between varieties within nitrogen treatments. All varieties reflected significant responses in uptake to applied nitrogen at the first sampling; however MN 7125 showed no response past the first sampling date and Chris was not significant at the third harvest. Grain yields at harvest and total nitrogen removal with the grain at harvest were not influenced by either variety or nitrogen treatment

Table 1. Forage Yield, Forage N Content, Total Forage Nitrogen Removal and Yield Grain Characteristics of Three Small Grain Varieties as Influenced by Nitrogen Treatment.

Treatment		Forage Yield Harvest No.			Forage N Content Harvest No.		
Variety	N Rate	1	2	3	1	2	3
	#/A	T/A			%		
Chris	0	.52	1.44	2.48	3.16	2.24	1.57
Chris	120	.80	1.97	2.88	4.01	2.68	1.94
Era	0	.49	1.46	2.02	3.23	2.48	1.58
Era	120	.70	1.74	2.72	4.07	3.03	2.04
MN 7125	0	.59	1.39	2.68	2.82	2.35	1.57
MN 7125	120	.63	1.74	2.97	4.07	2.61	1.80
Significance		**	*	NS	**	*	*
BLSD(.05)		.13	.32		.30	.47	.33

		Forage N Removal			Wheat Grain Yield	Wheat Grain Test Wt	Wheat Grain N Content	Wheat Grain N Removal
		#/A			bu/A	#/bu	%	%/A
Chris	0	32.9	64.7	77.2	32.3	58.0	3.20	61.9
Chris	120	63.9	105.1	111.6	24.2	53.3	3.34	48.5
Era	0	31.6	73.3	65.1	32.0	53.2	2.96	56.5
Era	120	56.7	105.6	111.2	28.9	49.3	3.25	56.4
MN 7125	0	32.5	65.5	85.0	36.2	51.6	2.67	57.8
MN 7125	120	51.6	90.8	106.9	34.0	50.2	2.86	58.4
Significance		**	*	*	NS	*	**	NS
BLSD(.05)		8.0	26.2	37.1		5.1	.27	

PESTICIDE INTERACTION PLOTS AT ROSEMOUNT

Russell S. Adams, Jr.

The experiment studying the effects of combinations of the insecticide Furadan, the herbicide atrazine and soil pH was continued for the sixth and final year in 1978. Treatments included five residual lime treatments, Furadan at 0, 1/2 and 2 lb./A, atrazine at 0, 2, 4, and 8 lbs/A, and their combinations. Each treatment was replicated four times. The plots have been managed so as to maximize both weed and corn root worm infestation.

Data are summarized in Tables 1 and 2. Average yields for the six year period ranged from 69 to 104 bu/A. From Table 2 one can surmise that weed control accounted for about a 25 bu/A increase, corn root worm control about a 4 bu/A increase, improved soil pH a 6 bu/A increase. No interaction effects are evident in corn yields.

In terms of weed control Furadan demonstrated a significant reduction in weed growth. Weed growth varied inversely and proportionately to the amount of atrazine used, with no interaction effect between Furadan and atrazine evident. The 8 lb/A atrazine rate accomplished only 90% control of weeds. The reader needs be reminded that the plots were managed to maximize weed growth so that this degree of control is by no means typical. However, the data emphasize that to attempt 100% control is impractical.

Lodging was never a severe problem in this field, on the average affecting only about one-third of the stand. However, corn root worm control reduced lodging by nearly 50%. No effect of atrazine on corn root worm control could be observed nor was an interaction effect of atrazine and Furadan detectible. Lodging was substantially greater under higher pH conditions. Poorer control of root worms under these conditions has been confirmed.

Higher soil pH produced a very significant reduction in weed growth across all treatments. This was due primarily to the fact that atrazine is much more effective under these conditions.

Table 2. Effect of insecticide, herbicide and soil pH across all treatments.

Rate of Chemical lbs/A	Lodging %	Weeds t/A	Yield $ μ/A
Furadan			
0	35	1.23	87
1/2	26	1.08	92
2	19	0.90	92
Atrazine			
0	28	2.55	79
2	28	1.08	91
4	25	0.64	95
8	27	0.27	96
Soil pH			
~5.4	24	1.30	86
~6.3	24	1.29	89
~6.7	27	1.07	92
~6.8	27	1.01	90
~7.2	32	0.76	94

Table 1. The amount of lodging, weed growth, and corn yields in Atrazine-Furadan-pH studies at Rosemount, 6 year average

Rate of Furadan and Lime Status	No Atrazine			2 lbs/A Atrazine			4lbs/A Atrazine			8 lbs/A Atrazine		
	Lodging %	Weeds tons/A	Corn bu/A	Lodging %	Weeds tons/A	Corn bu/A	Lodging %	Weeds tons/A	Corn bu/A	Lodging %	Weeds tons/A	Corn bu/A
No lime--somewhat acid (∼pH 5.4)												
Furadan 0 lbs/A	36	2.78	69	35	1.58	83	38	0.72	86	34	0.48	87
1/2	16	2.68	76	21	0.78	91	22	0.82	86	20	0.30	96
2	15	2.34	81	23	0.92	91	10	1.00	90	20	0.20	97
Moderate lime-slightly acid (∼pH 6.3)												
Furadan 0 lbs/A	28	3.24	76	30	1.62	84	29	0.44	95	44	0.26	94
1/2	38	2.94	77	24	1.42	90	24	0.84	103	24	0.38	93
2	20	2.34	81	10	1.30	86	13	0.66	97	16	0.56	94
Well limed, near neutral (∼pH 6.8)												
Furadan 0 lbs/A	34	2.34	74	35	1.38	84	32	0.42	91	30	0.18	100
1/2	31	1.94	73	24	1.23	91	24	0.92	98	32	0.18	98
2	17	1.92	80	24	0.96	98	18	0.46	97	18	0.22	98
Heavily limed, slightly alkaline (∼pH 7.2)												
Furadan 0 lbs/A	41	2.64	73	40	0.76	90	36	0.34	92	37	0.08	93
1/2	30	2.02	87	29	0.74	96	28	0.28	104	29	0.10	98
2	30	1.64	92	31	0.10	97	20	0.32	104	27	0.08	103

ALFALFA AND RED CLOVER POTASSIUM TRIALS

Staples, Minnesota - 1978

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

Alfalfa and red clover trials at Staples were first extablished in July, 1970. At that time experiments were established using varying amounts of phosphorus, sulfur, lime and potassium. Soil tests were high for sulfur and phosphorus and after 1974 these trials were discontinued; no responses had been obtained. The lime trial was also discontinued at that time because lime in the irrigation water had raised the pH of all plots above 7. In the last 2 years pH in the trial area is above 7.6.

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

Yield and soil test results

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

Potassium soil tests were below expectations through 1976, even with annual treatments of 240 pounds of K_2O per acre. Table 1 shows a K test as low as 128 pounds of exchangeable K in 1976 where 2 treatments of 120 pounds of K_2O had been added annually since 1970. There the 120 pounds treatment was increased to 180 and the 240 pound treatment was increased to 360 for the 1978 crop. Soil tests taken in the fall of 1978 show an increase in the test levels up to 287 pounds of K from a 360 pound treatment.

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

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

There has been no real difference in yield between October or June application.

Yields of over 5 tons of alfalfa have been measured on the no-potash treated plots (1974 & 1975), while the 0 to 6 inch soil sample is very low, i.e., between 40 and 60 pounds of exchangeable K. Subsoil samples taken in 1974 show K tests of 50 at 1 to 2 feet and 20 at 2 to 3 feet deep indicating that subsoil K source cannot explain the good alfalfa yields on the check plots. In 1978, however, the no-potash plots yielded approximately 2 tons per acre and shows K deficiency symptoms.

Plant analysis

Generally October treated plots show more K in leaves at the first cut since the June application goes on just after the first cutting. On the other hand

K levels are higher for the third cut from June application than from the October treatment (Table 2).

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

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

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

	Soil Test K lbs/A						
	None	June 240	Oct. 240	June 120	Oct. 120	June 120+ Oct. 120	1978
Alfalfa							
1972	92	258	322	160	165	185	Avg. pH=7.6
1973	85	290	210	150	140	195	
1974	60	175	240	95	75	200	Avg. P Alf=47
1975	48	178	160	75	63	135	R.C.=72
1976	40	210	145	68	68	128	
1978**	54	287	216	123	91	212	
Red Clover							
1972	107	262	230	182	167	162	
1973	90	290	240	160	190	310	
1974*	135	180	200	150	155	180	
1975	60	180	83	108	60	115	
1978**	58	300	170	138	86	210	

*red clover failed in 1974, was reseeded August 1, 1974

**crops reseeded in 1977 to Anchor alfalfa and Arlington red clover. No yields or soil samples taken in 1977. Treatments of K_2O in 1978 were increased to from 120 to 180 pounds of K_2O per acre and the 240 pound treatment was increased to 360.

Table 1b. Potassium treatment effect on red clover and alfalfa yields in 1978.

		K_2O in lb/A annually and time of application						
Cutting	None	June 360	Oct. 360	June 180	Oct. 180	June 180 + Oct. 180	Significance	BLSD
Alfalfa								
1	.38	1.31	1.22	1.05	1.05	1.22	**	.20
2	.71	1.19	1.20	1.08	1.12	1.14	**	.14
3	.88	1.31	1.39	1.28	1.25	1.37	**	.12
Total	1.97	3.81	3.81	3.41	3.42	3.73	**	.32
Red Clover								
1	.96	1.40	.95	.87	1.12	1.06	ns	-
2	.97	1.19	1.21	1.20	1.20	1.19	**	.12
3	1.02	1.27	1.20	1.26	1.17	1.21	ns	-
Total	2.95	2.86	3.36	3.33	3.49	3.46	ns	-

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

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

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

Table 2a. Plant Analysis %K (1978)

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

Sufficiency levels for alfalfa 2.5%

Barley Fertilization Trials
Under Irrigation at Staples in 1978

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Mike O'Leary, Peter Groves, Mel Wiens.

Agricultural production on the sandy soils of central Minnesota has expanded in recent years due largely to the development of irrigation. Although corn, potatoes, alfalfa, and some vegetable crops are grown under irrigation, there is wide interest in the production of small grains. Considerable work has been done on the production of wheat under irrigation, but there is an increased interest in producing barley if satisfactory yields and acceptable quality can be obtained for malting. Three separate experiments were initiated to determine the importance of nitrogen fertilization on the production of malting barley under irrigation at Staples, Minnesota on a sandy loam soil in 1978.

Soil tests of the area taken prior to fertilization indicated an extractable phosphorus test of 78 lbs per acre, an exchangeable potassium test of 88 lbs per acre with a soil pH of 6.6. All experimental areas received 60 lbs K_2O/A and 10 lbs S/A as gypsum broadcast preplant and incorporated. 20 lbs P_2O_5/A was applied with the seed at planting time. Weeds were controlled with ¼ lb/A of bromoxynil + ¼ lb/A MCPA applied prior to 4 leaf stage.

A. Variety x Nitrogen Rate Trial

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

There was a significant varietal difference in yield potential, test weight, percent plump and percent protein in seed. (Table 1) Nitrogen increased yields significantly up to 90 lbs nitrogen per acre with significant increase in percent protein to 135 lbs nitrogen per acre. Nitrogen significantly decreased plumpness of the kernals and the test wt of the barley was significantly reduced with 135 lbs of nitrogen per acre. Malting grade barley (percent protein less than 13.5% and plump kernals greater than 65%) was produced with nitrogen rates to 45 lbs. nitrogen per acre.

The nitrogen content of the M-32 forage was significantly higher than the other varieties (Table 2). Nitrogen content and removal were significantly increased with nitrogen rates.

Table 1. Effect of variety and N rate on yield, test weight, % plumpness, and % protein of barley grain at Staples, MN in 1978.

Treatment	Yield	Test Weight	Plumpness	Protein
Variety	Bu/A	lbs/bu	%	%
Manker	60.8	45.7	56.0	13.25
Morex	59.3	44.1	63.2	13.81
M-32	64.6	42.4	64.1	12.63
Signif.	*	*	**	**
BLSD(.05)	4.3	1.8	3.1	.31
N RATE				
0 #N/A	40.6	45.3	72.5	11.38
45 #N/A	62.7	45.1	65.8	11.81
90 #N/A	73.5	44.2	56.7	14.19
135 #N/A	69.6	41.6	49.3	15.63
Signif.	**	**	**	**
BLSD(.05)	3.4	1.3	3.2	.44
Interaction				
Manker x 0#N/A	39.2	46.9	65.8	11.06
Manker x 45 "	61.0	46.8	60.2	11.63
Manker x 90 "	74.0	45.5	52.4	14.44
Manker x 135 "	69.0	43.7	45.6	15.94
Morex x 0 "	39.9	45.0	75.0	11.75
Morex x 45 "	63.1	44.6	69.7	12.19
Morex x 90 "	68.0	44.5	57.7	14.88
Morex x 135 "	66.1	42.1	50.5	16.44
M-32 x 0 "	42.6	44.0	76.6	11.38
M-32 x 45 "	63.9	43.9	67.6	11.50
M-32 x 90 "	78.4	42.7	60.1	13.19
M-32 x 135 "	73.6	39.1	51.9	14.50
Signif.	NS	NS	NS	NS
C.V.	7.6	3.8	7.0	4.7

Table 2. Effect of variety and N rate on dry matter yield; % N in tissue, and total N removal of barley forage at Staples, MN in 1978.

Treatment	Yield	N Content	N Removal
Variety	Tons/A	%	lbs/A
Manker	2.99	1.19	74.5
Morex	2.91	1.24	76.1
M-32	2.72	1.38	78.8
Signif.	NS	**	NS
BLSD(.05)	-	.07	-
N Rate			
0 #N/A	1.67	.98	32.6
45 #N/A	2.86	1.04	59.5
90 #N/A	3.37	1.43	96.3
135#N/A	3.59	1.64	117.4
Signif.	**	**	**
BLSD(.05)	.24	.10	10.0
Interaction			
Manker x 0 #N/A	1.65	.97	31.8
Manker x 45 #N/A	2.87	1.01	58.2
Manker x 90 #N/A	3.65	1.35	98.7
Manker x 135 #N/A	3.80	1.44	109.4
Morex x 0 #N/A	1.66	.95	31.4
Morex x 45 #N/A	3.01	1.01	60.6
Morex x 90 #N/A	3.22	1.34	85.8
Morex x 135 #N/A	3.75	1.68	126.6
M-32 x 0 #N/A	1.69	1.02	34.7
M-32 x 45 #N/A	2.73	1.09	59.8
M-32 x 90 #N/A	3.23	1.62	104.5
M-32 x 135 #N/A	3.23	1.80	116.2
Signif.	NS	NS	NS
C.V.	11.3	10.1	17.8

B. Time of Application Trial

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

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

The application of nitrogen significantly increased the yield and percent protein of the grain (Table 3). 90#N/A applied preplant and 90#N/A applied at 2/3 preplant and 1/3 early boot dignificantly decreased yields compared to the other application schemes. The three time application scheme produced significantly higher protein content.

Forage yield, percent N content, and nitrogen removal were significantly increased with nitrogen (Table 4). Two time application schemes percent nitrogen were lower than the other application schemes percent nitrogen. Three times of application scheme had significantly higher percent nitrogen than 90#N/A applied preplant.

C. Density x Nitrogen Rate x Potassium Rate

This trial was designed to evaluate the affects of seeding rate, nitrogen rate, and potassium rate on yield and quality of malting barley under irrigation. Treatments were set out in a factorial arrangement (2 x 2 x 2) replicated four times in a randomized complete block design. Seeding rates of 96 and 144 #/A, nitrogen rates of 90 and 135 #/A, and K_2O rates of 60 and 260 #/A were used. Nitrogen was applied as ammonium nitrate with 2/3 applied preplant incorporated and 1/3 applied at tillering stage. Potassium was applied preplant incorporated.

Nitrogen significantly increased grain yield and protein (Table 5). No significant difference was obtained due to density or potassium rates, however the interaction of density with potassium showed a significant decrease in yield at high density and high potassium rates.

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

Treatment Code	Yield Bu/A	Test Wt. #/bu	Plumpness %	Protein %
A	36.2	48.3	64.2	10.56
B	69.8	45.6	54.3	12.41
C	76.5	45.9	53.5	12.63
D	70.6	47.1	59.5	11.63
E	76.7	46.2	57.0	13.25
Signif.	**	NS	*	**
BLSD(.05)	4.9	-	6.2	1.00
C.V.	5.3	3.5	6.7	5.7

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

Treatment Code	Yield T/A	N Content %	N Removal #/A
A	1.68	.74	24.5
B	3.30	1.07	70.5
C	3.80	.98	76.9
D	3.42	.92	63.9
E	3.38	1.18	79.7
Signif.	**	**	**
BLSD(.05)	.76	.12	22.8
C.V.	16.2	8.6	24.1

Table 5. Effect of seeding rate, nitrogen rate and potassium rate on yield, grain protein, test weight, and percent plump of Manker Barley at Staples, 1978.

Treatment			Yield	Grain Protein	Test Weight	Plump
Seeding Rate			Bu/A	%	lbs/bu	%
96 #/A			77.1	14.6	44.1	51.4
144 #/A			75.0	14.8	45.5	53.1
Significance			NS	NS	NS	NS
N-Rate						
90 #/A			73.2	14.1	45.6	54.2
135 #/A			78.9	15.3	44.0	50.3
Significance			**	**	NS	NS
BLSD (.05)			3.8	.6	-	-
K_2O Rate						
60 #/A			76.4	14.7	44.9	54.3
260 #/A			75.7	14.7	44.6	50.2
Significance			NS	NS	NS	NS
Interaction						
Seeding Rate	#N/A	#K_2O/A				
96	90	60	71.1	13.8	44.7	55.0
96	90	260	77.1	14.2	43.9	51.6
96	135	60	78.8	15.1	44.3	53.0
96	135	260	81.2	15.3	43.4	46.0
144	90	60	73.8	14.5	46.2	57.4
144	90	260	70.8	13.8	47.5	52.9
144	135	60	81.8	15.4	44.5	51.8
144	135	260	73.7	15.4	43.7	50.4
Significance			NS	NS	NS	NS
C.V., %			5.8	6.7	11.4	5.8

Influence of Nitrogen Rate, Timing of Application and Use of Nitrification Inhibitors on Irrigated Corn at Staples.

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

Nitrogen management on irrigated sands has been one of the grower's chief concerns for best utilization of nitrogen. To minimize losses of nitrogen due to leaching, nitrogen is usually applied in split applications either through irrigation water or sidedressed during the growing season. Concerns exist as to whether nitrification inhibitors can stop leaching losses of nitrate nitrogen. Can nitrogen be applied once with a nitrification inhibitor thereby eliminating the need for split applications? What effect on yield will they have? The objectives of this experiment are to investigate the influence of nitrogen application on yield and nitrogen utilization of corn under irrigation. Also to determine the impact of nitrification inhibitors on nitrogen management under irrigation.

Experimental Procedures

Nine treatments were replicated four times and combined in a randomized complete block design. The treatments were established on a Sverdrup sandy loam at the CMDIR station at Staples, Minn. Potassium (200 # K_2O/A) and sulfur (25 #S/A as $CaSO_4$) were broadcast and disked in prior to planting. The treatments included a check, two nitrogen rates (80 and 160 # N/A as urea), two methods of application and two nitrification inhibitors (N-Serve-Dow Chemical, Terrazole-Olin Corporation). Nitrogen treatments were applied in either one single preplant application or in multiple applications during the growing season. Split applications of nitrogen were applied on May 5 (preplant), June 13 (12" height), June 27 (36" height), and July 13 (prior to silking) in a ratio of 1/6, 1/6, 3/6, and 1/6 respectively.

Nitrification inhibitor treatments were applied with the single nitrogen application treatments as coatings onto the urea (0.5 #a.i./A) for both N-Serve and Terrazole. The preplant nitrogen applications were broadcast over the plot area and immediately incorporated by disking. An adapted corn variety (Pioneer 3978 - 85 day R.M.) was hand planted on May 5 in 30" rows at a population of 26,000 seeds/A. Good weed control was obtained with a tank mix of Atrazine and Sutan. The experimental area received a total of 29.72 inches of water from rainfall and irrigation during the growing season.

Leaf samples from opposite and below the ear at silking were collected on July 27, dried and analyzed for Kjeldahl nitrogen. Dry matter production and nitrogen utilization were determined by harvesting one row 15 ft. long from each plot on September 14 (Physiological maturity). Ears were separated from the stalks, field weights obtained and samples removed for moisture determination and nitrogen analysis. Yields were obtained October 10 by harvesting two rows 20' long. Field weights were obtained and samples collected for moisture and nitrogen concentration. Corn grain yields were adjusted to 15.5% moisture.

General Results

Corn grain yields in 1978 ranged from 121 to 180 bu/A (Table 1). Nitrogen responses up to 80 #N/A were obtained. No additional yield increases were obtained with the 160 #N/A rate. Splitting the applications at both the 80 and 160 #N/A rate resulted in no significant increase in yield. The nitrification inhibitors had no effect on yield. Nitrogen concentration in corn grain showed increases up to the 160 #N/A rate. Split applications of nitrogen increased the nitrogen content in corn grain at the 80 #N/A rate. Terrazole increased the percent nitrogen in corn grain at the 80 #N/A rate but not at the 160 #N/A rate. N-Serve had no effect on the percent nitrogen in corn grain at either rate. Nitrogen concentration in leaf samples increased with nitrogen rates up to 80 #/A. Splitting of the nitrogen applications and use of nitrification inhibitors at both rates showed no increases in percent nitrogen in the leaf. Nitrogen removal in corn grain increased up to 80 #N/A with splitting of the nitrogen applications being more effective than the single application. Terrazole with the 80 #N/A rate in a single application was as effective as the split nitrogen application.

Total corn dry matter production was increased up to the 80 #N/A rate of application (Table 2). Splitting of the nitrogen applications and use of nitrification inhibitors resulted in no influence in total corn dry matter production.

Nitrogen content and nitrogen removal of the corn stover showed increases up to the 160 #N/A rate (Table 3). Splitting the nitrogen applications and nitrification inhibitor treatments had no influence in percent nitrogen in stover. Split applications did show increases in nitrogen content in grain and nitrogen removal in grain at the rate of 80 #N/A. N-Serve and Terrazole showed increases in nitrogen content in the grain and N-Serve increased nitrogen removal at the 80 #N/A rate of application. The nitrification inhibitors did not show any increase in nitrogen content or nitrogen removal of the grain at the rate of 160 #N/A.

Table 1. Influence of Nitrogen Rate, Timing of Nitrogen Application, and Nitrification Inhibitors on Leaf Nitrogen Concentration, grain yield and Nitrogen Utilization of Corn.

Treatments			Leaf N	Corn Grain		
N Rate	No. of Appl.	Inhibitor		Yield	N	N Removal
#/A			%	bu/A	%	#/A
0	-	0	2.04	120.9	1.09	62.4
80	1	0	3.07	163.3	1.26	97.4
80	1	N-S	2.96	167.6	1.30	103.4
80	1	Terr.	2.99	171.8	1.41	115.1
80	4	0	3.29	178.3	1.36	114.6
160	1	0	3.20	163.7	1.35	104.2
160	1	N-S	3.19	179.5	1.38	116.8
160	1	Terr.	3.24	172.9	1.40	114.2
160	4	0	3.43	171.2	1.28	104.0
Signif.			**	**	**	**
BLSD(.05)			.29	19.2	.06	14.1
C.V.			6.9	8.1	3.7	9.9

Table 2. Influence of Nitrogen Rate, Timing of Nitrogen, Application and Nitrification Inhibitors on the Stover and Grain Components of Corn at Physiological Maturity.

Treatments			Corn Dry Matter		
N Rate	No. of Appl.	Inhibitor	Stover	Grain	Total
#/A				T/A	
0	-	0	2.53	2.40	4.93
80	1	0	3.27	3.45	6.72
80	1	N-S	3.13	3.64	6.77
80	1	Terr.	3.35	3.54	6.89
80	4	0	3.41	3.73	7.14
160	1	0	3.60	3.61	7.21
160	1	N-S	3.26	3.21	6.47
160	1	Terr.	3.49	3.76	7.25
160	4	0	3.54	3.63	7.17
Signif.			**	**	**
BLSD(.05)			.34	.33	.51
C.V.			7.3	7.0	5.6

Table 3. Influence of Nitrogen Rate, Timing of Nitrogen Application, and Nitrification Inhibitors in Nitrogen Utilization of Corn at Physiological Maturity.

Treatments			Corn Forage				
N Rate	No. of Appl.	Inhibitor	N Content		N Removal		
			Stover	Grain	Stover	Grain	Total
#/A			-------%-------		---------#/A---------		
0	-	0	.78	1.14	39.2	54.7	93.9
80	1	0	.87	1.27	56.5	87.3	143.8
80	1	N-S	1.13	1.46	71.4	105.6	177.0
80	1	Terr.	1.05	1.37	70.0	96.6	166.6
80	4	0	1.07	1.36	73.0	101.1	174.1
160	1	0	1.16	1.34	83.5	97.0	180.5
160	1	N-S	1.07	1.40	70.1	89.9	160.0
160	1	Terr.	1.11	1.41	77.2	106.2	183.4
160	4	0	1.23	1.36	85.3	99.6	184.9
Signif.			+	**	**	**	**
BLSD(.05)			.28	.10	18.3	11.5	23.1
C.V.			17.8	5.4	17.8	9.1	10.3

N Rate Studies of Dryland and Irrigated Wheat and Oats With and Without Legume Underseeding, Staples 1978

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

1978 was the fourth crop year of studies investigating the effect of N rates on oat and wheat yields under intensive irrigation. A dryland study evaluating N rates initiated in 1977 was continued in 1978.

The study evaluating the effect of red clover as an underseeding and as a plowdown crop prior to seeding of grain was continued.

Stout oats, Era wheat, and Lakeland red clover were the varieties used in the study. The experiment consists of a randomized complete block design with four replications and four N rates. Urea was the N source. N rates were 0, 40, 80, and 120 for oats and 0, 60, 120, and 180 for wheat.

N was applied to oats in two applications. One-half just prior to seeding and one-half immediately preceeding boot formation.

Wheat received one-third of the N prior to seeding, one-third at stooling, and one-third before urea was incorporated by harrowing prior to seeding and by irrigation following seeding. Desired seeding rate was 120 pounds for oats, 96 pounds for wheat, and 16 pounds per acre for red clover.

Plots were moldboard plowed on April 12, harrowed twice and packed prior to seeding. The crops were planted on April 14.

Oats were harvested July 21 and the wheat harvested on August 11.

Table 1. Wheat Grain Yield as Influenced by N Rates, Staples 1978 (Chemical weed control, intensive irrigation).

Lbs N/A	Bu/A	Test wt Lbs/Bu	% N in Grain	Lbs N Removed
0	13.6	57.8	2.64	21.4
60	35.4	56.6	2.51	53.2
120	37.5	54.6	2.85	63.8
180	35.6	53.3	3.18	67.9
Signif.	**			*
BLSD (.05)	3.3	N.S.	N.S.	6.9

Table 2. Wheat Grain Yield as Influenced by N Rates, Staples 1978 (Following plowdown of Red Clover, intensive irrigation, and chemical weed control).

Lbs N/A	Bu/A	Lbs/Bu	% N in Grain	Lbs N Removed
0	30.8	56.4	2.51	46.4
60	34.1	54.4	2.73	56.1
120	34.9	54.7	2.98	62.4
180	37.1	55.6	3.10	68.9
Signif.				
BLSD (.05)	N.S.	N.S.	N.S.	N.S.

Table 3. Wheat Grain Yield as Influenced by N Rates, Staples 1978 (Red Clover underseeding, intensive irrigation).

Lbs N/A	Bu/A	Lbs/Bu	% N in Grain	Lbs N Removed
0	25.8	55.9	2.60	40.4
60	24.0	54.1	3.01	43.2
120	24.1	53.0	3.28	47.3
180	22.3	53.0	3.28	43.5
Signif.	N.S.	N.S.	**	N.S.
BLSD (.05)			.29	

Table 4. Wheat Grain Yield as Influenced by N Rates, Staples 1978 (Dryland, chemical weed control).

Lbs N/A	Bu/A	Lbs/Bu	% N in Grain	Lbs N Removed
0	11.5	60.2	2.60	17.9
60	23.9	59.3	2.68	38.4
120	24.2	57.4	3.13	45.6
180	21.2	56.8	3.18	40.2
Signif.	**	**	**	**
BLSD (.05)	4.3	.6	.17	6.6
C.V.	13.8	1.0	3.9	12.3

Table 5. Oat Grain Yields as Influenced by N Rates, Staples 1978 (Chemical weed control, intensive irrigation).

Lbs N/A	Bu/A	Lbs/Bu	% N in Grain	Lbs N Removed
0	38.4	33.8	2.06	25.4
40	77.0	30.7	2.07	51.0
80	100.0	31.2	2.43	77.8
120	101.8	29.4	2.34	76.3
Signif.	**	*	**	**
BLSD (.05)	6.2	2.8	.16	3.7
C.V.	5.3	5.4	5.9	4.4

Table 6. Oat Grain Yields as Influenced by N Rates, Staples 1978 (Red Clover underseeding, intensive irrigation).

Lbs N/A	Bu/A	Lbs/Bu	% N in Grain	Lbs N Removed
0	84.5	30.5	2.04	55.2
40	88.2	29.4	2.24	63.1
80	86.5	29.1	2.36	65.3
120	80.5	28.2	2.52	65.0
Signif.	N.S.	**	**	**
BLSD (.05)		1.1	.22	5.5
C.V.	4.3	2.1	5.9	5.4

Table 7. Oat Grain Yields as Influenced by N Rates, Staples 1978 (Chemical weed control, dryland).

Lbs N/A	Bu/A	Lbs/Bu	% N in Grain	Lbs N Removed
0	31.9	34.0	2.60	19.3
40	54.0	33.5	2.68	39.5
80	50.4	33.0	3.13	40.0
120	61.2	32.3	3.18	48.0
Signif.	**	N.S.	**	**
BLSD (.05)	8.9		.16	6.6
C.V.	11.9	2.4	4.8	11.9

Summary: Wheat yields and test weight were reduced by disease, primarily scab. Oat yields were to a much lesser extent but appeared to lower test weight, particularly with the irrigated oats.

Table 8. Wheat Grain Yields, Bu/A, Staples Station, 1975-1978.

N, Lbs/A	Irrigated: Chemical Weed Control				Irrigated: Red Clover Underseeding				Irrigated: Plow Down of Red Clover				Dryland			
	0	60	120	180	0	60	120	180	0	60	120	180	0	60	120	180
1975 1/	7	18	21	24	5	13	16	17								
1976	24	53	66	68	53	58	55	57	59	70	69	67				
1977	27	47	65	69	51	50	52	41	53	58	58	59	9	17	22	20
1978	14	35	38	36	26	24	24	22	31	34	35	37	12	24	24	21

1/ N rates 0, 40, 60, and 120 Lbs/A in 1975 only.
Late spring, excessive high temperatures May and June

Table 9. Oat Grain Yields, Bu/A, Staples Station, 1975-1978.

N, Lbs/A	Irrigated: Chemical Weed Control				Irrigated: Red Clover Underseeding				Dryland			
	0	40	80	120	0	40	80	120	0	40	80	120
1975	24	36	41	35	24	45	52	41				
1976	54	84	101	111	86	88	90	93				
1977	45	90	106	114	84	101	110	101	32	63	60	62
1978	38	77	100	102	84	88	86	80	32	54	50	61

Table 10. Nutrient Removal in Dryland Oat Grain and Straw, Staples Station, 1977.

Lbs N/A Applied	Lbs/A Straw	N	P_2O_5	K_2O	Bu/A Grain	N	P_2O_5	K_2O	Total nutrients removed in grain and straw, Lbs/A N	P_2O_5	K_2O
0	1037	3	12.4	26.8	32	22	18.2	6.9	25	30.6	33.7
40	1981	6	9.8	51.7	63	48	36.2	13.8	54	46.0	65.5
80	2114	11	5.6	55.5	60	50	34.3	17.9	61	39.9	73.4
120	2032	12	5.3	55.1	62	52	34.5	18.7	64	39.8	73.8
Signif.	*	**	NS	*	**	**	**	**			
C.V.	25.6	33	65.1	28.5	7.6	21.3	7.0	11.6			

Table 11. Nutrient Removal in Dryland Wheat Grain and Straw, Staples Station, 1977.

Lbs N/A Applied	Lbs/A Straw	N	P_2O_5	K_2O	Bu/A Grain	N	P_2O_5	K_2O	Total nutrients removed in grain and straw, Lbs/A N	P_2O_5	K_2O
0	400	2.2	1.5	8.0	9.4	14	6.1	3.3	16.2	7.6	11.3
60	1100	7.5	3.9	26.6	16.9	28	10.9	6.1	35.5	14.8	44.0
120	1100	10.4	3.4	31.2	21.6	40	14.1	7.8	50.4	17.5	39.0
180	1420	14.3	3.6	35.6	19.6	38	13.0	7.3	52.3	16.6	42.9
Signif.		**	*		**	**		**			
C.V.		33.0	24.1		13.8	15.4		14.0			

Table 12. Nutrient Removal in Irrigated Oat Grain and Straw, Staples Station 1977.

Lbs N/A Applied	Lbs/A Straw	N	P_2O_5	K_2O	Bu/A Grain	N	P_2O_5	K_2O	Total nutrients removed in grain and straw, Lbs/A N	P_2O_5	K_2O
0	1242	7.2	8.0	31.4	45	35	13.0	6.9	42	21.0	38.3
40	2480	12.1	7.8	71.6	90	58	24.2	13.8	70	32.0	85.4
80	3097	22.8	6.9	74.8	106	97	29.7	17.9	120	36.6	92.7
120	3400	26.1	7.13	115.4	114	112	33.1	18.7	138	40.2	134.1
Signif.	**	**	N.S.	**		**	**	**			
C.V.	4.1	23.6	23.6	16.9		10.7	7.0	11.6			

Table 13. Nutrient Removal in Irrigated Wheat Grain and Oats, Staples Station 1977.

Lbs N/A Applied	Lbs/A Straw	N	P_2O_5	K_2O	Bu/A Grain	N	P_2O_5	K_2O	Total nutrients removed in grain and straw, Lbs/A N	P_2O_5	K_2O
0	1726	7.2	7.4	30.1	29	35	12.4	8.7	42.2	19.8	38.8
60	3387	12.1	8.1	75.6	47	58	21.6	14.1	70.1	29.7	89.7
120	4831	22.8	7.3	153.4	65	97	25.8	18.1	119.8	33.1	171.5
180	4079	26.1	7.8	130.2	69	112	31.7	20.7	138.1	39.5	150.9
Signif.	**	**	N.S.	**	**	**	**	**			
C.V.	17.8	23.6	26.2	18.5	10.3	10.7	24.4	13.4			

Water Quality Studies

H. Meredith, M. Wiens, and R. Munter

Water quality studies were continued in 1978 to gain a greater insight as to dissolved minerals in irrigation water.

Experimental plots on the Staples Station were intensively sampled to determine the effect of dissolved minerals in the irrigation water on soil pH.

Table 1. Soil pH of Blocks 1 and 2 Cropped to Wheat and Oats 1975-1978, Staples Station.

Treatment	1975 1/	1976 2/	1977 2/	1978 2/
1	5.9	6.3	6.7	6.7
2	5.9	6.2	6.5	6.5
3	5.9	6.1	6.4	6.3
4	5.8	6.0	6.3	6.2

1/ April sampling
2/ August sampling

Treatments:
1 - no nitrogen
2 - 50 lbs N/A/yr
3 - 100 lbs N/A/yr
4 - 150 lbs N/A/yr

Table 2. Soil pH of the Soil Profile under Blocks 1, 2, 2A, and 3A. Staples Station (Sampled in August 1975).

Depth, In.	1	2	2A	3A
3-6	5.5	5.8	5.7	5.8
6-9	5.4	5.7	5.7	6.0
9-12	5.7	5.7	5.7	6.2
12-18	5.5	5.4	5.6	6.5
18-24	5.7	5.5	5.7	6.4
24-36	5.8	5.7	5.9	6.3
36-48	6.0	7.2	7.6	6.4

Table 3. Irrigation Water Application 1975-1978 and Total Calcium Carbonate Equivalent.

Year	Inches	Lbs $CaCO_3$ eq/A/yr
1975	13.5	470
1976	24.1	796
1977	15.8	706
1978	13.3	617
Total	66.7	2589

Table 4. Calcium Carbonate Equivalent of Dissolved Minerals in Irrigation Water, Staples Station Expressed as mg $CaCO_3$ eq/l (Center Well).

1975	1976	1977	1978
164	175	238	236
148	136	238	222
132	172	200	178
155	113	224	173
182	149	228	264
157	133	174	194
141		140	176
		136	198
		180	
Average:			
154	146	198	205

Table 5. Analyses of Water Samples of the Three Pumping Wells at Staples Station Used for Plot Work, 1978.

		Lbs/A in water	
Sampling date	Well	S	$CaCO_3$ eq
5/2	North	.4	59
	South	.2	48
	South	.2	50
5/15	Center	.7	50
5/24	Center	.5	61
	North	.4	59
	South	.4	50
6/14	North	.6	58
7/7	Center	.6	56
	North	.6	62
7/10	South	.4	53
8/7	South	.3	50
Average		.44	55

Water samples were taken on 16 farms in the area in 1978 from sources as creeks, ponds, pits, and wells. The average $CaCO_3$ eq per acre with water was 43. The range was 8 to 80. Only 3 samples were below 20 and only 1 was above 60.

SOUTHERN EXPERIMENT STATION - WASECA
WEATHER DATA - 1978

Month	Period	Precipitation 1978	Precipitation Normal	Avg. Air Temp. 1978	Avg. Air Temp. Normal	Growing Degree Days 1978	Growing Degree Days Normal
		inches		°F			
January	1-31	1.14	.73	2.8	12.9		
February	1-28	.45	.96	7.0	17.5		
March	1-31	.84	1.94	24.8	28.5		
April	1-30	3.82	2.48	44.6	45.6		
May	1-10	.86		48.8		48.0	
	11-20	.59		60.6		123.0	
	21-31	3.95		67.8		193.5	
	Total	5.40	3.86	59.1	57.7	364.5	323
June	1-10	.24		61.2		127.0	
	11-20	2.71		68.8		184.0	
	21-30	0.43		69.6		196.5	
	Total	3.38	4.75	66.5	67.1	507.5	521
July	1-10	1.27		70.5		201.5	
	11-20	0.54		71.2		210.0	
	21-31	2.19		66.2		179.0	
	Total	4.00	4.02	69.3	71.4	590.5	637
August	1-10	1.07		65.4		161.0	
	11-20	1.00		70.8		205.5	
	21-31	0.72		69.6		214.0	
	Total	2.79	3.60	68.6	69.7	580.5	583
September	1-30	3.97	3.45	65.8	60.3	489.0	310
October	1-31	.59	1.89	47.0	50.3	40.0	44
November	1-30	2.95	1.25	29.8	32.9		
December	1-31	1.55	1.02	10.7	19.0		
Year	Jan-Dec	30.88	29.95	41.4	44.4	2572.0	2418
Growing Season	May-Sept	19.54	19.68	65.9	65.3	2532.0	2374

Notes:

1) Highest temp. on September 8 - 97°

2) Highest 24-hour precipitation on September 13 - 2.60"

3) Frost on October 8

4) Maximum air temps ranged between 86 and 97° from September 3-12

POSTEMERGENCE APPLICATION OF UAN (28% N) TO CORN

Waseca, 1978

G. W. Randall

Urea-ammonium nitrate (UAN) solutions are rapidly gaining acceptability in Minnesota as a source of nitrogen fertilizer. One of the common uses of UAN is to combine herbicides with the N solution and to apply both in one application, commonly called "weed and feed". Another possible usage for UAN is a late postemergence treatment in areas where N has been lost by denitrification or leaching. Sometimes this late treatment is placed over the top of corn or banded as a substitute for side-dressing anhydrous ammonia. The purpose of this study was to increase the efficiency of N fertilizer applied as UAN to corn by determining the:

1) maximum rate of UAN applied postemergence to corn without significant plant damage and/or yield loss.

2) optimum stage of corn growth or method of application for greatest N efficiency.

3) possible synergistic effect of UAN and atrazine on corn production.

EXPERIMENTAL PROCEDURES

A randomized complete-block experiment with 20 treatments (Table 1) and five replications was continued again in 1978 on a Webster clay loam at the Southern Experiment Station. Broadcast P and K (0+80+120 N+P_2O_5+K_2O/A) was applied to corn stalks and plowed down in October 1977. Supplemental N as ammonium nitrate was added to each plot to bring the total N amount to 150 lb N/A (except trt 3 which received 200 lb N/A). The ammonium nitrate was broadcast and disked in before planting.

Corn (Pioneer 3709) was planted in 30-inch rows at 26,100 ppa on May 16. Starter fertilizer (140 lb/A of 0-23-30) and insecticide (1 lb Furadan/A) were used. Weeds were chemically controlled with Lasso plus Bladex (3 + 2½ lb/A).

UAN was applied over the top of the corn with a calibrated bicycle sprayer at the 4-leaf (June 7) and 8-leaf (June 22) stages. Weather conditions were cloudy and moderately warm (73°F) on the 7th and partly cloudy and warm (77°F) on the 22nd. A light shower (0.07") fell within 24 hours after the 8-leaf stage treatments were applied. Atrazine was mixed with the UAN and applied at the rate of 2 lb/A at the 4-leaf stage (trts 18, 19 & 20). At the 12-leaf stage premeasured amounts of UAN were sidedress-applied by hand (July 10). No cultivation followed the sidedress application.

Early plant growth as affected by the application at the 4- and 8-leaf stages was determined on 10 plants from the border rows of each plot on June 22 and July 11. All other data were obtained from the center two rows of each four-row plot.

Results

Topdress applications to emerged corn at the 4-leaf stage did affect the vigor and growth about the same as in 1977. However, the severe visual symptoms (necrosis) did not occur as rapidly. The cloudy conditions at application perhaps accounted for the delay of up to 48 hours. The inclusion of atrazine in the UAN increased the leaf burn approximately equal to an additional 30 lb N increment as UAN, i.e., 60 lb N with atrazine was similar to 90 lb N without atrazine. The damage due to atrazine was slightly less than in 1977.

Early plant growth measured 15 days after application at the 4-leaf stage showed significant stunting with all UAN rates above 30 lb N/A (Table 1). Plant weights were reduced 12, 25, 31, 45 and 55% by the 30, 60, 90, 120 and 150-lb rates, respectively. Adding two pounds atrazine/A to the 60, 90 and 120-lb N rates reduced weights from the 150-lb soil treatment by 37, 46 and 55%, respectively.

The early stunting was less apparent 5 weeks after application. Plant weights from the 30, 60 and 90-lb N rates as UAN were not different from the 150-lb N soil-applied treatment (Table 1). However, the 120 and 150-lb rates without atrazine and the 90 and 120-lb rates with atrazine were still significantly smaller.

At the 8-leaf stage, topdressed UAN resulted in only slightly more burning and necrosis than comparable rates applied at the 4-leaf stage. This was markedly different than in 1977 when applications of all rates of UAN at the 8-leaf stage resulted in significant weight reductions. In 1978, plant weights were changed by +17, +4, -14, -19 and -38% by the 30, 60, 90, 120 and 150-lb N rates, respectively (Table 1). Perhaps the rainfall of 0.07" within 24 hours of application in 1978 accounted for the difference between years.

The treatments receiving sidedress applications of UAN at the 12-leaf stage (1 day before weights were taken) had the largest plants, which indicates that the plants were not suffering from N deficiency before the late sidedressing.

Plant heights to the top of the tassel and to the base of the ear in late August were influenced by both the rate and stage of UAN application (Table 1). However, no rate X stage interaction was found in 1978 contrary to 1977.

Final population was not influenced at the 95% level.

Table 1. Effect of post-emergence application of UAN on growth, height and final population of corn at Waseca in 1978.

	Treatments			Plant Growth		Plant Height		Final
	N rate[1]		Growth[2]					
No.	UAN	AN	stage	6/22[3]	7/11[4]	Tassel	Ear	population
	-----lb N/A------		leaf	---g/plant----		---inches---		ppA x 10^{-3}
1	0	0	pre		45	93	40	23.6
2	0	150	"	6.7	52	99	44	23.9
3	0	200	"		54	100	45	23.3
4	30	120	4	5.9	52	97	42	23.3
5	30	120	8		61	99	44	23.7
6	60	90	4	5.0	47	99	44	23.1
7	60	90	8		54	97	42	22.9
8	60	90	12		63	100	45	24.3
9	90	60	4	4.6	47	99	44	24.5
10	90	60	8		45	97	41	23.5
11	90	60	12		51	98	43	24.2
12	120	30	4	3.7	42	98	42	23.5
13	120	30	8		42	96	41	24.2
14	120	30	12		57	98	44	24.8
15	150	0	4	3.0	38	98	41	24.3
16	150	0	8		32	95	38	22.2
17	150	0	12		50	97	44	22.9
18	60 + 2 At[5]	90	4	4.2	46	98	42	24.3
19	90 + 2 At	60	4	3.6	44	97	41	23.8
20	120 + 2 At	30	4	3.0	42	98	42	22.8
	Significance:			**	**	**	**	+
	BLSD (.05) :			1.1	8	3	2	
	CV (%) :			20.	13.4	2.2	3.7	5.1
Individual Factors								
	UAN Rate (lb N/A)							
	60				54.8	99	44	23.4
	90				47.4	98	43	24.1
	120				46.9	97	42	24.2
	150				40.5	96	41	23.1
	Significance:				**	+	**	+
	BLSD (.05) :				4.4		1	
	Growth Stage							
	4-leaf				43.5	98	43	23.8
	8-leaf				43.4	96	41	23.2
	12-leaf				55.3	98	44	24.0
	Significance:				**	**	**	+
	BLSD (.05) :				3.7	1	1	
	Rate X Stage IA				NS	NS	NS	NS

[1] Supplemental N as AN (ammonium nitrate) was added to each plot to total 150 lb N/A except trt. 3 which received 200 lb N.

[2] UAN applied at the 4- and 8-leaf stages was topdressed. UAN applied at the 12-leaf stage was sidedressed.

[3] 15 days after application at the 4-leaf stage.

[4] 34 days and 19 days after application at the 4- and 8-leaf stages, respectively.

[5] Atrazine was applied at 2 lb/A with UAN.

Nitrogen in the leaf opposite and below the ear at silking was influenced significantly by the N treatments (Table 2). All N treatments resulted in higher N concentrations than the check. No difference in N content existed between the 4 and 8-leaf stages of N application but both were significantly higher than when applied at the 12-leaf stage. This probably indicates insufficient time for uptake between N application and sampling (17 days).

Grain yields were influenced again in 1978 (Table 2). When comparing the 20 treatments only the 150-lb N rate as UAN and 120-lb N rate as UAN plus atrazine applied at the 4-leaf stage and the 120 and 150-lb N rates applied at the 8-leaf stage reduced yield significantly below the 150-lb N soil-applied treatment (no. 2). These reductions averaged -12, -9, -8 and -17%, respectively. Yields were reduced significantly (11.8 bu/A) by the 150-lb treatment when averaged across all three application dates. UAN applied at the 8-leaf stage reduced yields by 12.2 bu/A when averaged across all N rates. Applications at the 4 and 12-leaf stages when averaged across rates did not affect grain yield.

Grain moisture at harvest was highest for the check treatment and was generally decreased by the applications at the 8 and 12-leaf stages.

Grain N (protein) was increased significantly over the check by all N treatments except no. 11 (Table 2). Differences in grain N were not found among the N rates as UAN. Highest grain N was associated with the UAN applied at the 8-leaf stage, which was in direct contrast to the 1977 results.

Summary

UAN applied to the growing corn plant did result in some phytotoxicity but was not as severe as in 1977. Perhaps the application at the 4-leaf stage in 1978 as compared to 5-leaf in 1977 and the slight rain shower following the 8-leaf application in 1978 were the main reasons for less phytotoxicity. Applications at the 4-leaf stage resulted in greater phytotoxicity with increasing N rates; however, yields were only depressed with the 150-lb N rate as UAN and the 120-lb N rate of UAN plus atrazine. When applied at the 8-leaf stage the severity of leaf burn was again increased with increasing N rate. Yields were reduced by both the 120 and 150-lb N rates as UAN at this stage. Sidedressed UAN resulted in yields equal to the soil-applied treatment.

Table 2. Effect of post-emergence application of UAN on leaf N, corn grain yield, grain moisture and grain N at Waseca in 1978.

No.	N rate[1] UAN	N rate[1] AN	Growth[2] stage	Leaf N	Grain Yield	Grain Moisture	Grain N
	-----lb N/A------		leaf	%	bu/A	--------%--------	
1	0	0	pre	2.46	112.7	26.4	1.28
2	0	150	"	2.85	149.3	23.4	1.44
3	0	200	"	2.89	148.1	24.4	1.47
4	30	120	4	2.85	144.1	25.2	1.41
5	30	120	8	2.85	149.1	24.0	1.54
6	60	90	4	2.81	146.0	24.6	1.48
7	60	90	8	2.86	144.8	23.0	1.51
8	60	90	12	2.72	151.7	22.9	1.49
9	90	60	4	2.86	146.8	24.2	1.48
10	90	60	8	2.92	142.6	22.5	1.51
11	90	60	12	2.88	144.4	24.1	1.39
12	120	30	4	2.86	143.1	24.2	1.45
13	120	30	8	2.77	136.8	24.2	1.52
14	120	30	12	2.68	149.6	23.3	1.43
15	150	0	4	2.86	131.9	25.7	1.44
16	150	0	8	2.92	124.1	24.4	1.51
17	150	0	12	2.70	145.1	23.0	1.44
18	60 + 2 At[3]	90	4	2.91	145.2	23.7	1.51
19	90 + 2 At	60	4	2.82	144.5	25.2	1.46
20	120 + 2 At	30	4	2.86	136.3	24.7	1.49
	Significance[4] :			**	**	**	**
	BLSD (.05) :			.12	10.9	1.8	.13
	CV (%) :			3.6	6.2	5.4	5.7
Individual Factors							
	UAN Rate (lb N/A)						
	60			2.80	147.5	23.5	1.49
	90			2.88	144.6	23.6	1.46
	120			2.77	143.2	23.9	1.47
	150			2.83	133.7	24.4	1.46
	Significance:			*	**	NS	NS
	BLSD (.05) :			.08	6.0		
	Growth Stage						
	4-leaf			2.85	142.0	24.7	1.46
	8-leaf			2.87	137.1	23.5	1.51
	12-leaf			2.75	147.7	23.3	1.44
	Significance:			**	**	**	*
	BLSD (.05) :			.06	5.2	.8	.05
	Rate X Stage IA			NS	NS	NS	NS

[1] Supplemental N as AN (ammonium nitrate) was added to each plot to total 150 lb N/A except trt. 3 which received 200 lb N.

[2] UAN applied at the 4- and 8-leaf stages was topdressed. UAN applied at the 12-leaf stage was sidedressed.

[3] Atrazine was applied at 2 lb/A with UAN.

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

CORN FERTILIZATION WITH NITROGEN CONTAINING ACA

1976-78, THREE-YEAR SUMMARY

Waseca, MN

G. W. Randall

Additives to nitrogen (N) fertilizers have gained popularity within the last few years. One of these additives, ACA, an acronym for agricultural crop additive, is produced and sold by Amoco Oil Company for inclusion with anhydrous ammonia for corn. The purpose of this study was to evaluate ACA applied with N on corn production in south-central Minnesota.

Experimental Procedures

Field studies to evaluate the inclusion of ACA in anhydrous ammonia were conducted on a Webster clay loam at the Southern Experiment Station during 1976, 1977 and 1978. Corn was grown each year with the preceding crop being soybeans in the first two years and corn in the last year. Supplemental P and K was broadcast applied each year.

Three rates of N (0, 75 and 150 lb/A) as anhydrous ammonia were used each year in a randomized, complete-block design with six replications. In 1976, 100 lb N/A was substituted for the 75 lb rate. Both the 75 and 150-lb rates were applied with and without ACA. The ammonia was applied with a standard tool-bar applicator with 4 shanks (1976) or 6 shanks (1977 and 1978) spaced 30" apart. Application consisted of starting the injection and ammonia release approximately 10 to 15 feet outside of the plot and then proceeding immediately at 3 MPH into and through the 55' long plots. All N was applied approximately 7" deep.

Tissue samples were taken of the leaves at silking, of the silage at physiological maturity and of the grain at harvest. All samples were analyzed for total N. Silage yields were taken from 20 feet of row (10' in 1976) while grain yields were obtained by combine harvesting the center two rows of each plot with a modified JD3300 combine.

Results

Nitrogen levels within the leaves, silage and grain were increased significantly by the N treatments in two of the three years (Table 1). In 1977, leaf N, silage N and grain N were all improved by the addition of N. In 1978, linear increases in leaf and grain N to N rate were found while silage N was increased with the first N increment. The inclusion of ACA did not influence the N concentrations of any of the plant tissue parts in any year.

Table 1. Influence of ACA on the N concentration in the corn leaf, silage and grain at Waseca for the three years of the study.

Treatment		Nitrogen								
		1976			1977			1978		
N rate	ACA	leaf[1]	silage	grain	leaf	silage	grain	leaf	silage	grain
lb N/A		%								
0	-	1.87	1.03	1.58	2.37	.84	1.42	2.48	1.10	1.39
75(100)[2]	-	1.82	1.09	1.62	2.93	.96	1.55	2.80	1.24	1.52
75(100)	+	2.08	1.08	1.62	2.99	.94	1.55	2.85	1.35	1.58
150	-	1.97	1.12	1.66	3.04	.97	1.57	3.00	1.26	1.67
150	+	1.95	1.08	1.58	3.00	1.04	1.57	3.03	1.25	1.60
Significance:		NS[3]	NS	NS	**	*	*	**	*	**
BLSD (.05) :					.25	.11	.10	.17	.15	.11
CV (%) :		13.1	5.6	3.5	8.0	9.0	5.1	5.2	9.2	6.1

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

[2] 100 lb N rate used in 1976.

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

Silage yields were increased significantly by the addition of N and the inclusion of ACA in two of the three years (Table 2). ACA improved the silage yields by 0.71 and 0.62 T DM/A in 1976 and 1977, respectively, but did not improve silage yields in 1978. No explanation can be given for the high check plot yield found in 1976.

Table 2. Influence of ACA on silage and grain yield at Waseca for the three years of the study.

Treatment		Yield					
		1976		1977		1978	
N rate	ACA	silage	grain	silage	grain	silage	grain
lb N/A		T DM/A	bu/A	T DM/A	bu/A	T D M/A	bu/A
0	-	8.30	118.8	6.64	118.2	7.15	126.4
75(100)[1]	-	8.05	138.1	7.40	145.0	8.35	159.9
75(100)	+	8.43	136.6	8.00	151.3	8.12	155.9
150	-	7.86	133.1	7.76	149.3	8.41	163.8
150	+	8.92	134.2	8.40	150.2	8.46	164.1
Significance:		+	**	**	**	*	**
BLSD (.05) :			6.8	.89	15.7	.92	9.0
CV (%) :		8.1	4.5	9.4	9.2	8.6	5.3

[1] 100 lb N rate used in 1976.

Grain yields were improved significantly each year by the addition of the first N increment (Table 2). Neither additional N nor the addition of ACA influenced grain yields.

Summary

Nitrogen content of the plant tissue (leaf, silage and grain) and grain yield were generally increased by the addition of N but not by the inclusion of ACA. Silage yields, however, were improved in two of three years by ACA.

INFLUENCE OF EXTEND APPLIED WITH UAN (28% N) ON CORN PRODUCTION

Waseca, 1978

G. W. Randall

Extend, a nitrogen (N) regulator marketed by Kalo Laboratories, Inc., has been purported to provide more efficient use of liquid N fertilizers by encapsulating a portion of the N molecules. The Extend is then said to impart slow release properties to this N, thereby, protecting against N losses and also holding the N within the root zone for a longer period of time.

The purpose of this study was to determine the effect of Extend on

a) the release of NH_4-N from UAN and the movement of N in the surface rooting zone

b) the uptake of N by corn

c) the grain and silage yield of corn.

Experimental Procedures

Ten treatments consisting of five N rates (0, 50, 100, 150 and 200 lb N/A) as UAN (28% N) were applied with and without Extend in a 5 x 2 completely randomized factorial design with six replications. Water was substituted for UAN in the 0 lb N treatment plus Extend. All treatments were applied preemergence to the soil surface on May 23 with a pre-calibrated bicycle sprayer. No incorporation was attempted. Flood jet nozzles (TK 2.5) spaced 30" apart were used.

Primary tillage of this Webster clay loam soil (Typic Haplaquoll) consisted of fall moldboard plowing the corn residue from the previous crop. Prior to planting the site was field cultivated twice. On May 17, Pioneer 3780 corn was planted in 30" rows at a population of 26,100 ppA. Starter fertilizer consisting of 140 lb 0-23-30/A ($N+P_2O_5+K_2O$) and an insecticide (Furadan at 1 lb a.i./A) were applied with the planter. Adequate amounts of broadcast P and K were applied the previous fall. Weeds were controlled by Lasso + Bladex (3 lb + 2½ lb/A) applied preemergence immediately after planting.

Soil samples consisting of 5 cores per composite were taken from all treatments on June 7 (15 days after treatment application) and from the 0, 100 and 200 lb N rates on June 22 (30 days after application) and on July 25 (63 days after application). June 7 samples were taken from the 0-8" profile while the subsequent samples were obtained from the 0-8" and 8-24" profiles. All soil samples were frozen immediately and were kept frozen until analysis. Ammonium and NO_3-N concentrations were determined by the Research Analytical Lab of the University.

Leaf samples (opposite and below the ear) from 10 random plants were taken on July 27 at the early silking stage. Silage yields were taken by harvesting 10 feet of row at physiological maturity on September 16. Subsamples were obtained for chemical and dry matter analyses by passing the stalks thru a silage chopper. All tissue samples were oven-dried at 150°F. Grain yields were taken on October 13 by combine harvesting the center two rows (each 55' long) with a modified JD 3300 plot combine. Grain samples for moisture and N analyses were obtained concurrently. All tissue analyses were conducted by the Research Analytical Laboratory.

Results

Soil NH_4-N and NO_3-N concentrations in the top 0-8" 15 days after treatment application were increased by the N treatments but were not influenced by the inclusion of Extend with the UAN (Table 1). Soil NO_3-N was increased linearly about 4-fold with N rate whereas NH_4-N was increased only slightly. A N rate x Extend interaction was not found.

Table 1. Influence of N rate and Extend on soil NH_4-N and NO_3-N in the 0-8" profile 15 days after treatment application.

Treatment			
N rate	Extend	NH_4-N	NO_3-N
lb N/A		ppm	ppm
0	-	6.8	10.3
0	+	7.0	10.7
50	-	7.6	18.1
50	+	6.7	17.3
100	-	8.1	24.4
100	+	8.1	25.4
150	-	8.4	29.4
150	+	9.5	35.3
200	-	9.8	43.3
200	+	8.1	39.8
Averages			
0 lb N/A		6.9	10.5
50 " "		7.1	17.7
100 " "		8.1	24.9
150 " "		8.9	32.3
200 " "		8.9	41.6
No Extend		8.1	25.1
Extend		7.9	25.7
Significance:			
N rate		**	**
Extend		NS	NS
N x E IA		NS	NS
N BLSD (.05):		1.2	5.1
CV (%) :		16.7	24.9

A linear increase in soil NO_3-N still remained 30 days after treatment application in both the 0-8" and 8-24" profiles (Table 2). Soil NH_4-N was not influenced by the N rates. Extend had no effect on either soil NH_4-N or NO_3-N. Interactions between the N rate and Extend were not shown.

Table 2. Influence of N rate and Extend on soil NH_4-N and NO_3-N in the 0-8" and 8-24" profile 30 days after treatment application.

Treatment		NH_4-N		NO_3-N	
N rate	Extend	0-8"	8-24"	0-8"	8-24"
lb N/A		ppm			
0	-	5.3	3.8	9.9	9.5
0	+	6.1	4.4	11.5	8.2
100	-	7.1	4.8	24.1	12.5
100	+	6.6	3.9	25.4	11.9
200	-	6.1	6.0	34.5	16.3
200	+	6.5	5.0	34.9	14.9
Averages					
0 lb N/A		5.7	4.1	10.7	8.9
100 " "		6.9	4.4	24.7	12.2
200 " "		6.3	5.5	34.7	15.6
No Extend		6.1	4.9	22.8	12.8
Extend		6.4	4.4	23.9	11.7
Significance:					
N rate		NS	NS	**	**
Extend		NS	NS	NS	NS
N x E IA		NS	NS	NS	NS
N BLSD (.05):				6.2	3.9
CV (%) :		25.7	34.5	31.9	34.8

A slight increase in soil NH_4- and NO_3-N due to N rate was shown 63 days after application (Table 3). However, nitrate-N at this time (silking stage) was quite low in both areas of the profile. The addition of Extend to the UAN fertilizer did not affect soil NH_4- or NO_3-N concentrations. Again, interactions were not found.

Table 3. Influence of N rate and Extend on soil NH_4-N and NO_3-N in the 0-8" and 8-24" profile 63 days after treatment application.

Treatment		NH_4-N		NO_3-N	
N rate	Extend	0-8"	8-24"	0-8"	8-24"
lb N/A		ppm			
0	-	6.2	4.9	4.3	2.1
0	+	6.6	5.4	4.2	2.1
100	-	9.2	5.2	3.5	2.7
100	+	8.4	5.2	4.0	2.4
200	-	8.7	6.6	8.1	5.3
200	+	8.8	5.1	8.0	5.0
Averages					
0 lb N/A		6.4	5.2	4.3	2.1
100 " "		8.8	5.2	3.7	2.5
200 " "		8.7	5.9	8.1	5.1
No Extend		8.0	5.6	5.3	3.3
Extend		7.9	5.2	5.4	3.1
Significance:					
N rate		*	NS	**	**
Extend		NS	NS	NS	NS
N x E IA		NS	NS	NS	NS
N BLSD (.05):		2.0		1.4	0.5
CV (%) :		26.4	24.2	29.8	19.5

Leaf, silage and grain N concentrations were influenced by the treatments (Table 4). Although leaf N in the check treatment was not extremely low, leaf N concentrations were increased significantly by the increasing N rates. Extend had no influence on leaf N.

Nitrogen concentrations in the silage were extremely variable (CV = 20.9). Thus, even though a significant interaction between N rate and Extend was found it cannot be interpreted. N rate and Extend did not affect silage N. N uptake in the silage was increased significantly by N rates up thru 100 lb/A; largely due to increased silage yields (Table 5).

Table 4. Influence of N rate and Extend on the leaf, silage and grain N levels and N uptake and removal amounts at Waseca.

Treatment		Leaf	Silage N		Grain N	
N rate	Extend	N	Conc.	Uptake	Conc.	Uptake
lb N/A		%	%	lb/A	%	lb/A
0	-	2.14	1.13	140	1.37	74
0	+	2.15	0.86	112	1.38	77
50	-	2.36	0.91	138	1.38	92
50	+	2.38	1.15	170	1.47	94
100	-	2.49	0.86	151	1.45	101
100	+	2.43	1.12	171	1.55	109
150	-	2.55	1.23	196	1.54	108
150	+	2.50	0.92	142	1.66	115
200	-	2.64	1.19	195	1.66	117
200	+	2.66	1.08	177	1.66	116
Averages						
0 lb N/A		2.14	0.99	126	1.38	75
50 " "		2.37	1.03	154	1.43	93
100 " "		2.46	0.99	161	1.50	105
150 " "		2.52	1.07	169	1.60	111
200 " "		2.65	1.13	186	1.66	116
No Extend		2.44	1.06	164	1.48	98
Extend		2.42	1.02	154	1.54	102
Significance:						
N rate		**	NS	**	**	**
Extend		NS	NS	NS	*	+
N x E IA		NS	**	*	NS	NS
N BLSD (.05):		.10		30	.07	6
N x E IA BLSD(.05):			.18	46		
CV (%):		5.6	20.9	22.5	6.0	7.8

Grain N (protein) concentrations were increased significantly by N rate (P = .01 level) and Extend (P = .05 level). Grain N was increased significantly with N rates up thru 150 lb/A. The inclusion of Extend resulted in an average increase of 0.06% N or 0.4% protein. This influence was greatest at the 50, 100 and 150 lb-N rates. Nitrogen removed in the grain (protein) was also increased by N rate (P = .01 level) and Extend (P = .10 level). This removal was influenced by both grain yield and grain N level.

Plant population at harvest was not influenced by any of the treatments (Table 5).

Table 5. Influence of N rate and Extend on corn production on a Webster clay loam at Waseca in 1978.

Treatment		Final plant	Silage	Grain	
N rate	Extend	population	yield	Moisture	Yield
lb N/A		ppA x 10^{-3}	T DM/A	%	bu/A
0	-	22.8	6.22	24.4	112.8
0	+	21.9	6.56	23.1	117.0
50	-	23.2	7.70	21.8	140.2
50	+	23.0	7.32	21.8	134.8
100	-	22.8	8.66	20.8	146.3
100	+	24.1	7.65	21.4	149.0
150	-	23.8	7.96	20.4	147.4
150	+	22.3	7.86	20.4	146.4
200	-	22.8	8.24	20.2	148.7
200	+	23.0	8.23	19.8	147.5
Averages					
0 lb N/A		22.3	6.39	23.8	114.9
50 " "		23.1	7.51	21.8	137.5
100 " "		23.4	8.15	21.1	147.6
150 " "		23.1	7.91	20.4	147.0
200 " "		22.9	8.23	20.0	148.1
No Extend		23.1	7.75	21.5	139.1
Extend		22.9	7.52	21.3	139.0
Significance:					
N rate		NS	**	**	**
Extend		NS	NS	NS	NS
N x E IA		NS	NS	NS	NS
N BLSD (.05):			0.54	1.0	5.2
CV (%) :		6.5	9.2	6.0	5.1

Silage and grain yield and grain moisture were affected significantly by the N rates but not by Extend (Table 5). Although the silage yields were somewhat variable, both silage and grain yields were increased by N rates thru 100 lb/A. Nitrogen rates of 150 and 200 lb/A resulted in the lowest grain moisture at harvest (an indication of maturity). No interactions between N rate and Extend were found.

Summary

The inclusion of Extend in UAN (28% N) applied preemergence to a Webster clay loam did not result in the regulation (slow release) of ammonium N as evidenced by soil NH_4- and NO_3-N analyses. Silage and grain yields were not influenced by Extend. Leaf and silage N concentrations also were not affected by Extend. However, Extend did result in slightly higher grain N (protein) values. Based on this one year's research, Extend cannot be recommended as an additive to UAN applied preemergence to a Webster clay loam soil.

SYMBEX
1978

Waseca, Minnesota

G. W. Randall and D. K. Langer

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

Experimental Procedures

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

Symbex soil inoculant was applied May 1 and corn (Pioneer 3780) was planted at a rate of 26,100 ppA in 30 inch rows on May 15 with the Symbex plots receiving Sym-Coated seed. Chemical weed control consisted of 3 qts Lasso/A and 2½ qts Bladex/A applied preemerge. The nitrogen for the Symbex + 30 lb N/A treatment was sidedressed as feed grade urea and the 175 lb N/A treatment was sidedressed as fertilizer grade urea. Both sidedressed treatments were cultivated in after application on June 17. Sym-Spray plus 9 lb N/A as feed-grade urea was applied to the Symbex treatments on July 24 just prior to tasseling.

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

Results

The nutrients N, P, Mg, Mn, Zn, and Cu were all increased significantly in the corn leaf with the addition of 175 lb N/A (Table 1). Symbex apparently had little effect on corn leaf nutrient concentration. The trend shows that the Symbex + 30 lb N/A did increase some of the nutrient concentrations probably due to the added nitrogen; however, none of these increases were statistically significant.

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

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

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

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

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

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

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

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

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

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

Summary

Symbex did not have any effect on silage or grain yields and did not influence grain protein or nutrient concentrations in the leaf. The addition of nitrogen appeared to increase yields, protein and some nutrient concentrations in the leaf.

Use of Terrazole as a Nitrification Inhibitor in Fall vs. Spring Nitrogen Application Program For Corn Production in Southern Minnesota

G.L. Malzer and G.W. Randall

The use of nitrification inhibitors on the heavy wet soils of southern Minnesota has gained considerable attention over the last several years. There are several chemicals known which are capable of delaying the rate of nitrification but there is only one currently on the market (N-Serve-Dow Chemical, U.S.A.). An experimental chemical Terrazole (Olin Corporation) has shown nitrificide characteristics and was evaluated under field conditions at the Southern Experiment Station at Waseca, MN in 1978. The objectives of the trial were to evaluate not only rate of nitrogen application but also timing of application and comparisons of different nitrogen forms with and without the use of Terrazole.

Experimental Procedures

Nineteen treatments including a control, two rates of nitrogen (75 and 150 #N/A) and a fall vs. spring application were combined with Terrazole at two rates of application above the control (0.5 and 1.0 #ai/A). Urea fertilizer was utilized in both fall and spring comparisons, while anhydrous ammonia was utilized only in the spring application programs. The nitrogen applied as urea was broadcast and immediately incorporated after application with Terrazole treatments consisting of coatings on the urea fertilizer. The anhydrous ammonia treatments were injected at 30" knife spacings, and Terrazole applications were made simultaneously with the use of a dual-tube anhydrous shank and a separate pressurized system for application of the Terrazole. All treatments were replicated four times and arranged in a randomized complete block design. Corn (Pioneer 3780) was planted into the experimental area in 30" rows at a seeding rate of approximately 24,000 seeds/A.

Leaf samples were collected from opposite and below the ear at silking, dried, and Kjeldahl nitrogen determined. Dry matter production was determined by harvesting 15' of row from each plot at physiological maturity separating the sample into ears and stover and subsamples collected for moisture determination and Kjeldahl nitrogen analysis for calculation of nitrogen removal. Corn grain yields were collected by machine harvesting the center two rows from each plot and collecting subsamples for moisture determination and Kjeldahl nitrogen. Soil samples were also collected from the surface 0-1 ft. depth from all treatments receiving 150 #N/A at approximately two week intervals after the application of the nitrogen and samples analyzed for ammonium and nitrate nitrogen. Soil samples were obtained to a depth of five feet at approximately month intervals from the same plots to monitor nitrate movement and accumulation in the soil profile.

General Results

Grain yields were above average in 1978, but yield responses to the application of nitrogen fertilizer were not obtained above the 75 #N/A rate of application. The higher rate of application (150 #N/A) significantly increased the nitrogen content in the leaf at silking as well as grain N and total N removal with the grain, but this did not reflect a yield increase.

The treatments had no influence on total dry matter production (stover, grain, or total), but did have a significant influence on other measured parameters dealing with nitrogen utilization and nitrogen availability.

In general, measured parameters such as leaf N at silking, grain N, and nitrogen removal with the grain indicated that nitrogen utilization was increased at the highest rate of application. With the spring application of fertilizer nitrogen there was very little difference between urea and anhydrous ammonia. Comparisons of fall vs. spring applications of urea reflected no significant differences between times of fertilizer application. Terrazole when applied with 150 #N/A appeared to have no significant effect on nitrogen availability. At the 75 #N/A rate of application, the highest rate of Terrazole application (1.0 #ai/A) with spring application appeared to reduce nitrogen availability. The same rate of Terrazole application in the fall showed trends of improved nitrogen availability. The interactions of nitrogen rate, timing of nitrogen application, and the interaction with nitrification inhibitor rates deserve further investigation.

Table 1. Influence of Nitrogen Form, Rate of Application, Time of Application, and Use of Terrazole as a Nitrification Inhibitor on Various Yield Components and Nitrogen Utilization Characteristics of Corn.

Treatments				Leaf	Yield Grain			Corn Forage Production							
								Stover			Grain			Total	
Date of Appl.	N Form	Terrazole Rate	N Rate	N	Yield	N	N Removal	Yield	N	N Removal	Yield	N	N Removal	Yield	N Removal
		#ai/A	#/A	%	bu/A	%	#/A	T/A	%	#/A	T/A	%	#/A	T/A	#/A
Control		0	0	2.00	124.6	1.12	65.9	4.49	.37	33.5	3.21	.97	62.8	7.69	96.2
Oct. 14	Urea	0	75	2.74	157.6	1.38	103.3	4.27	.42	36.0	3.76	1.25	94.3	8.03	130.3
Oct. 14	"	0	150	2.74	166.2	1.64	129.3	4.48	.53	47.2	3.96	1.49	117.6	8.44	164.8
Oct. 14	"	½	75	2.58	157.9	1.38	103.3	4.80	.48	45.7	4.08	1.29	105.3	8.87	151.0
Oct. 14	"	½	150	2.96	160.6	1.58	120.1	4.85	.53	51.0	3.97	1.57	124.5	8.81	175.5
Oct. 14	"	1	75	2.89	171.0	1.42	115.1	4.28	.46	39.6	3.80	1.33	101.1	8.08	140.7
Oct. 14	"	1	150	2.86	167.4	1.59	125.9	4.99	.51	51.1	4.16	1.48	123.2	9.14	174.3
May 3	A.A.	0	75	2.76	162.4	1.40	107.7	4.52	.48	43.2	4.12	1.40	115.7	8.65	158.9
May 3	"	0	150	3.01	161.9	1.72	131.8	4.94	.62	61.6	4.25	1.77	150.4	9.19	212.0
May 3	"	½	75	2.91	163.2	1.44	111.6	4.81	.60	58.0	4.15	1.54	127.8	8.97	185.8
May 3	"	½	150	2.97	163.2	1.80	138.7	4.48	.68	61.0	4.11	1.61	132.4	8.59	193.4
May 3	"	1	75	2.79	152.8	1.38	99.3	4.69	.53	49.7	3.99	1.46	117.4	8.69	167.1
May 3	"	1	150	3.04	161.4	1.68	127.7	4.96	.73	72.3	4.27	1.67	142.9	9.23	215.2
May 3	Urea	0	75	2.62	160.4	1.36	103.2	4.84	.47	45.4	3.98	1.31	104.0	8.82	149.4
May 3	"	0	150	2.94	160.0	1.62	122.0	4.77	.62	59.0	4.00	1.54	123.3	8.77	182.3
May 3	"	½	75	2.80	162.0	1.41	108.0	4.66	.42	39.2	3.93	1.33	104.8	8.58	144.0
May 3	"	½	150	2.67	159.8	1.50	113.2	4.66	.50	47.2	4.07	1.36	111.0	8.73	158.2
May 3	"	1	75	2.50	144.6	1.32	90.5	4.44	.38	33.6	3.74	1.21	90.6	8.17	124.2
May 3	"	1	150	2.75	150.0	1.61	114.2	4.65	.56	52.7	3.91	1.64	128.5	8.56	181.2
Significance				**	**	**	**	NS	**	**	NS	**	**	NS	**
BLSD(.05)				.15	17.8	.11	13.7		106	8.4		.39	19.6		25.5

AMELIORATION OF IRON CHLOROSIS BY COATING SOYBEAN SEEDS WITH IRON KE-MIN

Gyles W. Randall
Southern Experiment Station
University of Minnesota
Waseca, MN
1978

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

It has been reported that coating seeds with iron lignosulfonate materials has either partially or completely alleviated iron chlorosis symptoms in plants in some soils in the U.S. The purpose of this study was to determine if iron (as iron KE-MIN) coated on soybean seeds would serve as an effective iron source and, thus, would correct iron deficiency symptoms in soybeans grown in Minnesota.

EXPERIMENTAL PROCEDURES:

In late March, 1978, registered soybean seed (Corsoy variety, lot C-708) was purchased. This seed was delivered to Dr. F.E. Porter, Northrup King Company, for the seed coating. On April 7, his laboratory coated the soybeans to hold 8 and 16% iron KE-MIN by weight. The particulars of that preparation are shown in Table 1. A portion of the same seed lot was not coated but was planted in the studies to serve as a control.

Table 1. Amounts and kinds of material used in the coating of the soybean seeds.

COAT COMPONENT	16% Fe KE-MIN	8% Fe KE-MIN
Quantity produced in 10 lb batches	60 lb	120 lb
BATCH PREPARATION		
Seed	4540 g	4540 g
Water*	150	150
Fe KE-MIN	360	360
Water	100	100
Fe KE-MIN	360	
Adhesive	100	100
Peat Inoculant	20	20
Gypsum	350	350
Colorant	Orange	Carbon Black

* This water contains R. japonicum @ 1 x 10^9/ml, estimated and subject to count.

Appreciation is extended to Dr. F. E. Porter for coating the seeds and conducting a germination test on them.

After receiving the coated seed, the seed was divided into lots and given to three farmers for planting in areas of known iron chlorosis. A planting plan and identification stakes were provided for two of the cooperators. At the third site (Meyer) we participated with the farmer in the planting of the study. All farmers used a John Deere Max-Emerge planter and planted in 30" rows between May 18 and 23. A planting rate of 7-8 seeds per lineal foot was attempted. Notes were taken periodically during the season, especially at the Meyer site. Soil samples from the 0-8" layer were obtained in July from the Meyer site and at harvest (early October) at the Coy and Miller sites. All soil samples were submitted to the University of Minnesota Soil Testing Lab. for DTPA-extractable Fe analysis. Plant samples taken from the Meyer study were submitted to the U of M Analytical Research Lab. for analysis by emission spectroscopy.

The study was conducted at three sites. At the Coy and Miller sites, four planting strips through the chlorotic areas of the field were used to evaluate the 0, 8 and 16% seed coating treatments. These four strips were treated as reps. Four strips were also planted at the Meyer site, but each row was subdivided into 25' long sections to which six foliar treatments were applied. These treatments (Table 4) were applied on July 3 when the soybeans were in approximately the 3rd trifoliate stage.

All yields were obtained by hand harvesting 16' of row per plot and threshing in a stationary plot thresher which we transported from site to site.

RESULTS:

A. Coy site

Final stand was reduced significantly by both the 8 and 16% iron KE-MIN seed coat treatments; however, no difference was found between the 8 and 16% levels (Table 2). This reduction could have been due to either seed germination (personal communication with Dr. Cooper and Dr. Caldwell) and/or a reduced planting rate. In the former case, oil seeds apparently do not lend themselves well to seed coating because of impaired respiration. Thus, reduced stands could be expected, especially under field conditions. In a greenhouse germination test conducted by Dr. Porter, % germination was not delayed, however.

The latter case prevails when seeds of different sizes are planted with the John Deere Max-Emerge planter which uses a seed cup dispensing system. With this system, larger seeds are planted at lower rates (seeds/acre) than small seeds even at the same setting. Because coating the seeds increases seed size, we would expect somewhat lower planting rates with the 8 and 16% treatments.

Yields were not significantly affected by the iron treatments at this location.

The DTPA-extractable Fe for this site averaged 9.2 ppm which is substantially higher than the critical level of 4.5 ppm established by Colorado State University.

Table 2. Influence of coating soybean seed with iron KE-MIN on the final population and seed yield at the Burton Coy site.

Iron Coating		Population	Yield
%		beans/foot	bu/A
0		6.6	32.8
8		5.6	29.1
16		5.1	30.1
Significance[1/]	:	**	NS
BLSD (.05)	:	0.6	
CV (%)	:	8.	11.

[1/] **, *, and + indicate statistical significance at the 99, 95 and 90% probability levels; NS = not significant at the 90% level.

B. Miller site

Final stand was reduced substantially by the iron coating at this location (Table 3). This was due to the factors mentioned above and perhaps the flooding of the site compounded the problem (see notes below). As a result of this poor stand, yields were reduced significantly by the 16% treatment. DTPA-extractable Fe averaged 13.8 ppm at this site.

Table 3. Influence of coating soybean seed with iron KE-MIN on the final population and seed yield at the Sherman Miller site.

Iron Coating		Population	Yield
%		beans/foot	(bu/A)
0		5.6	26.4
8		3.7	26.0
16		2.8	20.5
Significance	:	**	*
BLSD (.05)	:	0.4	4.0
CV (%)	:	8.	13.

Notes:

Between 5 and 9 inches of rain fell in this area on June 16 and 17. Consequently, the whole plot area was flooded with water for up to 2 days. My observations on June 21 indicated no difference in plant size or chlorosis degree among the treatments, but the stand was markedly less with the 8 and 16% iron treatments. The soybeans were in the 1st and 2nd trifoliate stages. They also showed severe stress due to the flooding.

C. Meyer site

Coating the soybean seeds with 8 and 16% (by weight) Fe KE-MIN severely reduced the final population (Table 4). Reasons for this were discussed earlier. Even though yields were approximately 5 to 6 bu/A less when the seeds were coated, this difference was not statistically significant because of the high variability (CV = 34%).

Foliar application of various iron materials at the 3rd trifoliate stage did not influence the plant population but had a marked effect on yield (Table 4). All materials significantly increased soybean yield over the control. Highest yields were obtained with the 138-Fe (EDDHA) material applied without urea. The Fe KE-MIN treatments showed slightly lower yields, but these were not statistically less at the 95% level. Inclusion of the urea appeared to depress yields slightly. No interaction between seed coating and the foliar treatments was found.

Notes:

(1) On June 13, the soybeans were in the 1st trifoliate stage. The Corsoy beans without seed coating were beginning to exhibit iron chlorosis symptoms. Beans coated with 8 and 16% Fe were perhaps a day or two smaller in their growth and the plants did not show any chlorosis. The stands, however, were noticeably thinner than those not receiving seed coated iron.

(2) Soybeans were mostly in the late 1st to 2nd trifoliate stage on June 21. The 8% treatment showed slightly less chlorosis, a thinner stand and slightly less growth than the control treatment. Beans grown with the 16% treatment were more green (less chlorosis) and were slightly smaller than those with the 8% coating. The stand appeared similar to the 8% treatment.

(3) A very inconsistent response to the seed coating was observed on July 3. No response in some strips, slight response in others.

(4) Observations on August 31 concluded:

a) no consistent chlorosis difference between the seed coat treatments

b) a definite response to foliar-applied iron with the 138-Fe treatment looking the most consistent. High amount of variability was apparent.

Table 4. Influence of coating soybean seed with iron KE-MIN on the final population and seed yield at the Melvin Meyer site.

Seed coating	Foliar Fe Trt[1/] Material	Rate	Population	Seed yield
%		lb Fe/A	beans/foot	bu/A
0	None	0	4.9	28.1
	138-Fe[2/]	.15	6.0	44.6
	138-Fe + Urea[3/]	.15	5.1	36.4
	Fe KE-MIN	1.0	6.4	46.3
	Fe KE-MIN + Urea[3/]	0.5	6.3	42.4
	Fe KE-MIN + Urea[3/]	1.0	5.7	45.5
8	None	0	3.2	24.8
	138-Fe	.15	3.3	45.6
	138-Fe + Urea	.15	3.9	45.1
	Fe KE-MIN	1.0	3.9	33.8
	Fe KE-MIN + Urea	0.5	3.6	29.0
	Fe KE-MIN + Urea	1.0	3.7	35.0
16	None	0	2.4	19.4
	138-Fe	.15	3.7	45.9
	138-Fe + Urea	.15	3.7	46.4
	Fe KE-MIN	1.0	3.2	34.2
	Fe KE-MIN + Urea	0.5	3.2	35.7
	Fe KE-MIN + Urea	1.0	3.1	27.3

Individual Factors:

Seed Coating

Seed Coating		Population	Seed yield
0		5.7	40.5
8		3.6	35.6
16		3.2	34.8
Significance:		**	NS
BLSD (.05) :		1.2	

Foliar Treatments

Material	Rate	Population	Seed yield
None	0	3.5	24.1
138-Fe	.15	4.4	45.3
138-Fe + Urea	.15	4.2	42.6
Fe KE-MIN	1.0	4.5	38.1
Fe KE-MIN + Urea	0.5	4.4	35.7
Fe KE-MIN + Urea	1.0	4.2	35.9
Significance:		NS	**
BLSD (.05) :			10.9
CV (%) :		21.	34.
Seed x Foliar Interaction		NS	NS

[1/] All foliar materials were applied with a solution rate of 50 gallons/acre containing 0.25% v/v X-77 surfactant.

[2/] Sequestrene 138-Fe (EDDHA) by CIBA-GEIGY.

[3/] Urea was added to the solution at a rate of 5 lb N/A or 2.2% urea in solution.

Samples of the uppermost, mature trifoliate leaf were taken on July 8 and were submitted for analysis. Results given in Table 5 indicate a significant increase in leaf Mn, Zn, and Cu with the 16% treatment and leaf B with both the 8 and 16% treatments. Leaf Fe and Al values were markedly higher with the seed coat treatments but because of tremendous variability these differences were not significant. Leaf P values were extremely high with all treatments which may indicate a possible P accumulation when plants are suffering from an iron stress.

Table 5. Influence of coating soybean seed with iron KE-MIN on the nutrient concentrations of soybeans at the Melvin Meyer site.

Seed coating	P	K	Ca	Mg	Fe	Al	Mn	Zn	Cu	B
	Concentration[1]									
%	%				ppm					
0	.74	2.80	1.38	.61	155.	138.	178.	35.	7.4	41.
8	.73	2.88	1.35	.62	198.	183.	170.	37.	7.9	47.
16	.85	3.04	1.38	.65	215.	210.	208.	47.	9.7	48.
Signif:	NS	NS	NS	NS	NS	NS	**	*	+	*
BLSD(.05):							18.	8.		4.
CV(%):	10.	6.	4.	5.	22.	28.	6.	11.	15.	6.

1/ Uppermost, mature trifoliate leaf at the early bloom stage. Only those plots which did not receive foliar-applied Fe were sampled.

Five days after the iron materials were foliar-applied, all plots were evaluated for phytotoxicity symptoms of the leaf tissue to the iron materials. Visual response to the materials was also noted by subjectively rating the degree of mottling of the leaves. Results from these subjective ratings are given in Table 6. Phytotoxicity was highest with the treatments containing urea and lowest with the 138-Fe (EDDHA) treatment. Color response was about equal for the 138-Fe and the 1.0 pound Fe KE-MIN treatments.

Table 6. Influence of foliar application of iron materials on the phytotoxicity symptoms and early color response of soybeans.

Foliar Treatment: Material	Foliar Treatment: Rate	Phytotoxicity[1]	Color[2] response
	lb Fe/A		
None	0	0.0	0.0
138-Fe	.15	0.2	2.2
138-Fe + Urea	.15	2.1	2.3
Fe KE-MIN	1.0	0.8	2.1
Fe KE-MIN + Urea	0.5	1.2	1.8
Fe KE-MIN + Urea	1.0	1.9	2.5

1/ Range from 0 to 3 where 0 = no phytotoxicity and 3 = severe phytotoxicity.

2/ Degree of green color response as indicated by mottling on a scale from 0 to 3 where 0 = no response and 3 = good response.

Soil samples (0-8") were taken in July from two sites exhibiting iron chlorosis of soybeans. One site was on the Melvin Meyer farm in Waseca County. The other was on the Bud Sanders, Jr. farm in Watonwan County (no KE-MIN studies were conducted here). Samples were taken from three areas at each site: (a) normal to slightly chlorotic soybeans, (b) moderately chlorotic soybeans and (c) severely chlorotic soybeans. Plastic equipment was used for sampling.

Each sample was thoroughly mixed and then separated into (a) a sample which was air dried, (b) a sample which was oven dried at 150°F with forced air, and (c) a sample which was frozen for future use. The frozen samples were removed from the freezer on January 3, 1979 and on the 4th were divided into three groups again: (a) same as above, (b) same as above, and (c) a sample which was kept field moist for analysis. All samples were analyzed for DTPA-extractable Fe on January 8.

The results shown in Table 7 indicate a number of inconsistencies in the data as a result of sample preparation. Some observations are:

(1) There is a range of values which separates the chlorotic from the non-chlorotic areas but the critical level cannot be ascertained from these samples.

(2) There is very little difference between the values obtained from the moderate and severe areas.

(3) Keeping the air-dried samples from July (Sept. analysis) until January did not alter the extractable Fe.

(4) Keeping the samples frozen until January resulted in a 9% increase in extractable Fe.

(5) Oven drying resulted in a 35% increase in extractable Fe.

(6) Analyzing the samples on a field moist basis resulted in values approaching the critical level of 4.5 ppm established by Colorado State University. All values obtained with air or oven drying were considerably higher than CSU's 4.5 ppm value.

Table 7. Influence of storage and drying method on DTPA extractable Fe.

Site	Visual chlorosis	July preparation			Jan. 1979 preparation		
		Air[1/]	Air	Oven	Air	Oven	Field moist
		Fe (ppm)					
Meyer (Waseca County)	None	46.3	44.5	52.0	44.0	56.0	57.0
	Moderate	9.3	9.5	10.5	11.0	15.5	4.0
	Severe	8.5	8.5	9.5	8.5	13.5	3.0
Sanders (Watonwan County)	Slight	16.8	17.0	22.5	15.5	26.0	12.0
	Moderate	10.8	8.0	14.0	10.5	15.5	6.0
	Severe	8.9	8.5	13.0	8.0	13.5	4.0

[1/] The air-dried samples from the July preparation were also analyzed in September, 1978.

CONCLUSIONS:

Coating of soybean seeds with iron KE-MIN (8 and 16% by weight) did not alleviate iron chlorosis problems when these seeds were planted in soils known to exhibit iron chlorosis symptoms. Yields were not increased at any of the three sites but were decreased at one site. Plot population was reduced by the seed coating at all sites. Foliar application of the 138-Fe and Fe KE-MIN materials did improve the soybean yields significantly. DTPA-extractable Fe from these soils was substantially higher than the critical level reported by Colorado State University.

CONSERVATION TILLAGE STUDY

Waseca, 1978

G. W. Randall and J. B. Swan

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

Experimental Procedures

To evaluate some of these conservation tillage practices on continuous corn an experiment was established in 1975 on a Webster clay loam at the Southern Experiment Station. Five tillage treatments (Table 1) were replicated four times. Each plot was 20' wide by 125' long. Tile lines spaced 75' apart lie perpendicular to the rows within all plots.

Ridges are built along the corn rows for the till-plant (Ridge) treatment by cultivation in June each year. After harvest the stalks are chopped and the moldboard and chisel plow operations are performed in early November. On May 4 the moldboard and chisel plow plots were field cultivated once with the chisel plots receiving a prior disking.

Corn (Pioneer 3709) was planted at a rate of 26,100 ppA on May 5. The no-tillage, fall plow and fall chisel treatments were planted with a John Deere Max Emerge planter equipped with 2" fluted coulters. A Buffalo till planter was used for the till-plant treatments.

Broadcast P and K were applied at a rate of 0+40+100 (lb $N+P_2O_5+K_2O$/A) in October, 1977. Nitrogen (175 lb N/A as ammonium nitrate) was broadcast on May 4. Starter fertilizer (13+32+42 lb $N+P_2O_5+K_2O$/A) and an insecticide (1 lb Furadan/A) were applied to all plots at planting. Chemical weed control consisted of 3 lb Lasso and 2½ lb atrazine/A applied pre-emergence. Treatments 2, 3, 4, and 5 were cultivated in mid-June. Weed control was excellent in all cultivated treatments.

Planting depth was determined by cutting off the coleoptile at the soil surface from all the plants in a 3-meter length of row in each plot 25 days after planting. The seeds were then excavated and the length of the coleoptile to the seed was measured. Early plant growth was determined by harvesting the above ground portion of 10 random plants per plot 40 days after planting. Yields were taken by combine harvesting four rows from each plot.

Results

Significant differences in final population, grain moisture, grain protein, N removal in the grain and grain yield were found among the tillage treatments (Table 1). Final population of those treatments planted with the John Deere planter were slightly less than those planted with the Buffalo till planter; even though both were set to drop about 26,000 plants per acre. This is in contrast to the two previous years when plant populations with the till-planter have been lower. Perhaps the planting depth (Table 2) can account for the differences found in 1978.

Table 1. Influence of tillage methods on continuous corn production at Waseca in 1978.

Treatment	Final popl'n	Grain Moist.	Grain Protein	Grain N Removal	Grain Yield	1975-78 Avg. Yield
	x 1000	--%	--%	lb/A	--bu/A	--bu/A
No tillage[1]	24.1	26.0	9.94	110.5	147.2	108.0
Fall plow, f. cult.[1]	24.2	24.2	9.81	121.6	164.0	130.0
Fall chisel, disk, f. cult.[1]	24.7	23.4	10.12	121.0	157.3	117.0
Till plant (Ridge)	26.2	23.6	11.06	138.6	165.4	130.0
Till plant (Flat)	25.6	24.6	9.75	123.7	167.6	130.0
Significance:	**[2]	**	*	**	**	
BLSD (.05) :	1.0	1.4	.84	12.2	9.5	
CV (%) :	2.7	3.6	5.0	6.3	3.8	

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

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

Grain yields in 1978 were highest with the till-plant (both ridged and flat) and the moldboard plow treatments. Slightly lower yields were obtained with fall chiseling and significantly lower yields (P=.05) with no tillage. A definite reason for the chisel plow treatment yielding 6.7 bu/A less than the moldboard plow treatment cannot be given. Lack of good weed control brought about by a heavy residue cover (corn and weed) with no cultivation may explain most of the yield reduction with no tillage. The heavy thatch layer apparently inactivates the pre-emergence herbicides allowing a dense growth of grassy weeds.

Identical four-year yield averages (130 bu/A) have been found with the till-plant treatments and a conventional tillage system using the moldboard plow (Table 1). Average yields were reduced by 13 and 22 bu/A with the chisel plow and no tillage systems.

Grain moisture was significantly higher with no tillage (Table 1). Nitrogen in the grain (protein) and N removal per acre (N content X yield) were also significantly affected by the tillage treatments. Interpretation of the protein data is difficult other than all tillage treatments resulted in satisfactory protein levels and, thus, N deficiency must not have occurred.

Surface residues from the preceding corn crops showed an accumulation of up to 4.8 tons dry matter per acre with continuous no tillage (Table 2). Approximately 3 tons/A was still on the soil surface following the till-plant operations and only 1.7 T/A following the chisel plowing.

Table 2. Influence of tillage methods for continuous corn on surface residue, seeding depth, and early plant growth at Waseca in 1978.

Treatment	Surface residue	Planting Depth Average	S.D.	Range	Early plant growth
	T DM/A	---------mm---------			g/10 plants
No tillage	4.8	50.8	8.2	32-77	44
Fall plow	Trace	69.6	5.0	48-86	93
Fall chisel	1.7	64.4	6.0	51-82	81
Till plant (Ridge)	3.3	47.0	10.8	13-81	88
Till plant (Flat)	3.1	48.3	10.4	26-76	73
Significance:	**	**			**
BLSD (.05) :	1.2	8.7			25
CV (%) :	25.7	10.4			20.8

Planting depth was significantly deeper with the moldboard plow and chisel systems using the standard John Deere planter. When this planter was used on the no tillage plots, the depth was shallower and was not different than the till-plant systems. The variability of the planting depth as measured by the standard deviation (S.D.) and shown by the range was lowest for the plow and chisel systems, intermediate for no tillage and highest for the till-plant systems. Seeds were placed as shallow as 13 mm (½ inch) and as deep as 81 mm (3 inches) with the till-planter which demonstrates the need for special attention in setting the till planter. Lack of proper adjustment more than likely will lead to loss of stand due to shallow planting.

A 50% reduction in early plant growth (EPG) was noted with the no tillage treatment in comparison to the other four systems. No significant EPG difference was found among the moldboard, chisel or till-plant systems. The correlation between EPG and grain yield was +.613** with a regression equation of Yield (bu/A) = 139.6 + 2.725 EPG.

Nutrient uptake by the small plants was calculated by multiplying the nutrient concentrations (Table 4) by the EPG (Table 2). Uptake of Ca, Fe, Mn and Cu was significantly higher with the moldboard plow, chisel and till-plant systems than with no tillage (Table 5). Uptake of P, K and B with the moldboard plow, chisel and till-plant (ridge) systems was greater than with no tillage; however, there was no difference between no tillage and till-plant (flat). With the exception of Ca and Mg, nutrient uptake was always highest with the fall moldboard plow system.

Table 5. Influence of tillage methods for continuous corn on small whole plant nutrient uptake at Waseca in 1978.

	Nutrient								
Treatment	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	-----g/10 plants----				--------mg/10 plants--------				
No tillage	.177	1.76	.22	.14	17.6	2.12	1.85	.329	.398
Fall plow	.382	3.98	.51	.26	60.4	6.45	3.51	.755	.813
Fall chisel	.327	3.19	.40	.24	47.8	5.21	2.70	.614	.681
Till plant (Ridge)	.318	3.16	.52	.38	43.8	4.74	3.46	.677	.697
Till plant (Flat)	.267	2.56	.40	.28	46.4	4.54	2.86	.585	.580
Significance:	*	**	**	*	**	**	*	**	*
BLSD (.05) :	.123	.93	.14	.14	16.4	1.45	1.28	.144	.222
CV (%) :	25.3	20.5	22.3	32.1	24.8	20.9	25.9	16.2	21.6

Leaf samples were taken from the leaf opposite and below the ear at silking. With the exception of Mg, nutrient concentrations were not affected significantly (P=.10) by the tillage systems although a trend toward lower K concentrations with the till-plant systems was noticed (Table 6). A concomitant significant increase in Mg was associated with these slightly lower K values.

Table 6. Influence of tillage methods for continuous corn on the nutrient concentration in the earleaf at Waseca in 1978.

	Nutrient									
Treatment	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	-----------%-----------					----------ppm----------				
No tillage	2.74	.28	2.01	.57	.33	101	38	23	7.2	10.5
Fall plow	2.89	.28	2.09	.60	.30	96	51	23	6.9	11.2
Fall chisel	2.82	.27	2.09	.61	.33	96	50	23	7.2	12.4
Till plant (Ridge)	2.88	.28	1.87	.66	.39	97	42	23	7.1	13.0
Till plant (Flat)	2.91	.28	1.93	.64	.38	98	50	26	7.6	12.8
Significance:	NS	NS	NS	NS	*	NS	NS	NS	NS	NS
BLSD (.05) :					.06					
CV (%) :	4.1	6.4	6.8	7.1	10.3	8.4	24.6	11.4	6.3	15.7

Soil temperature at the 4-inch depth measured by thermocouples placed directly beneath the seed was affected by the surface residues in the four-week period following planting (Table 3). Average temperatures were warmest with the moldboard plow treatment (65.3°) and coolest with the till-plant (flat) (61.9°) and no tillage treatments (61.5°). The chisel treatment (64.0°) was always slightly warmer than the till-plant (ridge) system (63.0°).

Table 3. Soil temperature (4" average) after planting as influenced by tillage practices at Waseca in 1978.

Tillage Treatment	Period 5/14 - 20	5/21 - 27	5/28 -6/3	6/4 -10
	°F			
No tillage	58.7	63.0	59.9	64.3
Fall plow	63.0	67.3	61.8	69.1
Fall chisel	61.3	65.4	61.2	67.9
Till plant (Ridge)	60.3	64.8	60.7	66.2
Till plant (Flat)	59.7	63.9	59.9	64.2

The small whole plants taken for EPG measurements were chemically analyzed (Table 4). A slight reduction in P and K concentration with the till-plant systems was noticed; however, the K differences were not significant (P=.10 level). Plant Mg was increased by the till-plant systems and probably resulted from the interaction with K. Plant Fe was higher for all treatments that received some tillage, indicating that soil had splashed up on the plants, thus, contaminating the samples.

Table 4. Influence of tillage methods for continuous corn on small whole plant nutrient concentrations at Waseca in 1978.

Treatment	Nutrient P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%				ppm				
No tillage	.41	4.02	.50	.32	392	48	41	7.5	9.1
Fall plow	.41	4.27	.55	.28	655	70	38	8.1	8.8
Fall chisel	.40	3.94	.50	.29	595	65	33	7.6	8.4
Till plant (Ridge)	.36	3.58	.58	.42	487	54	39	7.7	7.9
Till plant (Flat)	.36	3.56	.55	.37	633	64	39	8.4	7.9
Significance:	+	NS	NS	*	**	NS	NS	NS	NS
BLSD (.05) :				.08	163				
CV (%) :	6.8	10.0	11.6	15.3	16.9	21.3	11.8	12.8	12.6

Soil samples were taken from all plots in 1-foot increments to a depth of 5 feet in early October. Samples were immediately dried and analyzed for NO_3-N. Results shown in Table 7 indicate that the majority (55 to 66%) of the NO_3-N was located in the 3-5' zone for all treatments. Also, there was no difference in total NO_3-N accumulation within the top 5' among the tillage systems. These relatively high NO_3-N levels indicate that more than sufficient N was available for optimum plant growth. However, these levels were substantially lower than those found in November of 1977. Perhaps much of this decrease in soil NO_3-N could be ascribed to leaching below the 5' zone, movement into the tile lines, and/or denitrification.

Table 7. Nitrate-N distribution in the soil profile on October 3, 1978, as influenced by tillage at Waseca.

Depth	No tillage	Fall plow	Fall chisel	Till-plant Ridge	Till-plant Flat
feet	ppm				
0-1	7.6	10.9	10.6	10.4	9.4
1-2	3.1	3.2	3.2	3.2	3.0
2-3	5.9	6.8	7.0	4.8	7.9
3-4	14.6	11.3	15.8	13.5	12.0
4-5	18.0	14.1	17.4	17.5	15.5
lb NO_3-N/A in 0-5' profile[1]	195	184	215	195	190

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

Soil samples were collected from the 0-7" layer on May 16 by Dr. Dave MacDonald and Alan Pierce and analyzed for nematodes. Results shown in Table 8 indicate a marked population of Pratylenchus (lesion) nematodes with a much lower population of Helicotylenchus (spiral) nematodes. Populations were not affected by the tillage treatments.

Table 8. Influence of tillage methods for continuous corn on nematode populations at Waseca in 1978.[1]

Treatment	Nematodes Pratylenchus	Nematodes Helicotylenchus
	No./100 cc soil	
No tillage	491	46
Fall plow	379	28
Fall chisel	306	22
Till plant (Ridge)	546	10
Till plant (Flat)	406	36
Significance:	NS	NS
BLSD (.05) :		
CV (%) :	61.2	86.6

[1] Data from Dr. Dave MacDonald and Alan Pierce, Dept. of Plant Pathology.

European corn borer (ECB) counts were obtained by Dr. Huai Chiang and Dan Palmer from random plots before harvest to determine the initial ECB levels in the fall of 1977. ECB counts were also taken from each plot following the fall operations and again following the spring operations and planting. The initial counts totaled 52.5 borers/36 ft^2 or 3.7 borers/plant, which would be considered a high population (Table 9). ECB counts were greatly reduced by fall stalk chopping and tillage with no differences observed among the tillage treatments. Over winter mortality and the spring operations reduced the ECB numbers in the residual plant material significantly (P=.05) from the fall levels. Again, no differences were observed among tillage treatments.

Table 9. Influence of tillage methods for continuous corn on the European Corn Borer (ECB) population at Waseca in 1977 and 1978.[1]

Tillage Treatment[4]	Preharvest Avg.	Preharvest S.D.	Oct., 1977[2] Avg.	Oct., 1977[2] S.D.	May, 1978[3] Avg.	May, 1978[3] S.D.
	---No. Borers in 6'x6' square area----					
No tillage	52.5[5]	12.4	3.0	1.8	1.8	1.7
Fall plow			2.8	2.1	1.8	1.5
" " (not chopped)			2.8	2.8	0.8	0.5
Fall chisel			3.0	1.8	0.8	1.0
Till-plant (Ridge)			3.5	3.3	0.5	0.6
" " (Flat)			2.8	2.9	1.0	0.8
Significance:			NS		NS	

[1] Data from Dr. Huai Chiang and Dan Palmer, Dept. of Entomology, Fisheries and Wildlife.

[2] Post fall field operations.

[3] Post spring field operations and planting.

[4] All treatments were stalk chopped except for a small segment of the fall plow plots.

[5] Obtained from random plots in each rep. Calculates to 3.7 borers/plant.

Summary

Continuous corn production on a Webster clay loam can be maintained adequately with reduced forms of tillage. Four-year averages show identical yields with conventional tillage (moldboard plow and field cultivate) and the till-plant systems. Chisel plowing resulted in slightly lower yields. No tillage can be recommended on these soils.

LIME STUDIES - WASECA, 1978

John Grava, G. W. Randall, C. J. Overdahl, J. N. Lensing

Investigations on effects of liming on crop yield, chemical composition of plant tissue and chemical properties of the soil were continued at the Southern Experiment Station. Liming experiments have been conducted with soybeans and alfalfa since 1972. Similar investigations with corn were initiated in 1971 and terminated in 1977.

SOYBEANS

Dolomitic limestone was applied to the continuous soybean experiment in the spring of 1972. The experiment was relimed at the end of the 1975 growing season. Soybean plots received the following cultural treatments in 1978:

Tillage: Chisel plowed in fall 1977
Fertilizer: None
Herbicide: 1 lb. Treflan and 2.5 lb. Amiben preemergence

Hodgson variety was planted on May 19 with population of 8 beans/foot. The plots were harvested on September 27.

Liming had no effect on soybean yield (Table 1). The concentration of manganese and copper in the trifoliate leaves was decreased by the application of limestone at relatively high rates (Table 2).

ALFALFA

The liming experiment with alfalfa was established in the spring of 1972. Vernal alfalfa was grown for four years. The experiment was relimed in the fall of 1975 and a stand of Agate alfalfa was established in the spring of 1976.

The yield was not significantly increased by lime applications (Table 3). Liming resulted in slight changes in the concentration of some plant nutrient elements of alfalfa tissue (Table 4). Phosphorus concentration in alfalfa tissue of 2nd and 3rd cutting was slightly increased by the application of limestone. Manganese concentration was decreased by liming in all three cuttings while copper content was decreased in tissue of first and third cutting alfalfa. Aluminum and boron concentration was decreased in tissue of third cutting alfalfa.

Soil test results of samples collected in August 1978 are reported in tables 5 to 10.

See "Report on Field Research in Soils", Soil Series 88, 1972, pp. 140-141; Soil Series 89, 1973, pp. 154-159; Soil Series 91, 1974, pp. 190-197; Soil Series 95, 1975, pp. 148-156; Soil Series 97, 1976, pp. 134-142; Soil Series 99, 1977, pp. 142-150; Soil Series 103, 1978, pp. 141-149, for results obtained in previous years.

Soybean Area - Liming resulted in higher soil pH values than those measured in Control plots. These pH increases, however, were slight and confined mainly to the top 6 or 12 inches of soil. An application of 20 tons of limestone per acre within six years was required to increase the soil pH of top 6 inches to 6.4, compared to pH 5.4 for Control.

Alfalfa Area - Liming treatments in the alfalfa experiment had a somewhat more pronounced effect on soil pH than that observed with soybeans. The soil pH was increased by liming, to some extent, of the soil in upper 12 inches. The greatest pH change, however, occurred mainly in the top 3 inches of soil. This probably was due to shallow incorporation of limestone in 1975. The old stand of alfalfa had been plowed up in August 1975. Then in November, limestone was reapplied and incorporated into the soil by disking in spring of 1976.

SUMMARY AND CONCLUSIONS

Two liming experiments with soybeans and alfalfa, grown continuously, have been conducted at the Southern Experiment Station since 1972. The experimental area includes two fine textured soils (Le Sueur clay loam and Cordova silty clay loam). The surface soil has a pH of 5.5, and a lime requirement of 6.5 tons/acre (SMP buffer index 6.1). The subsoil is neutral at a 24-30 inch depth (alfalfa area) or 30-36 inch depth (soybean area). Free carbonates are found at 36-42 inch depth.

While liming has resulted in generally higher pH values than the Control, the pH increase has not been as large as originally anticipated.

Crop yields have not been affected by liming. Concentration of some micronutrient elements in plant tissue has been reduced by the application of lime. This is to be expected, considering the effect of higher soil pH on the availability of manganese and zinc. However, even the highest lime rates have not decreased the concentration of these nutrient elements to such an extent so as to cause deficiencies.

Table 1. Yield of soybeans, Waseca lime plots, 1978.

Rate of Lime Ton/Acre	Yield Bu/Acre
0	49
2.5	49
5	50
7.5	48
10	49
Significance	ns
CV %	3.2

Table 2. Chemical composition of soybean trifoliate leaves, Waseca lime plots, 1978.

Rate of Lime	P	K	Ca	Mg	Al	Fe	Zn	Cu	Mn	B
Tons/Acre	----% in dry matter-----				-----ppm in dry matter------					
0	0.40	1.76	1.38	0.48	39	146	41	5.4	61	56
2.5	0.41	1.84	1.34	0.48	38	144	41	5.0	51	55
5	0.41	1.78	1.39	0.49	43	154	41	5.1	53	55
7.5	0.42	1.81	1.39	0.52	38	148	42	4.7	50	55
10	0.41	1.84	1.44	0.49	39	146	40	4.7	48	53
Significance	ns	ns	ns	ns	ns	ns	ns	*	*	ns
BLSD (.05)	-	-	-	-	-	-	-	0.6	10	-
CV %	3.0	3.6	4.9	5.2	17.2	6.2	5.8	8.8	13.8	3.7

Table 3. Yield of alfalfa, Waseca lime plots, 1978.

Rate of Lime	Hay Yield			
Tons/Acre	1st Cutting	2nd Cutting	3rd Cutting	Total
	--------------------Tons/Acre--------------------			
0	1.83	1.62	1.31	4.76
2.5	1.83	1.66	1.37	4.86
5	1.71	1.65	1.38	4.74
7.5	1.49	1.67	1.39	4.55
10	1.82	1.66	1.41	4.89
Significance	ns	ns	ns	ns
CV %	15.1	6.7	7.1	5.6

Average of six replications.

Table 4. Chemical composition of alfalfa, Waseca lime plots, 1978.

Rate of Lime	P	K	Ca	Mg	Al	Fe	Zn	Cu	Mn	B
Tons/Acre	----% in dry matter-----				-----ppm in dry matter------					
				First Cutting						
0	0.33	2.79	1.64	0.29	138	191	37	5.0	46	43
2.5	0.33	2.74	1.62	0.30	126	180	35	4.4	32	42
5	0.33	2.71	1.64	0.31	157	208	36	4.5	30	40
7.5	0.34	2.62	1.72	0.33	138	197	35	4.1	26	41
10	0.34	2.69	1.58	0.31	115	169	34	3.9	30	39
Significance	ns	ns	ns	ns	ns	ns	ns	*	**	ns
BLSD (.05)	-	-	-	-	-	-	-	0.5	5	-
CV %	4.7	4.1	8.9	8.8	35.1	21.8	8.3	7.9	9.6	5.8
				Second Cutting						
0	0.31	2.39	1.49	0.29	346	387	28	5.8	69	46
2.5	0.32	2.29	1.49	0.30	225	282	26	5.5	40	43
5	0.34	2.33	1.54	0.31	200	266	26	5.6	35	44
7.5	0.34	2.26	1.53	0.31	187	246	25	5.3	27	41
10	0.33	2.32	1.54	0.31	215	290	27	5.4	37	42
Significance	+	ns	ns	ns	ns	ns	ns	ns	**	ns
BLSD (.05)	0.02	-	-	-	-	-	-	-	8	-
CV %	3.4	3.6	7.4	4.9	38.5	24.1	6.2	9.0	13.9	6.6
				Third Cutting						
0	0.31	2.39	1.80	0.35	223	283	30	7.6	77	55
2.5	0.33	2.33	1.83	0.36	183	251	30	6.8	46	51
5	0.33	2.39	1.66	0.35	142	213	30	6.4	36	44
7.5	0.33	2.32	1.70	0.36	158	222	28	6.2	36	44
10	0.33	2.34	1.73	0.36	158	236	32	6.2	39	45
Significance	*	ns	*	ns	*	ns	ns	**	**	**
BLSD (.05)	0.02	-	0.10	-	62	-	-	0.7	9	4
CV %	3.5	4.3	4.7	4.0	26.4	19.2	14.5	9.1	17.7	6.6

Table 5. Effect of lime treatment on soil pH after seven years of soybeans at Waseca (1978).

Depth (inches)	Lime Rate (T/A)[1/]				
	0	2.5	5.0	7.5	10.0
0-6	5.4	5.8	5.9	6.2	6.4
6-12	5.4	5.8	5.9	6.1	6.1
12-18	5.8	5.9	5.8	6.0	6.0
18-24	6.0	6.0	6.0	6.1	6.4
24-30	6.3	6.4	6.4	6.5	6.6
30-36	6.8	7.0	6.9	7.2	7.1

1/ These lime rates were applied twice (spring, 1972 and fall, 1975)

Table 6. Effect of lime treatment on soil P after seven years of soybeans at Waseca (1978).

Depth (inches)	Lime Rate				
	0	2.5	5.0	7.5	10.0
	lb/A				
0-6	106	115	101	112	101
6-12	60	60	60	64	55
12-18	11	10	10	11	8
18-24	5	5	4	4	4
24-30	4	4	4	4	7
30-36	6	5	5	9	6

Table 7. Effect of lime treatment on soil K after seven years of soybeans at Waseca (1978).

Depth (inches)	Lime Rate				
	0	2.5	5.0	7.5	10.0
	lb/A				
0-6	219	242	224	218	226
6-12	184	180	170	179	175
12-18	158	146	157	152	155
18-24	177	159	150	151	148
24-30	164	150	150	153	146
30-36	169	145	144	146	146

Table 8. Effect of lime treatment on soil pH after seven years of alfalfa at Waseca (1978).

Depth (inches)	Lime Rate (T/A)[1/] 0	2.5	5.0	7.5	10.0
0-3	5.5	6.3	6.6	6.9	6.8
3-6	5.4	5.8	6.1	6.3	6.5
6-12	5.5	5.8	6.0	6.2	6.1
12-18	6.2	6.2	6.1	6.3	6.1
18-24	6.6	6.5	6.4	6.7	6.4
24-30	7.2	7.0	6.8	7.0	6.8
30-36	7.6	7.5	7.4	7.4	7.2

1/ These lime rates were applied twice (spring, 1972 and fall, 1975)

Table 9. Effect of lime treatment on soil P after seven years of alfalfa at Waseca (1978).

Depth (inches)	Lime Rate (T/A) 0	2.5	5.0	7.5	10.0
	---pp2m---				
0-3	96	86	76	84	92
3-6	82	83	68	64	73
6-12	55	49	54	49	56
12-18	7	6	8	9	8
18-24	6	3	5	4	6
24-30	7	6	6	3	8
30-36	12	9	10	8	10

Table 10. Effect of lime treatment on soil K after seven years of alfalfa at Waseca (1978).

Depth (inches)	Lime Rate (T/A) 0	2.5	5.0	7.5	10.0
	---pp2m---				
0-3	265	254	248	271	256
3-6	186	190	164	166	182
6-12	183	180	160	168	175
12-18	168	183	158	168	189
18-24	164	175	147	163	207
24-30	158	188	172	163	184
30-36	165	170	171	165	162

Nitrogen Fertilization of Annual Canarygrass

G.L. Malzer and G. Varvel

Nitrogen fertilization and management for annual canarygrass as well as other small grain crops continues to be one of the key inputs that producers must consider in their overall management operations. Optimum nitrogen management should result in the highest economic production potential, and at the same time, do it with the least amount of input so as to maximize profit for the producer. To examine the importance of not only nitrogen rates but also nitrogen form on annual canarygrass production, a field trial was established in Northwestern Minnesota.

Experimental Procedures

Eleven treatments including a control, six rates of nitrogen as ammonium nitrate, and two rates of nitrogen as urea and 28% nitrogen solution were incorporated into a randomized complete block design with six replications. The experimental area was a Fargo clay near Northcote, MN in Kittson county. The area had a soil pH of 7.6, a Bray P-1 Extractable Phosphorus test of 29(high) and an exchangeable potassium test of 600+ pounds/acre (very high). The average residual nitrate nitrogen level over the experimental area was 140 pounds of NO_3-N/acre in the 0-2 foot depth. All fertilizer treatments were applied as broadcast treatments in the spring.

General Results

Current nitrogen fertilizer recommendations based upon a zero to two foot test of 140#N/A would have suggested that no additional fertilizer nitrogen would be required to attain high yields of annual canarygrass. The yield results obtained in 1978 (Table 1) would support the calibration information, in that no yield response was obtained with the addition of fertilizer nitrogen. Since no nitrogen response was obtained, no differences due to the use of varying nitrogen forms would be anticipated. The question remains as to what yield levels could be obtained from the existing nitrate nitrogen in the soil. The nitrogen content in the grain (Table 2) is higher than what we normally find with most high yielding spring wheat varieties. Even with the higher protein (%N) levels total nitrogen removal (Table 3) with the grain were not large because of the yield levels obtained. This would suggest that canary seed production as far as net nitrogen removal with the crop would probably not be as large as a comparable crop of other small grains such as spring wheat.

Although not statistically significant, the trend was again established where excessive nitrogen rates may actually reduce grain yields. This has been observed not only with canary seed, but also with other small grains over the last several years. Such interactions appear to be related to nitrogen, soil moisture and the climatic conditions encountered throughout the year.

The yield results obtained this year along with the past information would support and encourage the use of the nitrate nitrogen test for making recommendation for fertilizer application. Further research information may be desirous and warranted to ascertain nitrogen needs under higher yielding conditions and calibration information of those soils which do test low in residual nitrate nitrogen.

Table 1. Influence of nitrogen rate and nitrogen form on the seed yield of annual canary grass. - Kittson Co. - 1978.

	Seed yield - #/A			
	Nitrogen Form			
Nitrogen Rate	Control	Ammonium Nitrate	Urea	28% N Solution
#/A				
0	792			
20		853		
40		850	851	794
60		881		
80		865	791	847
120		855		
200		776		

No significant (.05) difference in treatment means

Table 2. Influence of nitrogen rate and nitrogen form on nitrogen content of the seed.

	Nitrogen content - %			
	Nitrogen form			
Nitrogen Rate	Control	Ammonium Nitrate	Urea	28% N Solution
#/A				
0	3.17			
20		3.36		
40		3.22	3.26	3.42
60		3.21		
80		3.38	3.41	3.27
120		3.20		
200		3.34		

No significant (.05) difference in treatment means

Table 3. Total nitrogen removal with the grain as influenced by nitrogen rate and form of nitrogen fertilizer.

	Nitrogen removal with grain -#/A			
Nitrogen Rate	Control	Ammonium Nitrate	Urea	28% N Solution
#/A				
0	25.1			
20		28.7		
40		27.4	27.7	27.2
60		28.3		
80		29.2	27.0	27.7
120		27.4		
200		25.9		

No significant (.05) difference in treatment means

Foliar Fertilization of Corn

G.L. Malzer, S. Evans, and W.W. Nelson

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

Experimental Procedures

Two experiments, each consisting of six treatments, were established in 1978 with one at the West Central Experiment Station at Morris and one at the Southwest Experiment Station at Lamberton. The experimental areas had been planted to bulk corn on each station and had therefore received normal NPK soil treatments as recommended by soil tests. The treatments established consisted of a control, two rates of NPKS solution, and two dates of application. The NPKS solution contained nutrients in the ratio of 6:2.3:3.7:0.6 and was made utilizing urea, potassium polyphosphate, and potassium sulfate. Treatment rates were based upon nitrogen applied, but should not be interpreted as just nitrogen application. The treatment rates consisted of 10 #N/A and 20 #N/A with these rates applied one week prior to tasseling or after pollination (approx. 3 weeks later). A treatment where 10 #N/A was applied early and 10 #N/A applied late to the same area was included at both locations. All treatments were applied with a high-boy sprayer with a minimum of 20 gal./A of solution being applied. Minimum plot sizes were six thirty-inch rows, 55 ft. long with six replications of each treatment. At harvest the center two rows from each plot were either hand harvested or machine harvested and subsamples collected for moisture determination and nitrogen analysis.

General Results

No significant positive responses to foliar applications of NPKS solution were found with corn at either location in 1978. Foliar applications at Lamberton had no influence on yield protein, content (%N) or total nitrogen removal. Foliar applications at Morris resulted in lower yields (.10) and reduced nitrogen utilization when split applications (10 & 10) of foliar fertilizer were utilized. Although not significant at the 10% level a five plus bu/A increase was observed at the low rate of application prior to tasseling. The influence of application date, time of application during the day, as well as the impact of smaller more frequent applications deserve further consideration.

Table 1. Yield, Nitrogen Content of Grain, and Nitrogen Removal by Corn Grain as Influenced by Rate and Time of NPKS Foliar Application to Corn.

Treatments		Corn Grain		
N Rate	Appl. Date	Yield	N Content	N Removal
#/A		bu/A	%	#/A
		West Central Experiment Station		
0	-	110.6	1.68	87.8
10	Early	115.8	1.66	91.0
20	Early	111.1	1.73	90.8
10	Late	107.6	1.66	84.6
20	Late	104.6	1.72	85.1
10 & 10	Early & Late	100.0	1.66	78.4
Significance		+	NS	+
BLSD(.05)		9.7		8.7
		Southwest Experiment Station		
0	-	131.2	1.65	102.3
10	Early	123.6	1.62	95.0
20	Early	127.6	1.65	99.6
10	Late	127.1	1.64	99.0
20	Late	118.6	1.67	93.6
10 & 10	Early & Late	121.6	1.66	95.7
Significance		NS	NS	NS
BLSD(.05)				

Deep Sampling of Soils for Residual Nitrates and its Potential as a Diagnostic Technique for Corn Production in Southwestern Minnesota

G.L. Malzer, G. Holcomb, W.W. Nelson, and S. Evans

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

Experimental Procedures

Nine locations in Southwestern Minnesota were established in the fall of 1977. One location was located on the Southwest Experiment Station-Lamberton, one at the West-Central Experiment Station-Morris; and seven locations on farmer cooperator fields (Table 1). At each location eight treatments with two replications were established. Four treatments were applied in the fall as 0, 40, 80, and 120 # N/A as ammonium nitrate, and similar treatments were established in the spring at each location. Soil samples were collected at three different times; in the fall and spring prior to fertilization treatments, and from the controls in the fall following completion of the experiment. Samples were collected to a depth of five feet in increments of one foot except for the surface, which was split into 6" increments. All samples were analyzed for nitrate nitrogen and soil moisture (Table 3). All cooperators were asked to follow normal management practices for the areas except for nitrogen fertilization or manure application.

Treatments were evaluated by obtaining leaf samples from opposite and below the ear at silking for nitrogen analysis, grain yields and nitrogen utilization by the grain.(Table 2)

General Results

The yields obtained from the experimental locations were excellent in 1978. Since differences between fall and spring applications of nitrogen were minor the respective treatments were averaged together to give more precision with rates of nitrogen application (Table 2). Only one location (4) out of the nine established reflected a significant positive yield increase to the application of fertilizer nitrogen.

Factors such as leaf nitrogen at silking, grain nitrogen and nitrogen removal with the grain are often utilized as guidelines in assessing nitrogen availability. Of the nine locations, four to seven locations showed positive responses to at least one of the above parameters. The increased availability, however, resulted in a yield increase only at one location. Marginal leaf nitrogen concentrations (2.5-2.7%) were observed at only two locations, while total nitrogen removal with the grain (protein/acre) was increased at four locations.

Yields and nitrogen utilization appeared to be highly correlated with soil nitrate nitrogen, but positioning of the nitrate in the soil profile as well as total soil nitrate nitrogen appeared to be important in nitrogen availability. Almost all of the locations tested low in nitrate nitrogen in the top two feet. Several locations had substantial amounts of nitrogen in the two to four foot depth. Nitrate nitrogen concentrations at the conclusion of the experiment suggested that the rooting systems were capable of extracting nitrate nitrogen to depths of 3-5 feet, but the depth of extraction varied between locations. The depth of nitrates within the profile also tended to reflect nitrogen availability. Nitrates in the two to three foot depth, as would be expected, were somewhat more available than the 3-4 foot depth. Very few locations showed appreciable extraction of nitrate nitrogen from the 4-5 ft. soil depth.

The use of a nitrate test for making fertilizer recommendations for corn appears to be a promising technique. Additional research to verify the depth necessary for sampling and the availability of nitrates deeper in the profile appears to be warranted.

Table 1. Location Number, Cooperator and County of the Experimental Sites.

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

Table 2. Influence of Nitrogen Treatments on Grain Yield, Leaf N at Silking, Grain N, and Grain Nitrogen Removal at Nine Locations in S.W. Minnesota

Nitrogen Rate	Location No. 1	2	3	4	5	6	7	8	9
#/A	Yield - bu/A								
0	112.7	141.0	108.0	125.3	117.1	135.4	116.5	147.9	93.2
40	127.6	146.1	101.4	121.4	136.6	136.2	115.7	145.1	91.8
80	133.5	142.9	107.4	131.6	128.3	134.8	123.2	149.4	99.3
120	117.1	151.1	101.6	139.0	127.0	140.5	118.1	141.0	94.2
Significance	NS	NS	NS	*	NS	NS	NS	NS	NS
BLSD(.05)				11.1					
	Leaf N-%								
0	2.64	2.72	3.50	2.86	2.67	2.94	2.41	2.92	3.22
40	2.86	2.92	3.17	2.98	2.64	2.93	2.34	3.00	3.31
80	3.04	3.13	3.62	3.24	2.79	2.87	2.54	3.03	3.60
120	3.23	3.10	3.26	3.28	2.76	3.19	2.68	3.04	3.77
Significance	**	+	NS	+	NS	+	NS	NS	**
BLSD(.05)	.25	.33		.29		.22			.25
	Grain N-%								
0	1.46	1.44	1.58	1.61	1.52	1.42	1.53	1.54	1.58
40	1.66	1.44	1.64	1.66	1.59	1.46	1.53	1.63	1.64
80	1.60	1.59	1.62	1.68	1.64	1.50	1.66	1.60	1.69
120	1.67	1.48	1.58	1.75	1.82	1.45	1.85	1.70	1.84
Significance	**	+	NS	+	**	NS	**	+	*
BLSD(.05)	.11	.11		.10	.15		.17	.13	.16
	N Removal with Grain-#/A								
0	78.1	96.7	80.6	95.4	83.6	90.6	84.5	107.0	69.8
40	100.2	99.2	78.5	95.0	102.9	93.6	83.6	111.7	71.6
80	100.9	107.5	82.2	104.9	99.2	95.2	96.9	113.1	79.4
120	92.5	106.2	76.1	115.2	109.2	96.3	103.4	115.2	81.9
Significance	*	NS	NS	**	+	NS	+	NS	NS
BLSD(.05)	16.7			8.4	17.8		14.4		

Table 3. Residual Nitrate Nitrogen Content by Depth at Nine Experimental Locations in S.W. Minnesota Measured at Three Different Times.

	Nitrate Nitrogen - #/Acre depth increment								
	Loc. 1			Loc. 2			Loc. 3		
depth -ft.-	Fall	Spring	Fall	Fall	Spring	Fall	Fall	Spring	Fall
0-½	15	8	14	11	14	19	8	11	65
½-1	19	10	7	7	15	9	14	19	21
1-2	90	32	25	18	22	10	56	40	20
2-3	126	111	30	23	45	10	55	37	29
3-4	9	18	60	54	108	122	5	56	54
Total	276	249	203	210	288	244	148	205	229

Previous Crop	Corn			Soybeans			Corn		
	Loc. 4			Loc. 5			Loc. 6		
	Fall	Spring	Fall	Fall	Spring	Fall	Fall	Spring	Fall
0-½	6	6	49	7	15	9	8	19	17
½-1	9	14	59	10	9	9	12	17	11
1-2	19	27	31	52	32	32	22	24	51
2-3	46	30	20	141	148	44	109	68	88
3-4	97	46	22	68	105	41	188	252	84
4-5	52	49	34	32	102	40	70	109	88
Total	229	175	215	310	411	175	409	489	339

Previous Crop	Soybeans			Corn			Corn		
	Loc. 7			Loc. 8			Loc. 9		
	Fall	Spring	Fall	Fall	Spring	Fall	Fall	Spring	Fall
	7	11		8	24	16	10	12	12
	8	8		17	16	9	13	19	6
	21	19		17	31	11	29	39	9
	22	22		21	32	12	78	101	34
	37	24		23	27	21	37	160	63
	22	22		20	29	27	28		31
Total	117	106		106	159	96	195	331	155

THE INFLUENCE OF NITRATE-NITROGEN OF SOUTHEASTERN MINNESOTA SOILS AND RESPONSE OF CORN TO ADDED NITROGEN FERTILIZER - 1978

C. Simkins - M. O'Leary - J. Lensing

In the spring of 1978, nitrate-nitrogen determinations were made on farmers corn fields in southeast Minnesota. Samples were taken in Dodge, Goodhue, Houston, Olmsted, Steele, Wabasha, and Winona Counties. Farmers applied their normal amount of nitrogen prior to planting their corn leaving 4 strips in their field where no nitrogen was applied. A comparison of yields was made on the treated and non-treated areas at harvest time.

Nitrate-Nitrogen Levels in the Soil - Spring 1978

Analysis were made on increments at six different depths:

0-6", 6-12", 12-24", 24-36", 36-48", 48-60"

The level of nitrate-nitrogen to a five foot depth is shown in Table 1. The total nitrate-nitrogen to a depth of 5 feet exceeded 100 lbs. per acre in all fields except two.

When one considers the nitrate-nitrogen to a depth of 2 feet one finds that approximately 50 percent of the fields contained less than 100 lbs. per acre of nitrate-nitrogen.

The number of fields falling within various levels at the 2 foot depth were as follows:

Lbs/Acre* NO_3N 2 Foot Depth	No Fields
0-30	4
31-55	5
56-85	2
86-120	5
121-150	1
Over 150	4

*Does not include Hempstead location

Table 1. Nitrate-Nitrogen in Several Southeast Minnesota Corn Fields - Spring 1978

	DEPTH INCHES						TOTAL
Cooperator	0-6"	6-12"	12-24"	24-36"	36-48"	48-60"	0-5'
			LBS/ACRE				
Dodge County							
Darr 2	22	19	64	69	60	31	266
Darr 1	14	16	36	44	46	24	180
Moenning	11	8	13	58	46	48	184
Rehwaldt	14	13	28	43	46	28	172
Goodhue County							
Bodin	27	17	64	32	20	13	173
Quiggle	83	73	110	65	36	30	397
Voxland	30	27	115	115	61	40	388
Houston County							
Beranek	7	5	11	16	23	14	76
Davison	13	13	30	43	38	31	168
Hempstead	32	33	84	114	100	55	418
McCormick	53	28	40	84	64	46	315
Hochiet	50	50	75	111	153	142	581
Olmsted County							
Pagel	11	8	10	23	32	14	102
Steele County							
Abbe	39	29	42	36	39	34	219
Strodtman	22	23	23	24	26	20	138
Klemmenson	16	16	22	39	20	13	126
Wabasha County							
Cerise	22	28	48	21	15	17	151
Drysdale	15	12	26	69	69	24	215
Graner	20	19	117	86	9	7	258
McNallen	6	4	7	10	26	26	79
Winona County							
Redig	43	18	34	84	69	37	285

Yields of Corn on Nitrogen Fertilized and Un-Fertilized Areas

Yields of corn on all fields except one exceeded 100 bushels per acre. Three locations were not harvested due to flooding and inability to plant. The Hemsted location was also flooded several times and although the soil indicated a rather high nitrate-nitrogen level (149 lbs. in the top feet) there was an excellent response to nitrogen fertilizer (36 bu. increase). Yields and quantity of nitrogen used are shown in Table 2.

Table 2. Yields of Corn Grain on Nitrogen Fertilized and No Nitrogen Fertilized Areas - Southeast Minnesota - 1978

Cooperator	Nitrogen Lbs/A	Yield bu/A No Nitrogen	Yield bu/A Nitrogen	Increase
Darr 1	170	141	168	27
Darr 2	170	122	135	13
Moenning	162	109	130	21
Rehwaldt	160	140	157	17
Bodin (irrigated)	186	148	151	3
Quiggle	203	143	151	8
Voxland	124	134	138	4
Beranek	NOT HARVESTED			
Davison	167	141	152	9
Hempstead	179	88	124	36
McCormick	134	168	163	-5
Hochiet	127	163	153	-10
Pagel	100	62	82	20
Abbe	150	151	150	-1
Strodtman	NOT PLANTED			
Klemmensen	152	128	152	24
Cerise	155	119	127	8
Drysdale	140	129	144	15
Graner	147	134	138	4
McNallen	NOT HARVESTED			
Redig	20 Ton Manure	127	121	-6

Results and Discussion

The average yield increase from nitrogen use at various nitrate-nitrogen levels 0-24" depth are shown in Table 3.

The response in corn yields to added nitrogen fertilizer (range from 100 to 203 lbs/N per acre) decreased with increasing level of soil nitrate-nitrogen.

The data suggests that the greatest increase in corn yields due to nitrogen fertilizer occurs when the nitrate-nitrogen level is below 85 lbs. of nitrate-nitrogen per 2 foot soil depth.

A comparison of the percent increase of corn yields with the nitrate-nitrogen level of the soil at a 2 foot depth indicates a correlation of $r^2 = 0.74$ significant at the 1% level. The equation is:

$$\% \text{ yield increase} = \frac{892.3}{\text{Lbs } NO_3N \text{ (0-2')}} - 3.11$$

Table 3. Levels of NO_3N at 2 Foot Depth and Yield Increase Due to Nitrogen Fertilization - Southeast Minnesota - 1978

Level* Lbs/Acre	Yield Increase Bu/A
0-30	20
31-55	19
56-85	18
86-120	4
121-150	-3
Over 150	1

*Does not include Hempstead location

Yield increases from these trials on farmers fields indicate that the nitrate-nitrogen level to a 2 foot depth is a good indicator of the need for additional nitrogen for corn.

Results from the past two years research would indicate that those fields with more than 150 lbs. of nitrate-nitrogen in the top 2 feet are unlikely to respond to nitrogen fertilizer applications.

Experience from these trials also indicate the test is not a good indicator of nitrogen needs on fields that may be subjected to flooding or extremely poor drainage conditions.

NITROGEN CARRYOVER IN THE SOIL PROFILE ON CONTINUOUS CORN AND RELATIONSHIP TO THE NEXT YEAR'S YIELD

C. J. Overdahl and R. P. Schoper

In 1969, an experiment was initiated in Martin County to study nitrogen needs and accumulation of nitrogen in the soil profile. After the completion of the 1975 crop year, a bulletin, Miscellaneous Report 153, was published.

In 1976, the design on the experimental site was altered to further study the nitorgen accumulation and to attempt to determine whether measuring this accumulation would result in predictions of nitrogen needs the following year. Plots were split and no additional nitrogen treatments were made on half of each plot. This allowed for an observation on how long the accumulation lasted. There are two sets of plots just 28 feet from each other. One plot is on land under many years of continuous corn; the other was virgin land until 1970, and in continuous corn since then.

Drouth and smut was a serious problem in 1976; in 1977 drouth again limited yields. Although 1977 was generally a good rainfall year in Minnesota, the rather severe drouth of North Central Iowa extended into the Martin County area. In 1978, rainfall was high and resulted in the most satisfactory yields.

Table 1. Nitrate tests from fall 1975 compared to 1976 corn yields (under long-time continuous corn).

Test Depth	Annual Nitrogen Treatments/Acre - 1970 to 1976					
	0	50	100	150	200	400
	(nitrate-N 1975 - lbs/acre)					
0 - 2'	36	40	60	136	168	420
0 - 3'	48	48	132	208	252	624
	(corn yields 1976 - bu/acre)					
	60a	79a	92b	80b	78ab	89b

Table 2. Nitrate tests from fall 1975 compared to 1976 corn yields (virgin land until 1970)

Test Depth	Annual Nitrogen Treatments/Acre - 1970 to 1976					
	0	50	100	150	200	400
	(nitrate-N 1975 - bu/acre)					
0 - 2'	60	60	84	108	276	488
0 - 3'	80	96	136	180	392	748
	(corn yields * 1976 - bu/acre)					
	98	104	99	109	103	98

* no significant nitrogen effect on yield

Table 3. Nitrate tests from fall 1976 compared to 1977 corn yield (under long-time continuous corn)

Test Depth	Annual Nitrogen Treatments/Acre 1970 to 1976: 0	50	100	150	200	400
	(nitrate-N 1976 lbs/acre)					
0 - 2'	36	36	96	116	236	460
0 - 3'	44	48	128	204	312	524
	(corn yields* bu/acre 1977)					
No N in 1977	81	97	92	102	84	91
N added 1977	85	93	100	93	91	80

* Drouth limited 1977 yields, no significant treatment effect.

Table 4. Nitrate tests from fall 1976 compared to 1977 corn yield (virgin land until 1970).

Test Depth	Annual Nitrogen Treatments/Acre 1970 to 1976: 0	50	100	150	200	400
	(nitrate-N 1976 lbs/acre)					
0 - 2'	36	64	136	176	264	636
0 - 3'	52	88	248	248	338	680
	(corn yields* bu/acre 1977)					
No N in 1977	104	106	103	100	110	89
N added 1977	94	102	108	107	114	95

* Drouth limited 1977 yields, no significant treatment effect.

Table 5. Nitrate tests from fall 1977 compared to 1978 corn yield (under long-time continuous corn).

	Annual Nitrogen Treatments/Acre 1970-1976					
Test Depth	0	50	100	150	200	400
			(nitrate-N 1977 lbs/acre)			
0 - 2'	40	56	56	92	104	380
0 - 3'	84	126	92	196	166	588
			(corn yields bu/a 1978)			
No N since 1976	101	112	115	144	141	146
No N since 1977	112	125	136	157	157	159

BLSD = 20 bu.

Table 6. Nitrate tests from fall 1977 compared to 1978 corn yield (virgin land until 1970).

	Annual Nitrogen Treatments/Acre 1970-1976					
Test Depth	0	50	100	150	200	400
			(nitrate-N 1977 lbs/acre)			
0 - 2'	32	56	96	52	48	116
0 - 3'	72	180	402	228	198	528
			(corn yields* bu/acre 1978)			
No N since 1976	164	161	161	163	168	169
No N since 1977	162	171	172	173	171	162

*No significant treatment effect

Table 7. Percent nitrogen in 6th leaf at tasselling time according to nitrogen treatment. Martin County 1976, 1977, 1978.

	Lb N/Acre Annually 1970 to 1976					
	0	50	100	150	200	400
plots under long term continuous corn						
1976	1.6	2.1	2.4	2.3	2.6	2.6
1977 A*	1.8	2.2	2.3	2.5	2.5	2.6
B*	1.8	2.2	2.3	2.5	2.4	2.5
1978 A*	2.0	2.1	2.3	2.6	2.4	2.4
B*	1.7	2.1	2.3	2.6	2.5	2.5
virgin land until 1970, continuous corn 1970 to 1978						
1976	1.9	2.4	2.3	2.4	2.3	2.5
1977 A	2.2	2.4	2.4	2.6	2.6	2.5
B	2.1	2.4	2.4	2.4	2.5	2.4
1978 A	2.1	2.5	2.8	2.6	2.7	2.7
B	2.3	2.6	2.9	2.8	2.8	2.7
related corn yields bu/acre, long term continuous corn plots						
1976	60	76	92	80	78	89
1977 A	81	97	92	102	84	91
B	94	102	108	107	114	95
1978 A	101	112	115	144	141	146
B	112	125	136	157	157	159

1976 sampled July 21
1977 sampled July 21
1978 sampled July 24
*A - no N applied 1977
*B - regular N treatments made 1977

Table 8. Nitrate-N to 6 feet in pounds per acre, 1978.

	Annual treatment of N, lb/acre before 1977											
	0		50		100		150		200		400	
	A	B	A	B	A	B	A	B	A	B	A	B
0-1	29	29	30	31	27	26	33	27	32	26	33	32
1-2	8	8	7	8	7	8	9	9	10	7	55	50
2-3	8	8	16	8	33	9	52	28	60	20	142	150
3-4	12	9	49	17	33	29	99	59	110	59	208	236
4-5	18	16	65	32	55	50	90	86	167	68	214	233
5-6	27	20	71	44	55	48	103	99	199	101	142	211
	virgin area, (rep 7 & 8 only and no B areas sampled)											
0-1	30	-	32	-	38	-	51	-	47	-	52	-
1-2	7	-	7	-	8	-	59	-	27	-	115	-
2-3	7	-	12	-	34	-	113	-	99	-	335	
3-4	11	-	24	-	34	-	193	-	153	-	472	-
4-5	17	-	32	-	77	-	160	-	260	-	500	-
5-6	18	-	33	-	67	-	167	-	127	-	449	-

A - nitrogen treatments omitted 1977, 1978

B - nitrogen omitted only in 1978

Summary

It was not possible to determine the effect of profile nitrates on corn yield for 1976 and 1977 since low rainfall prevented significant yield increases from nitrogen.

In 1978 on the long term cultivation plots (Table 5) there was a significant effect on yield from 150 pounds of nitorgen applied two years earlier. This 150 maintained a nitrate test down to 2 feet at 92 pounds per acre compared to only 40 on the check plot. Where the nitrate test was 104 or 380 from higher nitrogen treatments, no further significant yield increase was obtained.

On the plots receiving 100 pounds of nitrogen in 1977 but none in 1978, treatment carryover gave a significant yield increase in 1978. The soil nitrate test to 2 feet was 56 pounds. Soil nitrate test above this gave higher yields. The 150 pound carryover treatment from 1977 gave the maximum yield. Rates of 200 or 400 pounds gave nitrate readings of 104 and 380 pounds, but no higher yield than where the nitrate test was 92 pounds.

On these fine textured soils there was considerable nitrogen effectiveness 2 years after treatment. Perhaps this is related to low rainfall conditions in 1976 and 1977.

It is difficult to speculate on the importance of sampling to 3 feet.

Use of N-Serve in Fall vs. Spring Nitrogen Application Programs on Fine Textured Soils of Minnesota

G.L. Malzer, G.W. Randall, W.W. Nelson, S.Evans, and G. Varvel

A considerable interest has developed over the last several years concerning the use of N-Serve as a nitrification inhibitor with ammonium forming fertilizers on the fine textured soils of Minnesota. On many of these fine textured soils depending on the climatic conditions encountered and internal soil drainage, losses of nitrate nitrogen may occur through denitrification. If this loss occurs, a portion of the plant available nitrogen is lost, and yield reductions may develop. With the normally cool wet spring conditions which are encountered on most of these soils there may also be a considerable advantage in time management, associated with earlier nitrogen fertilization. This condition exists provided that nitrogen losses are not severe in the interim period. If nitrification inhibitors are capable of minimizing the production of nitrate nitrogen with fall nitrogen applications they may have the advantage of minimizing potential nitrate nitrogen losses as well as increasing the length of time that would be available in the fall to apply nitrogen (prior to 50-55^{o} soil temperatures).

Experiments were established at four University of Minnesota Experiment Stations with the following objectives: 1) to evaluate the importance of timing of nitrogen application (fall vs. spring) on yield components and nitrogen utilization of corn and spring wheat; 2) to determine the importance of soil temperature on the rate of nitrification with early and late applied nitrogen; and 3) to examine the influence of N-Serve on yield components, nitrogen utilization by the crops, and its influence on the rate of nitrification within the soil.

Experimental Procedures

Four similar experiments were established one each at the Southern Experiment Station at Waseca, the Southwest Experiment Station at Lamberton, the West Central Experiment Station at Morris and the Northwest Experiment Station at Crookston. Each experiment consisted of four times of nitrogen application (3 fall and 1 spring) two rates of nitrogen in addition to a check and all potential nitrogen treatments and times of application either had N-Serve at 0.5 # ai/A applied with it or contained no N-Serve. Times and rates of nitrogen application were adjusted for each experimental site to conform with the geographic area. The experimental treatments at each location are included in Table 1.

Each experimental site was fertilized with phosphorus and potassium according to soil test recommendations prior to establishment of treatments. All nitrogen applications were made with anhydrous ammonia with N-Serve injected into the tank for the appropriate treatments. Anhydrous knife spacings were 30" for corn production and approximately 15" for wheat. All primary tillage was done prior to the first nitrogen application with only secondary tillage prior to planting. Several areas within each plot received no tillage after nitrogen application for use in collection of soil samples from the anhydrous applicaton zones.

In order to follow the rate at which the ammonium nitrogen was converted to nitrate nitrogen soil samples were collected and analyzed from a 0-1 ft. depth over the anhydrous injection area at approximately one week intervals following nitrogen application. Soil samples were also collected and analyzed at monthly intervals to a depth of five feet in order to follow nitrate nitrogen accumulation within the soil profile.

Treatment influences on nitrogen utilization by the crop were evaluated in several manners. Corn leaf samples from opposite and below the ear at 50% silking were collected and analyzed for Kjeldahl nitrogen content. Forage dry matter production and nitrogen removal was measured by hand harvesting 15' of row from the corn plots, separation of samples into ear and stover components, field weights obtained and nitrogen content and moisture determined from subsamples. Grain yields were obtained by either hand harvesting or machine harvesting known areas from each plot and then determination of the nitrogen content (protein) by Kjeldahl analysis for calculation of nitrogen removal.

General Results

Positive yield responses were obtained to the application of nitrogen in only two locations (Waseca and Crookston). The yield levels attained within all four experiments and experimental locations were above average reflecting the good growing conditions that were experienced in 1978. The high yields that were obtained when no nitrogen was applied (control) reflect the high nitrogen supplying power of these soils (residual and mineralizable).

The nitrogen content of the leaf opposite at below the ear at silking was significantly influenced by the treatments in all three locations growing corn (Table 2). The nitrogen content of the leaf when nitrogen was applied in the early fall, was significantly lower than the later fall or spring applications at all locations. Only at the Waseca location was leaf N concentration higher with a spring application than with the two later fall applications. Leaf N content increased with nitrogen rates up through the highest rate applied at all three locations. N-Serve had a positive influence on leaf N content at Morris, a negative influence at Lamberton, and no significant influence at Waseca.

Grain yields (Table 3) were influenced relatively little by treatments. Only the Waseca and Crookston experiments gave positive yield responses to nitrogen application, with only the Crookston location with wheat reflecting a yield response to the highest rate of nitrogen applicaton. Timing of nitrogen application significantly influenced yields in only one location (Lamberton), with the spring and mid fall treatment lower than the earliest fall applications. This suggests that some other factor other than those investigated was influencing yield, since no nitrogen response was indicated at Lamberton. There was no yield advantage to the use of N-Serve with fall N applications at any of the four experimental locations. A significant yield advantage at the medium nitrogen rate was observed with N-Serve in spring applications at Waseca. No other locations reflected responses with spring applications.

Total nitrogen removal with the grain was significantly influenced by treatments at all four locations. In general nitrogen removal reflected rates and times of application with increasing removal at the higher rates of applications and reduced uptake with early application dates. Only at Lamberton was nitrogen removal decreased with spring application. Nitrogen removal with the grain was not influenced by time of application at the Crookston location. N-Serve had no positive influence on nitrogen removal with the grain at any location. A significant reduction in nitrogen removal was obtained with N-Serve at the Lamberton location.

The rate at which ammonium nitrogen was converted to nitrate nitrogen is presented in Table 5. In general, the later nitrogen was applied in the fall, the greater the ammonium concentration the following spring. The nitrification reaction appeared to take place much more rapidly at the Morris and Crookston locations than was evident at Lamberton or Waseca. The use of N-Serve appeared to have an effect on delaying nitrification, but the extent of influence was dependent upon location and time of application. Whether delaying nitrification will have any influence on nitrogen availability will depend upon the climatic conditions encountered and the net nitrogen losses experienced during or prior to the growing season.

Table 1. Experimental Treatments with Fall vs. Spring Nitrogen Application with and without N-Serve.

Experimental Location	Nitrogen Rate	Date of Appl.		N-Serve Rate	Test Crop
	#/A	1977-78		#ai/A	
Waseca	0	9/14	10/14	0,½	Corn
	75	11/7	5/2		(Pioneer 3780)
	150				
Lamberton	0	9/15	10/6	0,½	Corn
	50	11/1	5/11		(Pioneer 3780)
	100				
Morris	0	8/25	9/28	0,½	Corn
	40	10/25	5/17		(Dekalb XL12)
	80				
Crookston	0	8/24	10/2	0,½	Wheat
	40	10/25	4/27		(Era)
	80				

Table 2. Nitrogen Content of the Leaf Opposite and Below the Ear at Silking as Influenced by Nitrogen Rate, Timing of Nitrogen Application and Use of N-Serve.

Treatments[1]			Leaf N Content		
Date of N Appl.	N Rate	N-Serve	Waseca	Lamberton	Morris
		0.5 #ai/A		%	
Control	0	No	2.13	2.84	2.52
Early Fall	Med.	No	2.64	2.98	2.83
Early Fall	Med.	Yes	2.66	2.94	3.14
Early Fall	High	No	2.65	3.14	3.06
Early Fall	High	Yes	2.64	3.11	3.04
Mid Fall	Med.	No	2.65	3.18	3.16
Mid Fall	Med.	Yes	2.68	3.20	3.23
Mid Fall	High	No	2.94	3.23	3.33
Mid Fall	High	Yes	2.94	3.15	3.41
Late Fall	Med.	No	2.54	3.19	3.10
Late Fall	Med.	Yes	2.72	2.91	3.19
Late Fall	High	No	2.96	3.29	3.34
Late Fall	High	Yes	2.91	3.22	3.34
Spring	Med.	No	2.80	3.06	3.26
Spring	Med.	Yes	2.81	3.05	3.26
Spring	High	No	3.06	3.22	3.23
Spring	High	Yes	3.18	3.81	3.42
Significance			**	**	**
BLSD(.05)			.22	.15	.18
Factorial Arrangement					
Application date					
Early fall			2.65	3.04	3.02
Mid fall			2.80	3.19	3.28
Late fall			2.78	3.15	3.24
Spring			2.96	3.16	3.29
Significance			**	**	**
BLSD(.05)			.11	.08	.08
Nitrogen rate					
Med.			2.69	3.06	3.15
High			2.91	3.21	3.27
Significance			**	**	**
BLSD(.05)			.11	.06	.06
N-Serve					
No			2.78	3.16	3.16
Yes			2.82	3.11	3.25
Significance			NS	+	**
BLSD(.05)				.05	.06

[1]See Table 1 for dates and rates of nitrogen application.

Table 3. Influence of Nitrogen Rate, Timing of Nitrogen Application and N-Serve on Grain Yields - 1978.

Treatments[1]			Grain Yields			
Date of N Appl.	N Rate	N-Serve	Waseca	Lamberton	Morris	Crookston
		0.5#ai/A	----------	----------	bu/A	----------
Control	0	No	130.6	119.2	115.6	32.5
Early Fall	Med.	No	158.0	129.0	131.0	47.3
Early Fall	Med.	Yes	159.9	127.0	125.3	43.9
Early Fall	High	No	168.7	127.6	127.0	51.8
Early Fall	High	Yes	171.4	123.6	126.7	49.5
Mid Fall	Med.	No	174.3	122.4	132.0	44.7
Mid Fall	Med.	Yes	163.7	125.4	133.6	47.4
Mid Fall	High	No	166.3	122.5	131.1	53.2
Mid Fall	High	Yes	165.6	117.5	129.3	54.2
Late Fall	Med.	No	170.7	124.3	129.4	43.0
Late Fall	Med.	Yes	172.1	122.3	130.3	39.6
Late Fall	High	No	170.5	125.8	131.6	51.8
Late Fall	High	Yes	171.0	123.8	135.3	50.6
Spring	Med.	No	162.4	126.4	126.5	47.0
Spring	Med.	Yes	176.7	119.9	128.6	45.5
Spring	High	No	166.2	121.3	130.0	47.9
Spring	High	Yes	165.4	121.5	129.3	52.1
Significance			**	NS	NS	**
BLSD(.05)			12.2			8.4
Application date						
Early Fall			164.5	126.8	127.5	48.1
Mid Fall			167.5	122.0	131.5	49.9
Late Fall			171.1	124.0	131.7	46.3
Spring			167.7	120.1	128.6	48.1
Significance			NS	*	NS	NS
BLSD(.05)				4.4		
Nitrogen rate						
Med.			167.2	123.5	129.6	44.8
High			168.1	123.0	130.0	51.4
Significance			NS	NS	NS	NS
BLSD(.05)						2.7
N-Serve						
No			167.1	123.8	129.8	48.3
Yes			168.2	122.6	129.8	47.8
Significance			NS	NS	NS	NS
BLSD(.05)						

[1] See Table 1 for dates and rates of application.

Table 4. Influence of Nitrogen Rate, Timing of Nitrogen Application and N-Serve on Nitrogen Removal with the Grain.

Treatments[1]			Grain N Removal			
Date of N Appl.	N Rate	N-Serve	Waseca	Lamberton	Morris	Crookston
		0.5#ai/A				
Control	0	No	66.8	81.0	71.1	41.3
Early Fall	Med.	No	102.0	97.8	92.5	65.6
Early Fall	Med.	Yes	101.8	90.5	101.5	67.2
Early Fall	High	No	120.8	90.4	102.7	75.3
Early Fall	High	Yes	122.0	89.1	94.9	65.3
Mid Fall	Med.	No	119.2	92.4	103.6	60.7
Mid Fall	Med.	Yes	110.6	93.9	100.5	63.9
Mid Fall	High	No	128.0	102.9	107.4	76.5
Mid Fall	High	Yes	126.2	95.2	114.9	76.7
Late Fall	Med.	No	110.2	88.8	101.4	58.6
Late Fall	Med.	Yes	115.4	90.8	101.7	54.1
Late Fall	High	No	134.9	99.4	111.0	76.6
Late Fall	High	Yes	132.6	92.9	109.1	71.1
Spring	Med.	No	107.1	95.9	103.8	67.6
Spring	Med.	Yes	121.7	82.2	98.4	63.3
Spring	High	No	127.8	93.4	111.3	75.5
Spring	High	Yes	129.3	89.2	107.4	77.2
Significance			**	**	**	**
BLSD(.05)			13.3	9.5	11.3	11.5
Factorial Arrangement						
Application date						
Early Fall			111.6	92.0	113.5	68.4
Mid Fall			121.0	96.1	124.5	69.5
Late Fall			123.2	93.0	127.3	65.1
Spring			121.5	90.2	125.3	70.9
Significance			*	+	**	NS
BLSD(.05)			7.6	4.1	6.5	
Nitrogen rate						
Med.			111.0	91.5	116.6	62.6
High			127.7	94.1	128.7	74.3
Significance			**	NS	**	**
BLSD(.05)			6.7		4.8	4.0
N-Serve						
No			118.7	95.1	122.2	69.5
Yes			120.0	90.5	123.1	67.4
Significance			NS	**	NS	NS
BLSD(.05)				3.1		

[1]See Table 1 for dates and rates of nitrogen application.

Table 5. Influence of Timing of Nitrogen Application and the Use of N-Serve on the Persistence of Ammonium Nitrogen Within the Soil in Early Spring.

Treatment		% of Original NH_4^+-N			
Date of N Appl.	N-Serve	Waseca	Lamberton	Morris	Crookston
	0.5#ai/A	May 10	May 18	May 25	May 17
		--------------------%			
Early Fall	No	6	24	5	14
Early Fall	Yes	12	57	12	20
Mid Fall	No	23	19	4	7
Mid Fall	Yes	42	35	5	26
Late Fall	No	32	53	9	7
Late Fall	Yes	43	78	12	21
Spring	No	79	38	32	57
Spring	Yes	85	68	35	100

HIGH PHOSPHORUS AND POTASSIUM RATES FOR CONTINUOUS CORN
1978

Gyles W. Randall, Samuel D. Evans and Wallace W. Nelson

EXPERIMENTAL PROCEDURES

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

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

Trt.	Application Year (Fall)				
No.	1973	1974	1975	1976	1977
	lbs. P_2O_5 + K_2O				
1	0 + 0	0 + 0	0 + 0	0 + 0	0 + 0
2	0 + 100	0 + 100	0 + 100	0 + 100	0 + 100
3	50 + 100	50 + 100	50 + 100	50 + 100	50 + 100
4	100 + 100	100 + 100	100 + 100	100 + 100	100 + 100
5	150 + 100	0 + 100	0 + 100	150 + 100	0 + 100
6	100 + 0	100 + 0	100 + 0	100 + 0	100 + 0
7	100 + 50	100 + 50	100 + 50	100 + 50	100 + 50
8	100 + 150	100 + 0	100 + 0	100 + 150	100 + 0
9	150 + 100	0 + 0	0 + 0	0 + 0	0 + 0
10	100 + 150	0 + 0	0 + 0	0 + 0	0 + 0

Treatment numbers 2, 3, 4, 5, 6, 7, 8 were broadcast on cornstalks and plowed down at all locations in the fall of 1977. Phosphorus was applied as CSP (0-46-0) and K as muriate of potash (0-0-60). Starter fertilizer was not used.

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

Table 2. Experimental procedures for the high P and K rate study on continuous corn at the three branch stations in 1978.

Variable	Lamberton	Morris	Waseca
Planting date	5/5	5/12	5/12
Row spacing	30"	30"	30"
Population	23,000	22,000	26,500
Hybrid	Pioneer 3780	Dekalb XL12	Pioneer 3780
Nitrogen rate	75# N	110# N	175# N
Herbicide	2.5# Eradicane + 1.5# Bladex/A (Bdct)	2# Lasso + 2.2# Bladex/A (Bdct)	3# Lasso + 2.5# Atrazine/A (Bdct)
Insecticide	1# Counter/A	1.2# Mocap/A	1# Dyfonate/A
Harvest date	10/9	10/5	10/5

RESULTS AND DISCUSSION

Soil samples were taken at the end of the 1978 growing season. Results obtained in 1978 were similar to those obtained in 1977. Soil test P was affected significantly at all three locations (Table 3). There appeared to be a linear response to annual P application. Soil test P was always lowest with treatments 1 and 2, which received no P, and treatments 9 and 10, which only received an initial application in 1973. Intermediate P levels were found with treatment 3 (50 lb P_2O_5 annually) and treatment 5 (150 lb P_2O_5 every third year) at all locations. Highest soil test P values were associated with the annual 100 lb P_2O_5 treatments at all locations. Use of the 1:50 soil to Bray P_1 solution ratio on the calcareous Aastad soil at Morris indicates high amounts of extractable P in this soil; over twice that indicated by the 1:10 ratio.

Soil test K was influenced (P=.10) by the K treatments at Lamberton but not at Morris and Waseca (Table 3). These results are almost identical to the last two years. As with P there appears to be somewhat of a linear response to the annual K applications but the relationship is not as pronounced. Soil pH was not related to the P and K treatments.

Approximately 5-6 weeks after planting, ten plants randomly selected from each plot were measured, harvested, dried and weighed to determine early plant growth. Early plant height was increased significantly (P=.01) by the treatments at all three locations (Table 4). Plant weight at Morris and Waseca were increased significantly but were not at Lamberton. Both plant weight and height were generally lowest with the check treatment (no. 1), the 0 P_2O_5 treatment (no. 2) and the two treatments which haven't been applied since 1973 (nos. 9 and 10). The growth response was due primarily to P. Early weight was increased over the 0 P_2O_5 rate (no. 2) by the 50 and 100 lb P_2O_5 rates by 19 and 15% at Lamberton, 35 and 81% at Morris, and 20 and 37% at Waseca, respectively. No effect of K was noticed except at the Waseca location where a 14% weight increase was noted with the 100 lb K_2O treatment.

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

Treatment No.	Description[2/]	pH La	pH Mo	pH Wa	P La	P M_{10}	P M_{50}	P Wa	K La	K Mo	K Wa
	lb P_2O_5+K_2O/A				--------	--------	lb/A	--------	--------	--------	--------
1	0 + 0	5.7	7.8	5.9	30	10	27	27	166	264	190
2	0 + 100	5.7	7.9	5.9	28	10	28	22	214	314	232
3	50 + 100	6.3	7.8	5.7	38	27	62	34	204	286	203
4	100 + 100	5.7	7.8	5.9	54	40	92	52	204	288	220
5	0 + 100	6.0	7.8	5.8	42	25	64	36	208	269	205
6	100 + 0	5.7	7.8	5.9	53	44	107	46	178	235	185
7	100 + 50	5.8	7.9	5.9	51	37	90	49	192	269	202
8	100 + 0	5.8	7.6	5.8	52	48	106	53	182	261	210
9	0 + 0	6.1	7.8	6.0	40	17	44	26	182	253	196
10	0 + 0	5.7	7.8	6.0	41	13	34	23	178	260	209
	Significance:[3/]	NS	NS	NS	**	**	**	**	+	NS	NS
	BLSD (.05) :				16	6	11	7			
	CV (%) :	7	3	4	23	16	13	14	12	13	11

[1/] Samples were taken in October before the 1978 treatments were applied.

[2/] Rates applied in fall of 1977 for 1978 crop.

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

Table 4. Early plant growth characteristics as influenced by high P and K rates at the three experimental sites in 1978.

Treatment No.	Description	Weight La	Weight Mo	Weight Wa	Height La	Height Mo	Height Wa
	lb P_2O_5+K_2O/A	g/dry plant			---inches---		
1	0 + 0	2.8	2.5	8.5	15	17	28
2	0 + 100	2.7	2.6	7.8	16	17	28
3	50 + 100	3.2	3.5	9.4	18	20	30
4	100 + 100	3.1	4.7	10.7	18	22	32
5	0 + 100	3.0	4.1	9.5	17	22	30
6	100 + 0	3.3	4.5	9.4	18	22	30
7	100 + 50	3.2	3.7	9.7	18	22	30
8	100 + 0	3.0	5.2	9.7	18	24	29
9	0 + 0	3.1	2.5	8.2	17	18	28
10	0 + 0	2.8	2.6	7.1	16	18	28
	Significance:	NS	**	*	**	**	**
	BLSD (.05) :		1.4	2.0	1.0	2.1	2.4
	CV (%) :	15	26	13	4	8	5

Table 5. Effect of high P and K rates on the nutrient concentrations in the small whole plants at the three experimental sites in 1978.

Treatment No.	Description	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb P_2O_5+K_2O/A	---------%---------				----------ppm----------				
						Lamberton				
1	0 + 0	.40	3.58	.60	.50	240	60	40	8	20
2	0 + 100	.39	4.21	.50	.39	213	56	37	8	22
3	50 + 100	.44	4.17	.59	.44	240	62	31	8	20
4	100 + 100	.44	4.52	.49	.35	253	53	32	7	23
5	0 + 100	.43	4.18	.57	.42	228	63	34	8	18
6	100 + 0	.43	3.65	.60	.48	216	58	34	7	19
7	100 + 50	.44	4.32	.55	.39	213	56	37	8	19
8	100 + 0	.42	4.01	.58	.41	222	57	32	7	20
9	0 + 0	.40	3.82	.60	.46	211	60	36	8	20
10	0 + 0	.40	3.80	.57	.44	224	54	36	8	21
Significance:		**	**	*	**	NS	NS	NS	NS	NS
BLSD (.05) :		.03	.41	.09	.08					
CV (%) :		4.9	6.8	9.2	11.2	12.0	14.6	15.4	9.4	12.4
						Morris				
1	0 + 0	.41	4.22	.75	.66	499	82	53	11	7
2	0 + 100	.41	4.88	.60	.55	478	77	52	10	7
3	50 + 100	.46	4.91	.69	.52	556	79	46	9	7
4	100 + 100	.45	4.80	.71	.54	523	79	43	9	7
5	0 + 100	.43	4.70	.65	.56	552	82	46	9	7
6	100 + 0	.46	4.12	.77	.64	539	84	42	9	7
7	100 + 50	.46	4.46	.74	.55	580	83	42	9	7
8	100 + 0	.48	4.42	.71	.59	552	80	40	8	6
9	0 + 0	.44	4.15	.74	.69	474	82	48	10	7
10	0 + 0	.42	4.33	.73	.64	472	80	52	10	7
Significance:		**	**	**	**	NS	NS	**	**	*
BLSD (.05) :		.03	.22	.07	.06			4	.8	.7
CV (%) :		4.4	3.7	6.3	7.3	13.5	6.4	6.2	5.6	5.5
						Waseca				
1	0 + 0	.49	2.97	.53	.38	425	60	48	8	7
2	0 + 100	.45	3.44	.50	.31	551	62	47	8	7
3	50 + 100	.50	3.56	.50	.34	412	65	48	7	7
4	100 + 100	.57	3.53	.52	.34	362	60	48	6	8
5	0 + 100	.52	3.29	.53	.32	331	69	46	8	8
6	100 + 0	.54	2.94	.60	.38	374	66	41	7	7
7	100 + 50	.54	3.04	.57	.38	371	64	45	7	7
8	100 + 0	.51	2.93	.52	.34	455	62	43	7	7
9	0 + 0	.49	2.92	.56	.40	395	66	45	9	7
10	0 + 0	.47	3.10	.51	.35	438	58	46	7	7
Significance:		**	**	**	+	*	NS	NS	**	*
BLSD (.05) :		.06	.30	.06		138			1.3	0.6
CV (%) :		7.3	6.6	6.4	11.8	19.2	9.2	16.0	11.2	5.1

The small plants were chemically analyzed with the results from all locations shown in Table 5. Concentrations of P, K, Ca and Mg were affected significantly by the treatments at all locations. Whole plant P and K were consistently increased by the P and K treatments while Ca and Mg were generally decreased by the K additions. A linear response to applied P was noticed only at the Waseca location. Zinc concentrations were depressed by the 50 and 100 lb P_2O_5/A rates at Morris and Lamberton; although because of high variability at Lamberton these differences were not significant.

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

No significant differences in final population were found among the 10 treatments at either Morris or Lamberton (Table 7). Grain moisture an indication of maturity at harvest was reduced significantly by both the P and K treatments at Morris (Table 7); however, P appeared to have a greater effect than K.

The influence of the five years of P and K application on silage and grain yields for all three locations is given in Table 8. Silage yields were not increased significantly (P=.10) by the P and K treatments at any location. Grain yields at Waseca after 5 years of treatment application were significantly increased (P=.01) primarily by the P treatments. Although a trend toward higher yields with P was evident at Morris, the differences were not significant at the 90% level. Grain yields at Lamberton were also not influenced.

Table 6. Effect of high P and K rates on the nutrient concentrations in the corn leaf at the three experimental sites in 1978.[1/]

Treatment No.	Treatment Description	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb P_2O_5+K_2O/A	---------%---------				---------ppm----------				
						Lamberton				
1	0 + 0	.24	2.05	.66	.48	111	40	27	5.0	12
2	0 + 100	.23	2.19	.63	.36	104	30	24	3.8	12
3	50 + 100	.24	2.23	.68	.39	102	38	20	3.9	12
4	100 + 100	.26	2.23	.70	.39	116	33	21	4.2	12
5	0 + 100	.24	2.15	.63	.39	98	40	21	4.1	12
6	100 + 0	.26	2.06	.70	.48	124	42	22	4.9	12
7	100 + 50	.25	2.25	.65	.41	106	35	22	4.4	12
8	100 + 0	.26	2.17	.65	.40	106	40	23	4.6	12
9	0 + 0	.25	2.06	.75	.52	131	45	23	5.1	13
10	0 + 0	.24	2.08	.62	.42	103	37	25	4.7	13
Significance:		NS	NS	+	*	**	NS	NS	*	NS
BLSD (.05) :					.10	15			1.0	
CV (%) :		6.4	7.4	8.4	13.6	8.9	18.4	16.8	12.9	12.0
						Morris				
1	0 + 0	.28	1.87	.63	.55	21	63	23	7.8	7
2	0 + 100	.28	2.18	.60	.48	21	59	23	8.0	6
3	50 + 100	.32	2.32	.63	.47	20	60	21	8.2	6
4	100 + 100	.34	2.32	.63	.44	21	65	19	7.8	6
5	0 + 100	.32	2.34	.59	.46	20	61	20	7.6	6
6	100 + 0	.38	1.97	.69	.58	20	73	17	8.4	6
7	100 + 50	.34	2.18	.65	.51	20	66	18	7.6	6
8	100 + 0	.36	2.16	.67	.50	22	67	17	8.2	5
9	0 + 0	.33	1.98	.65	.60	21	73	22	8.6	6
10	0 + 0	.31	2.13	.65	.55	20	68	22	7.2	6
Significance:		**	**	**	**	NS	**	**	NS	*
BLSD (.05) :		.03	.11	.07	.06		4	12		1
CV (%) :		5.8	3.7	6.4	7.9	8.3	4.9	6.1	10.7	8.3
						Waseca				
1	0 + 0	.29	2.29	.71	.40	100	80	32	7.7	8
2	0 + 100	.29	2.47	.62	.34	96	64	30	7.6	7
3	50 + 100	.29	2.60	.58	.34	104	72	27	7.2	7
4	100 + 100	.31	2.52	.68	.36	102	73	24	6.4	8
5	0 + 100	.31	2.57	.69	.38	100	74	28	7.5	7
6	100 + 0	.31	2.26	.73	.43	96	73	23	6.3	7
7	100 + 50	.31	2.37	.71	.39	102	76	25	6.3	7
8	100 + 0	.30	2.34	.70	.42	101	79	25	6.6	6
9	0 + 0	.30	2.31	.70	.42	100	80	31	7.6	7
10	0 + 0	.28	2.32	.64	.40	98	66	30	7.3	7
Significance:		+	**	**	**	NS	+	**	**	NS
BLSD (.05) :			.17	.05	.04			4	.9	
CV (%) :		4.9	4.8	4.8	7.2	5.1	10.4	9.7	8.1	16.0

1/ Leaf opposite and below the ear at silking.

Table 7. Population and grain moisture at harvest as influenced by high P and K rates in 1978.

Treatment No.	Treatment Description	Final Population La	Final Population Mo	Final Population Wa	Grain Moisture La	Grain Moisture Mo	Grain Moisture Wa
	lb $P_2O_5+K_2O/A$	plants/A x 10^3			--------%--------		
1	0 + 0	1/	21.7	22.8	15.4	29.2	21.8
2	0 + 100		22.1	23.0	14.8	25.9	22.4
3	50 + 100		21.7	22.2	14.4	23.1	21.8
4	100 + 100		21.8	22.4	14.9	21.7	20.8
5	0 + 100		22.0	22.1	14.6	24.7	21.6
6	100 + 0		21.9	24.4	14.9	23.3	21.4
7	100 + 50		22.1	22.0	14.5	22.6	21.9
8	100 + 0		22.2	23.4	15.2	22.1	21.2
9	0 + 0		22.0	22.4	15.4	25.7	20.7
10	0 + 0		21.6	22.4	15.0	26.1	21.5
	Significance:		NS	NS	NS	**	NS
	BLSD (.05) :					2.9	
	CV (%) :		1.3	5.2	6.6	8.2	3.9

1/ Final population data were not collected at the Lamberton station.

Table 8. Corn, silage and grain yields as influenced by high P and K rates in Minnesota in 1978.

Treatment No.	Treatment Description	Silage yield La	Silage yield Mo	Silage yield Wa	Grain yield La	Grain yield Mo	Grain yield Wa
	lb $P_2O_5+K_2O/A$	-----T DM/A-----			-------bu/A-------		
1	0 + 0	6.87	6.58	8.69	111.5	113.6	160.2
2	0 + 100	6.45	6.42	8.56	112.7	113.1	160.5
3	50 + 100	6.44	7.14	8.60	114.7	119.7	170.5
4	100 + 100	6.16	6.84	8.77	113.5	124.6	177.8
5	0 + 100	6.30	7.09	9.24	115.6	119.8	167.6
6	100 + 0	6.14	6.83	8.71	116.9	121.4	167.8
7	100 + 50	6.16	7.13	8.73	112.8	123.3	173.9
8	100 + 0	6.68	6.96	8.06	114.6	124.7	173.5
9	0 + 0	6.74	6.90	7.57	115.8	119.5	164.6
10	0 + 0	6.34	6.97	8.62	118.3	120.1	156.7
	Significance:	NS	NS	NS	NS	NS	**
	BLSD (.05) :						11.9
	CV (%) :	9.3	7.8	9.6	4.3	5.3	4.4

TILLAGE STUDY SUMMARY 1976-78 LANCASTER, WISCONSIN
UNIVERSITY OF WISCONSIN LANCASTER EXPERIMENTAL FARM

W. Paulson, Supt., A. E. Peterson, J. B. Swan, R. Higgs

Location: Extreme northwest corner of Lancaster Experimental Farm on north side of county road.

Soil: Rosetta Silt Loam, 9 percent north slope, moderately eroded.

Previous Crop: Corn

Experimental Design: 3 x 3 latin square.

Plot Size: 30' x 100'.

		Avg. Population at Harvest			Avg. Yield Bu/Ac			Yield
Year	Date Planted	Conv.	Chisel	No Till	Conv.	Chisel	No Till	Level of Significance
1976	May 10	15,827	18,005	20,086	104.9	104.0	97.5	NS
1977	May 17	21,538	22,345	20,247	152	146	137	NS
1978	May 10	17,780	20,167	21,175	128.3[b]	126.9[b]	137.0[a]	Sig. @ 5%

Individual Years Were Analysed Separately As 3 x 3 Latin Squares:

	1976 YIELDS Bu/A			
	(West) Col. 1	Col. 2	(East) Col. 4	Row Totals
(North) Row 1	93.6[c]	108.0[nt]	94.5[p]	296.1
Row 2	121.2[p]	98.5[c]	77.0[nt]	296.7
(South) Row 3	107.4[nt]	99.1[p]	120.0[c]	326.5
Col. Totals	322.2	305.6	291.5	919.3

1976 ANOVA					
SOURCE	DF	SS	MS	F	
Row	2	157.42	78.71	<1	NS
Col.	2	201.40	100.70	<1	NS
TMT	2	99.68	49.84	<1	NS
Error	2	1071.58	535.79		
Total		1530.08			

Tillage Treatments

c = Chisel Plow and Plant
p = Conventional Plow - Disk and Plant
nt = No Till

	1977 YIELDS Bu/A			
	(West) Col. 1	Col. 2	(East) Col. 4	Row Totals
(North) Row 1	140	131	150	421
Row 2	160	148	131	439
(South) Row 3	148	145	150	443
Col. Totals	448	424	431	1303

1977 ANOVA					
SOURCE	DF	SS	MS	F	
Row	2	101.56	50.78	<1	NS
Col.	2	91.56	45.78	<1	NS
TMT	2	344.22	172.11	2.0	NS
Error	2	172.22	86.11		
Total		709.56			

	1978 YIELDS Bu/A			
	(West) Col. 1	Col. 2	(East) Col. 4	Row Totals
(North Row 1	129.1	141.9	133.5	404.5
Row 2	127.1	131.1	137.3	395.5
(South) Row 3	131.7	124.2	120.6	376.5
Col. Totals	387.9	397.2	391.4	1176.5

1978 ANOVA					
SOURCE	DF	SS	MS	F	
Row	2	14.7	7.30	<1	NS
Col.	2	136.2	68.11	15.7 +	
TMT	2	178.14	89.07	20.48*	
Error	2	8.709	4.35		
Total		337.78			

+ Significant Difference at 10% Level
* Significant Difference at 5% Level

The yearly data were adjusted for differences in population and analyzed similarly. The results for 1976 and 1977 were identical. For 1978 treatments were significantly different at the 10 percent level rather than the 5 percent level as found on unadjusted data. [The population adjustment (1.5 bu/1000 plants) was developed from regression analysis of Δ yield (Conv - TMT) on Δ population (Conv - TMT) for 11 years.]

The combined data for the 3 years was alanyzed as a 3 x 3 factorial (Federer p. 192) to determine if there was a significant interaction between years and tillage.

ANOVA

SOURCE	DF	SS	MS	F
Reps	2	114.80	57.4	NS
Treatment	8	9117.59		
A Years	2	8495.55	4247.8	36.9** F.01 = 6.23
B Tillage	2	95.45	47.7	NS
AB Interaction	4	526.59	131.7	NS
Error	16	1840.57	115.0	
Total	26	11,072.96		

Only the main effect of years was significant (at the 1 percent level). The tillage main effect and the years tillage interaction were not significant.

Conclusions

1) Tillage treatments were significantly different in only one year, 1978.
2) For the 3 year period yields from the three tillage treatments were not significantly different. Yearly average yields were significantly different for the 3 years, and the interaction of years and tillage was not significant. This lack of a significant interaction is of interest because the growing season precipitation (adjusted for runoff soil moisture measurements) differed greatly for the 3 years.

Year	Departure From Normal Growing Season Precipitation (April thru August)
1976	-4.2 inches
1977	+0.7 inches
1978	+0.6 inches

GRASS SEED PRODUCTION AS INFLUENCED BY FERTILIZATION

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Research during 1978 included: (a) nitrogen source comparison on mineral soils, (b) nitrogen rate study on peat, and (c) copper study on peat. Six trials with timothy and Kentucky bluegrass were conducted on growers' fields in Roseau and Lake of the Woods counties. Fertilizer effects were determined by yield measurements and chemical analysis of grass tissue.

A. WEATHER CONDITIONS DURING 1977/78 GROWING SEASON

Comments on weather conditions are based on climatological data obtained by the U.S. Weather Station at Roseau (Table 1).

Generally, during the period from August 1977 to July 1978, a nearly normal amount of precipitation was received at Roseau, while the average air temperature was 2.5°F below normal. The temperature was nearly normal during September and October. During September, nearly 4 inches of rainfall was received, while October was relatively dry. From November to April, the temperature was about 4.3°F below normal and the precipitation was nearly 1 inch below normal. May was warm with slightly below normal rainfall. During June, nearly 2 inches of rainfall was received, about 1.5 inch below the normal amount. Over 6 inches of rainfall was received during July, which delayed some harvest operations and interferred with burning of fields.

Prepared for presentation at the Grass Seed Institute, Baudette, March 21, 1979.

Table 1. Precipitation and temperature data for the 1977/78 growing season as measured at Roseau Weather Station (KRWB Radio)*.

Period	Precipitation (inches) Total	Departure from Normal	Air Temperature (°F) Average	from Normal	GDD T_b=40°F
1977 Aug.	1.74	-1.48	57.9	-7.0	554
Sept.	3.83	1.22	54.4	- .2	432
Oct.	.87	- .35	45.0	.5	155
1977 Nov. to 1978 Apr.	4.23	- .70	12.6	-4.3	103
1978 May	1.97	- .48	57.3	5.4	536
June	1.92	-1.50	60.9	- .9	627
July	6.25	2.80	65.3	-1.9	784
Total	20.81	- .18			3191
Average			34.7	-2.5	
Normal (1941-1970)	20.99		37.2		3329

* Calculated from Climatological Data, Minnesota, Vol. 83 and 84, 1977 and 1978, U.S. Dept. of Commerce.

NOTE: Data for January, February and March represent averages for the northwest division (0.7 in.) because precipitation at Roseau was not recorded.

B. NITROGEN SOURCE COMPARISON

1. Urea vs. Ammonium Nitrate

Three field experiments, established in fall of 1975, were conducted on growers' fields. The soils contained 30-35 lb/acre of nitrate-N in the top two feet (Table 2). This amount of nitrate is relatively low when compared to the levels found after some cultivated crops or fallow. These levels, however, are 10 to 15 lb/A higher than the amount of nitrate found in the same soils a year ago. The main root zone (0-3 inches) contained only 3.5 - 4.6 pp2m nitrate-N. The soils were calcareous, with pH values near 8 (Table 3).

Nitrogen treatments included: (a) two different sources - urea and ammonium nitrate; (b) two N rates - 50 and 100 lb/acre; and (c) time of application - October 3 vs. April 24. All plots received a 0+40+40 treatment. Fertilizer materials were applied with a 3-foot Gandy spreader.

Kampe II Timothy showed good response to N fertilizer. Plots receiving nitrogen yielded 214 to 405 lb/acre of seed compared to 110 lb/acre yield for control. No yield differences, however, resulted from various nitrogen treatments (Table 4). Nitrogen concentration was increased by the application of higher N rate and fertilization in spring, but no concentration differences resulted from N source. Nitrogen concentration in tissue from check plots was 2.95%.

Timfor Timothy yield was not determined because of malfunction of threshing machine. Nitrogen concentration of tissue was not affected by N source, but the higher N rate (3.57 vs. 2.78% N) and spring fertilization (3.39 vs. 2.96% N), resulted in higher N concentration. Grass tissue collected from check plots had 2.49% N.

Park Kentucky Bluegrass yield was relatively low, ranging from 70 to 248 lb/acre. The check plots yielded only 32 lb/acre of seed and produced grass tissue with only 1.59% N. The N 100 treatment and fall fertilization increased the yield significantly over N 50 and spring application (Table 5). While higher N concentrations were associated with ammonium nitrate and N 100 rate, no such difference resulted from time of application.

Table 2. Amount of nitrate-N in the soil collected from 0-3, 3-6 and 6-24 inch depths.+

Location	Soil Texture	Sampling depth, inches 0-3	3-6	6-24	Total NO_3-N in 0-24"
		------NO_3-N pp2m------			Lb/A
Knochenmus Kampe II timothy	SICL	4.4	4.6	24.8	33.8
Hedlund Timfor timothy	SICL	4.6	5.9	24.0	34.5
Helmstetter Bros. Park K. bluegrass	SL	3.5	3.5	22.5	29.5
Knochenmus Timfor timothy	SIL	2.8	2.6	14.1	19.5
Kveen Park K. bluegrass	P	1.3	1.0	9.0	11.3

+ samples collected on October 4, 1977

Table 3. Soil test results of samples collected from 0-3, 3-6 and 6-24 inch depths.

Location	Sampling Depth (inches)	Texture	pH	Extractable P pp2m	Exchangeable K pp2m	DTPA Extractable Cu+ ppm
Knochenmus	0-3	SICL	8.0	20	196	
Kampe II timothy	3-6	SIL	8.3	18#	124	
	6-24	SIL	8.5	2#	62	
Hedlund	0-3	SICL	7.8	40#	118	
Timfor timothy	3-6	SICL	8.0	27#	76	
	6-24	SICL	8.5	15#	30	
Helmstetter Bros.	0-3	SL	7.6	43	210	
Park K. bluegrass	3-6	SL	8.0	14	80	
	6-24	SL	7.9	6#	54	
Knochenmus	0-3	SIL	8.0	18	290	
Timfor timothy	3-6	SIL	8.1	14#	195	
	6-24	SICL	8.2	4#	82	
Kveen	0-3	P	8.0	17	72	1.45
Park K. bluegrass	3-6	P	8.0	2#	31	1.26
	6-24	SIL	7.9	8#	128	
Kveen	0-3	P	6.8	24	149	1.18
Newport K. bluegrass	3-6	P	7.0	38	79	1.02

+ samples collected on 10/13/78

Bray-1 P, 1:50 soil/solution ratio

Table 4. Effects of nitrogen source, rate and time of application on seed yield and N concentration in tissue of Kampe II timothy, Luis Knochenmus Farm, Roseau County, 1978.

Treatment	Seed Yield lbs/acre	N percent in dry matter
(a) <u>Source</u>		
Urea	270	3.74
Ammonium Nitrate	289	3.75
Significance	ns	ns
BLSD (0.05)	-	
(b) <u>Rate</u>		
50 lbs/acre N	246	3.48a
100 lbs/acre N	313	4.01b
Significance	ns	**
BLSD (0.05)	-	.13
(c) <u>Date</u>		
October	243	3.38a
April	315	4.11b
Significance	ns	**
BLSD (0.05)	-	.22
C.V.	20	5

Values followed by different letters are significantly different (5% level).

Symbols indicating significance: NS - non significant
** - highly significant at 1% level

All plots received 0+40+40 lb/acre of P_2O_5 and K_2O.

Table 5. Effects of nitrogen source, rate, and time of application on seed yield and N concentration of Park Kentucky bluegrass, Helmstetter Bros. Farm, Lake of the Woods County, 1978.

Treatment	Seed Yield lbs/acre	N percent in dry matter
(a) Source		
Urea	141	2.25a
Ammonium Nitrate	144	2.50b
Significance	ns	**
BLSD (0.05)	-	.16
(b) Rate		
50 lbs/acre N	105a	2.07a
100 lbs/acre N	180b	2.66b
Significance	**	**
BLSD (0.05)	42	.30
(c) Date		
October	186b	2.32
April	99a	2.41
Significance	*	ns
BLSD (0.05)	44	-
C.V.	24	9

Values followed by different letters are significantly different (5% level).

Symbols indicating significance: NS - non significant
* - significant at 5% level
** - highly significant at 1% level

All plots received 0+40+40 lb/acre of P_2O_5 and K_2O.

2. Anhydrous Ammonia vs. Urea vs. Ammonium Nitrate

A fertilization trial was conducted with Timfor timothy on a mineral soil. All fertilizer materials were applied on October 4, 1977 with a fertilizer applicator designed for experimental work on cultivated land. Although some ripping of sod occurred, the damage was not sufficiently serious as it did not affect the yield (Table 6). Fertilization with nitrogen increased the N concentration in grass tissue and the yield of seed. Anhydrous ammonia produced significantly higher yield than urea, but it was not superior to ammonium nitrate.

Table 6. Effect of four nitrogen treatments on seed yield and N concentration in tissue of Timfor timothy, Knochenmus Farm, Roseau County, 1978.

Treatment	Seed Yield lbs/acre	N percent in dry matter
Check	101a	2.18a
Ammonium Nitrate + Knife	271bc	3.65c
Ammonium Nitrate	296bc	3.56c
Anhydrous Ammonia	321c	3.30b
Urea	250b	3.60c
Significance	**	**
BLSD (0.05)	58	.18
C.V.	21	5

Values followed by different letter(s) are significantly different (5% level).

All plots received 0+36+36 lb/acre of P_2O_5 and K_2O.

Nitrogen materials were applied at a rate of 100 lbs N/acre.

C. NITROGEN RATE STUDY ON PEAT

A field experiment with Park Kentucky Bluegrass on peat was established in the fall of 1975 to investigate the effectiveness of different N rates. Five nitrogen rates were used: 0, 20, 40, 60, and 80 lbs/acre and the treatments were replicated four times. All plots received uniform 0+40+40 lbs/acre phosphate and potash treatments. Fertilizer materials were applied with a Gandy spreader on October 5. The field was not burned because of rainy weather. The residue was removed by mowing.

Relatively low seed yield was produced at this location (Table 7). While nitrogen fertilization increased the N concentration of grass tissue, it had no beneficial effect on the yield.

Table 7. Effect of fertilization on seed yield and N concentration in tissue of Park Kentucky bluegrass on peat, Gus Kveen Farm, Roseau County, 1978.

N Rate lb/acre	Seed Yield lb/acre	N percent in dry matter
0	130	2.94a
20	187	3.24b
40	174	3.52bc
60	167	3.68cd
80	171	3.89d
Significance	ns	**
BLSD (0.05)	-	.29
C.V.	22	1

Values followed by different letter(s) are significantly different (5% level).

All plots received 0+40+40 lbs/acre of P_2O_5 and K_2O.

D. COPPER STUDY ON PEAT

The importance of copper fertilization in seed production of Kentucky bluegrass on peat was investigated in a field experiment during 1978. Copper sulfate and copper chelate were dissolved in water and sprayed to 10 x 20 ft. plots on April 25. The treatments were replicated six times. The field was renovated by plowing and disking in 1977. The entire plot area received 20+40+40 lb/acre of N, P_2O_5 and K_2O on October 5. Low copper availability was indicated by the soil test. The DTPA-extractable copper content ranged from 1.2 - 1.5 ppm in the top 3 inches of soil, and 1.0 - 1.3 ppm Cu at 3-6 inch depth.

The seed yield was not affected by fertilization with copper (Table 8). Copper concentration in tissue of Newport K. bluegrass collected from check plots was 1.5 ppm, considered a very low level. Copper sulfate (25.5% Cu) applied at 50 lb/acre rate, increased Cu concentration to 8.1 ppm. The application of copper chelate (13% Cu) increased Cu concentration in grass tissue only slightly above the values of check plots.

Table 8. Seed yield and copper concentration of Newport Kentucky bluegrass tissue as affected by fertilization with copper, Gustav Kveen Farm, Roseau County, 1978.

Copper Treatment	Seed Yield lb/acre	Copper, ppm in dry matter
None	163	1.5a
50 lb/acre copper sulfate	201	8.1b
2 lb/acre copper chelate	224	2.9a
4 lb/acre copper chelate	183	3.8a
Significance	ns	*
BLSD (0.05)	-	3.7
C.V.	26	73

Values followed by different letter are significantly different at 5% level.

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PASTURE FERTILIZATION TRIALS,
GOODHUE CO., 1976, 1977 and 1978
WASHINGTON CO., Kelly farms, 1978

C. J. Overdahl

Pasture trials at two locations were initiated in Goodhue County in the spring of 1976. The plots were located on the Dale Flueger and Jim Bryan farms. The purpose of the study was to observe benefits from rates and application times for nitrogen. Also, a comparison between ammonium nitrate and urea was made, as well as a measure of P and K needs. Yields were evaluated by clipping four times during the summer. Plots were fenced and no grazing was permitted.

The Flueger farm has mostly bromegrass, with some legume remaining, apparently from a previous improvement. The Bryan pasture appears to have a predominance of bluegrass, resulting in short growth during July 1976 and a clipping at this time could not be made. In 1977, the lack of grazing on the Bryan farm seemed to give the alfalfa a chance for revival and a thin stand of alfalfa occurred in all plots.

Data in the following tables are a progress report for 1976, 1977 and 1978.

A pasture trial was initiated at the Kelly farms in Washington County, managed by Morris Grogan. The objective of one trial was to document magnesium levels which, if low enough, could be related to grass tetany in cattle. Magnesium relationships to potash treatments, to added dolomitic lime and to magnesium sulfate applications were studied. A nitrogen trial was also conducted at this site and was adjacent to the magnesium plot. This plot had varying nitrogen treatments to 120 pounds and is a continuation of the nitrogen trials in Goodhue County.

The fine cooperation of Jim Bryan, Dale Flueger and Morris Grogan are gratefully acknowledged. Also, the efforts of Bob Schoper, Jerome Lensing and Mike O'Leary, research associates in the Soil Science Department, and Brian Schreiber, County Extension Agent in Goodhue County, are greatly appreciated. Without their help, the work wouldn't have been done.

This project was financed by the generous support of St. Paul Ammonia Products in 1976 and 1977; and supported by the Cenex Foundation in 1978.

Table 1a. Relationship of nitrogen treatments to pasture yield at the Bryan farm, Goodhue Co., 1976 and 1977.

N	P_2O_5	K_2O	Bryan* lbs/A		N response over check		Protein lbs/A	
			1976	1977	1976	1977	1976	1977
0	40	40	1642	3071	-	-	229	466
30	40	40	2248	3542	606	471	328	545
60	40	40	2685	3284	1043	213	378	518
90	40	40	3775	4555	2133	1484	642	769
120	40	40	4054	5138	2412	2067	680	888

Table 1b. Relationship of nitrogen treatments to pasture yield at the Flueger Farm, Goodhue Co., 1976, 1977, and 1978.

N	P_2O_5	K_2O	Flueger* lbs/A			N response over check			Protein** lbs/A		
			1976	1977	1978	1976	1977	1978	1976	1977	1978
0	40	40	3646	2383	3738	-	-	-	440	373	671
30	40	40	4789	3133	4701	1143	750	963	660	483	846
60	40	40	5301	3926	5580	1655	1543	1852	843	690	1033
90	40	40	7110	4868	5856	3464	2485	2018	1250	931	1123
120	40	40	6767	4881	6480	3121	2498	2742	1210	988	1289

* 3 cuttings at Bryan's and 4 at Flueger's, 1976; 4 cuttings at Bryan's and 3 at Flueger's, 1977; 4 cuttings at Flueger's, 1978.

** N removed times 6.25.

Table 2. The effect of split applications of nitrogen on pasture yield (lbs/acre dry matter). Goodhue Co. 1978.

Flueger Farm

$N + P_2O_5 + K_2O$	Cuttings 1	2	3	4	Total
60 + 40 + 40	1371	2119	1111	978	5579
60(1,3)* + 40 + 40	896	1218	1573	765	4452
significance (t test)	10%	1%	ns	10%	ns
120 + 40 + 40	1817	1984	1772	907	6480
120(1,3)* + 40 + 40	1378	1304	2131	641	5454
120(1,2,3,4)*+40 + 40	1450	2086	2060	1003	6599
significance					
60(1,3)* + 40 + 40	896	1218	1573	765	4452
60(1,3) (urea) + 40 + 40	925	1369	1526	950	4470
significance	ns	ns	ns	**	ns

* application code

1-early spring
2-following 1st cut
3-following 2nd cut
4-following 3rd cut

Table 3 The effect of potash, magnesium and dolomitic limestone on dry matter yield of grass pasture. Kelly farms. 1978.

	pounds dry grass/acre				
	Cuttings				
	1	2	3	4	Total
Lime 4 T/A	1690	2772	1226	939	6627
No lime	1803	2362	1336	1026	6527
Significance	ns	*	ns	ns	ns
BLSD (05)	-	353			
Lbs K_2O/A					
0	1850	2528	1230	911	6518
160	1716	2473	1113	886	6187
320	1767	2677	1228	928	6800
640	1624	2512	1545	1284	6964
1000	1803	2537	1313	942	6595
1000+100# Mg/A	1719	2674	1256	948	6596
Significance	ns	ns	ns	*	ns
BLSD (05)	-	-	-	184	-

All plots received 120# N/A and 40# P_2O_5/A

Table 4a. Emission spectrograph analysis 1st cutting, Kelly farm, Washington Co. 1978.

	%				ppm				
Treatment	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
No lime	.31	4.10	.30	.16	155	137	34	8	5
Lime 4 T/A	.31	4.48	.27	.14	155	149	35	8	5
Significance	ns	ns	+	*	ns	ns	ns	ns	ns
BLSD (5%)	-	-	.02	.01	-	-	-	-	-
lbs K_2O/A									
0	.35	4.16	.30	.16	153	133	36	8	5
160	.28	3.87	.29	.14	143	129	33	8	6
320	.33	4.47	.29	.14	162	153	35	8	6
640	.30	4.38	.29	.15	158	145	34	8	4
1000	.32	4.56	.28	.16	154	152	35	8	5
1000 + 100# Mg	.28	4.30	.28	.15	159	147	34	8	7
Significance	*	*	ns	ns	ns	+	ns	ns	ns
BLSD (5%)	.04	.44	-	-	-	18	-	-	-

Table 4b. 2nd Cutting

	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
No lime	.32	3.32	.30	.16	71	159	30	8	5
Lime 4 T/A	.34	3.56	.27	.15	70	204	30	8	6
Significance	ns	*	ns	ns	ns	ns	ns	ns	ns
BLSD (5%)	-	.23	-	-	-	-	-	-	-
lbs K_2O/A									
0	.34	3.20	.29	.16	66	169	30	8	6
160	.33	3.42	.30	.15	72	161	31	8	5
320	.31	3.41	.26	.13	66	190	30	8	5
640	.33	3.57	.28	.16	71	189	30	8	5
1000	.35	3.43	.32	.17	78	202	30	8	6
1000 + 100# Mg	.32	3.62	.27	.16	71	176	31	9	5
Significance	ns	ns	ns	+	ns	ns	ns	ns	ns
BLSD (5%)	-	-	-	.02	-	-	-	-	-

Table 5. The effect of varying nitrogen treatments on grass yield (dry matter). pounds per acre of nitrogen removed and percent.

Treatment N	P_2O_5	K_2O	lbs D.M./A 1	2	3	4	Total	%N 1	2	3	4
0	0	0	969	2066	1040	871	4946	2.75	2.32	2.73	3.20
0	40	40	1098	2129	1093	1018	5340	2.96	2.07	2.68	3.23
30	40	40	1314	2364	1038	1042	5759	3.05	2.29	2.69	3.11
60	40	40	1750	1978	1145	890	5763	3.70	2.71	2.66	3.39
*120(60+60)	40	40	1567	2295	1756	950	6568	3.72	2.48	3.37	3.43
Significance			**	ns	**	ns	**	**	**	**	ns
BLSD (05)			174	-	246	-	796	.41	.27	.35	-
C.V.			9.1	12.6	13.7	25.5	8.9	8.5	7.2	8.0	6.7

*60# N/A spring +
60# N/A after second cutting

Table 6. Soil tests average of 2 samples per plot at 0 to 3 and 3 to 6 inch depths, according to lime and potash treatments. Kelly farms, Washington Co. 1978.

potash treatment per acre 1978

	0			160			320			640			1000			1000 + Mg		
	pH	P	K	pH	P	K	pH	P	K	pH	P	K	pH	P	K	pH	P	K
0 to 3 inch depth																		
no lime	5.2	24	192	5.2	39	270	5.2	21	314	5.4	42	548	5.4	26	580	5.4	31	600+
lime	6.2	28	263	6.3	28	207	6.1	28	340	6.2	23	490	6.0	27	555	6.2	23	600+
3 to 6 inch depth																		
no lime	5.4	16	155	5.4	26	195	5.4	13	160	5.4	28	314	5.4	18	426	5.3	16	360
lime	5.6	22	201	5.6	15	129	5.4	16	236	5.5	15	264	5.5	21	375	5.5	16	479
Ave P & K 0-6"		23	203		27	200		20	263		27	404		23	484		22	510

Discussion and summary

Bryan and Flueger farms

This was the last year for the Goodhue County plots.

1. Significant increases in pasture yield were obtained from nitrogen additions. On the Bryan farm, the highest yield both years was from the 120 pounds of nitrogen per acre, but this was not significantly higher than 90 pounds per acre. On the Flueger farm, 90 pounds of nitrogen per acre gave approximately equal yields to 120 pounds in 1976 and 1977. When alfalfa was killed by 2,4D in 1978, the 120 pound treatment in the spring gave highest yield.

2. Protein yield increases follow the increases in grass yield and are directly in line with the nitrogen treatments.

3. Split applications did not yield higher than one application of the total amount in the spring.

   The large yields are usually in the first or second cutting which also gave the largest increases due to nitrogen treatment. Higher yields were obtained in midsummer from midsummer application, but the increases were not large enough to make up for the large early yields.

4. Soil tests of medium or high in P and high or very high in K resulted in no yield increases from additions of these two elements.

5. There was no significant difference in pasture yields where ammonium-nitrate and urea were compared. Sixty pounds per acre of nitrogen in two 30 pound applications were compared in this trial at both farms.

6. It would appear that approximately 100 to 120 pounds per acre of nitrogen, annually, along with a small amount of phosphorus and potassium for insurance, would be a highly satisfactory fertilizer program for grass pasture and best protein production.

7. Soil tests shown in Table 6 reveal that most of the phosphorus and potassium are in the top 3 inches of the soil.

Kelly farms

1. Lime, magnesium and potash additions did not affect grass yield, either upward or downward.

2. Generally, plant analysis showed that treatments had no significant effect upward or downward on magnesium content. Magnesium levels were the same even with 100 pounds of added magnesium for the first two cuttings, but the 3rd cutting showed .02 percent more magnesium from the added magnesium.

3. The 4 tons per acre lime treatment increased soil pH about 1 full pH unit in just 6 months.

4. Potash treatments increased the K test from 200 pounds of exchangeable K to nearly 600 pounds when treatment was 1000 pounds of K_2O per acre.

INFLUENCE OF FOLIAR APPLICATIONS OF FERTILIZER NUTRIENTS AND FUNGICIDE ON THE YIELD AND PROTEIN CONTENT OF SMALL GRAINS - 1978

C.A. Simkins, G.W. Randall, S.D. Evans, Gary Varvel, and H.L. Bissonnette

The foliar feeding of crops has been investigated by several scientists during the early 1950's. The yield and percent protein of several crops was increased by the spray application of nitrogen fertilizer (urea and ammonium nitrate). These increases were obtained on soils deficient in available nitrogen.

Foliar fertilization was reported to increase seed yields of soybeans in field experiments in Iowa. Researchers in other states have not obtained consistent increases in yield.

Several researchers have shown that the application of fungicides on small grains often results in economical increases in yield due to control of certain leaf diseases. The influence of the combined application of plant nutrients and fungicides on the yield and quality of small grains was of particular interest to the investigators.

Materials and Methods

These studies were conducted at 3 locations in Minnesota; Waseca, Morris and Crookston. The sites at these locations were selected to represent soils in a high state of fertility. The NO_3N level at the 3 locations contained more than 100 lbs. of NO_3N in the top 2 feet. The P and K soil test levels were also well above the critical levels normally associeted with response to additions of phosphorus and potassium fertilizer.

	Lbs/Acre		
SITE	NO_3N-2'	P	K
Crookston	130	28	290
Morris	110	31	300+
Waseca	118	32	300+

Urea, potassium polyphosphate, and potassium sulfate were combined to develop a foliar spray which would contain plant nutrients similar to the small grain crops. The following quantities were used:

	Pounds per ton
Urea	260
Potassium polyphosphate	177
Potassium sulfate	58
Water	1,505

This formulation resulted in a ratio of the nutrient elements of 6-2.3 and 3.7 for N, P_2O_5 and K_2O. Additionally, the formula supplied .5 percent sulfur. The material was applied at the rate of 26.4 gallons per acre or 250 pounds per acre. The quantity of nitrogen, phosphorus, potassium, and sulfur applied per acre was 15, 6, 9, and 1.3, respectively.

A fungicide--Manzate 200--was applied at the rate of 2 pounds per acre alone and in combination with the fertilizer nutrients.

Trials were established on wheat and oats at the Morris location and wheat at the Crookston and Waseca locations.

Treatments were as follows:

1. Control.

2. Foliar application of nutrients at flag leaf stage and 10 to 20 days later.

3. Fungicide applied at flag leaf stage and 10 and 20 days later.

4. Combinations of treatments 2 and 3.

Treatments were replicated four times. Spray applications were made at a pressure of 80 lbs. per sq. in.

Wheat and oats were seeded with a grain drill at conventional seeding rates of 90 and 60 lbs. of seed per acre respectively.

The wheat variety Era was seeded at all locations. The oat variety seeded at the Morris location was Dahl.

Results and Discussion

The grain yields at the various locations as influenced by fertilizer nutrient applications are shown in Table 1.

Table 1. Grain Yields as Influenced by Fertilizer Nutrient Applications - 1978

Lbs/Acre				Grain Yield Bu/A			
N	P	K	S	Oats Morris	Wheat Morris	Wheat Waseca	Wheat Crookston
0	0	0	0	90.4	27.0	31.7	58.1
15	6	9	1.3	84.4	25.2	32.3	55.3
30	12	18	2.6	84.1	26.0	31.1	57.9
15	18	27	3.9	85.8	24.6	29.5	55.3
		Sig.		NS	NS	NS	NS
		BLSD		--	--	--	--

No significant increases in grain yields were obtained as a result of the foliar application of plant nutrients. The yields of wheat at the Morris and Waseca locations were relatively low due in part to the severe attack of leaf diseases. The grain yields of wheat at the Morris and Waseca locations were significantly increased by the application of 2 lbs. per acre of Manzate Fungicide. The grain yields with and without fingicide application are shown in Table 2.

Table 2. Grain Yields as Influenced by Fungicide Spray Applications - 1978

	Grain Yields/Bu/A			
Fungicide	Oats Morris	Wheat Morris	Wheat Waseca	Wheat Crookston
Without	86.7	24.0	29.8	56.0
With	85.7	27.4	32.6	57.3
Sig.	NS	+	+	NS
BLSD (.05)	--	2.6	2.3	--

Yield increases from the application of fungicide at the Morris and Waseca locations was generally from 3 to 4 bushels per acre. Wheat yields at the Crookston location were not increased significantly by fungicide applications.

The foliar application of fertilizer nutrients resulted in significant increases in the protein content of the wheat grain at 2 of the 3 locations. It also resulted in a significant increase in the chaff and straw at the Crookston location. The percent protein in the wheat grain chaff and straw are shown in Table 3.

Table 3. Protein Content of Wheat Grain, Straw and Chaff - Foliar Applications - 1978

Lbs/N/Acre				Wheat Protein %				
N	P	K	S	Grain Morris	Grain Waseca	Grain Crookston	Chaff Crookston	Straw Crookston
0	0	0	0	18.2	17.0	15.1	4.6	3.6
15	6	9	1.3	18.2	16.9	15.2	4.7	3.7
30	12	18	2.6	18.5	17.2	15.4	5.0	4.0
45	18	27	3.9	19.6	17.7	15.6	5.1	4.1
Sig., BLSD, 5%				.4	.4	NS	.35	.36

The quantity of phosphorus and potassium contained in the chaff of the harvested wheat was measured at the Crookston location. The percent P and K are shown in Table 4.

Table 4. Percent Phosphorus and Potassium in Wheat Chaff - Crookston Location - 1978

Lbs/Acre N	P	K	%P	%K
0	0	0	.078	.854
15	6	9	.083	.885
30	12	18	.077	.969
45	18	27	.092	1.005
Sig., BLSD (.05)			--	.063

The foliar application of potassium sulfate resulted in significant increases in the K content of the wheat chaff. The phosphorus content of the wheat chaff was not consistently increased by foliar application of the fertilizer nutrients.

The application of fungicides did not result in significant increases in the protein content of the wheat or oat grain or the straw or chaff of the wheat at Crookston.

Summary

Foliar application of N-P-K and S, fertilizer nutrients, on wheat and oat plants did not result in significant increases in yield at 3 locations in Minnesota in 1978.

The foliar application of fertilizer materials containing nitrogen resulted in significant increases in the protein content of wheat grain at 2 of the 3 locations. The protein content of the straw and chaff of the wheat plant was also significant increased by foliar applications of fertilizer nitrogen.

The application of 2 lbs. of Manzate Fungicide increased wheat yields at the Morris and Waseca locations. This increase was consistently at a level of 3 to 4 bushels per acre.

N Rate, Source, and Incorporation Study

W. Nelson, S. Evans, G. Varvel, J. Lensing, and H. Meredith

Background: N losses from surface applied fertilizers containing urea have received much attention in the literature. These studies have been conducted in the laboratory under conditions favoring large losses of N. Field studies from urea containing fertilizers have shown N losses to be quite variable. Factors as soil pH, temperature, moisture, etc. are some of the more important variables.

The three leading broadcast N sources - urea, ammonium nitrate, and urea-ammonium nitrate solution - are surface applied and one-half of the treatments is incorporated with a tillage instrument prior to planting. Era wheat is used to deliniate N response.

Objective of Study: The primary objective of this study is to determine if crop response to applied nitrogen is altered when spring applied nitrogen is incorporated or nonincorporated prior to planting. Secondary objectives involve correlating N response to soil test nitrate and differing rates of applied N.

Duration of Study: The study was initiated in 1978. Intentions are to evaluate this study for at least three years at Crookston, Morris, and Lamberton. A fourth location will hopefully be added at Waseca in 1979 using corn as the indicator crop.

Nitrate Soil Test: The primary ingredient in the N source evaluation is the N response to applied N. Accumulated nitrate in the soil profile must be sufficiently low to require a need for supplemental nitrogen to attain high yields under favorable environmental conditions.

The guide to supplemental N use on wheat appears in University of Minnesota Extension Bulletin No. 416, page 8. Data in Table 1 is a summation of this guide.

Table 1. A Guide to N Use Based on Nitrate Soil Tests.

Nitrate Soil Test	Pounds $N\text{-}NO_3$ in Soil Profile	Lbs. N to Apply
Low	<50	90
Medium	50-100	70
High	>100	15

Nitrate tests at the three locations are summarized in Table 2.

Table 2. Nitrate Soil Tests at Lamberton, Morris, and Crookston, 1978.

Depth (ft.)	Lamberton	Morris	Crookston
		Lbs NO_3-N	
0-1	16	72	-- [1/]
1-2	12	60	72
2-3	26	129	--
3-4	57	120	--
4-5	48	50	--
	159	431	72

1/ 0-2'

Based on the nitrate soil test in the top 24 inches a nitrogen response would have been expected at Lamberton and Crookston. However, the lower profile, 2 to 5 feet, contained sufficient nitrate to negate a response to applied nitrogen at the yield level attained in 1979 at Lamberton, Table 3.

Table 3. Era Wheat Grain Yields, Test Weight and Percent N in Grain at Lamberton, Morris, and Crookston, 1978.

Trt			Lamberton			Morris			Crookston	
N Rate	N Source	Inc.	Bu/A	Test Wt.	% N Grain	Bu/A	Test Wt.	% N Grain	Bu/A	% N Grain
0	--	--	28.2	59.1	2.80	44.0	49.0	3.30	27.9	2.02
40	AN	+	33.2	60.5	2.74	46.1	49.2	3.25	45.5	2.12
80	AN	+	33.0	56.4	2.90	52.2	50.0	3.34	58.5	2.34
40	U	+	31.0	59.1	2.84	52.7	48.9	3.33	48.2	2.10
80	U	+	29.6	59.4	2.88	52.2	49.8	3.27	59.3	2.18
40	28%	+	28.4	60.0	2.78	50.3	50.0	3.23	45.4	1.98
80	28%	+	29.6	58.6	2.91	42.6	49.6	3.41	59.1	2.26
40	AN	--	29.4	59.8	2.82	50.8	49.4	3.32	44.0	1.99
80	AN	--	28.4	58.4	2.86	44.5	47.8	3.37	60.9	2.24
40	U	--	32.5	59.8	2.78	51.2	49.6	3.30	51.0	2.10
80	U	--	30.5	59.5	2.85	42.5	47.7	3.38	60.6	2.33
40	28%	--	28.6	59.3	2.84	44.4	48.2	3.25	43.5	1.98
80	28%	--	30.9	59.3	2.71	49.1	47.6	3.35	60.3	2.14
Signif.			NS	NS	NS	NS	NS	NS	**	**
BLSD (.05)			--	--	--	--	--	--	6.1	.15
C.V.			9.8	2.9	3.1	18.3	3.4	3.7	8.4	5.1

+ = incorporated
- = unincorporated

A yield response to applied nitrogen was observed at Crookston. Data in Table 4 indicate there was no difference in incorporation versus nonincorporation of applied N.

Table 4. Yield of Era Wheat and Percent N in Grain at Crookston, 1978.

Treatment	N Source	Yield Bu/A	% N in Grain
Check	--	27.9	2.02
AN	40_1 1/	45.5	2.12
AN	40_2 2/	44.0	1.99
Urea	40_1	48.2	2.10
Urea	40_2	51.0	2.10
28% N Soln	40_1	45.4	1.98
	40_2	43.5	1.98
AN	80_1	58.5	2.34
	80_2	60.9	2.24
Urea	80_1	59.3	2.18
	80_2	60.6	2.33
28% N Soln	80_1	59.1	2.26
	80_2	60.3	2.14
Signif.		**	**
BLSD (.05)		6.1	.15
C.V.		8.4	5.1

1/ = incorporated

2/ = unincorporated

Nitrogen fertilizer was applied on May 3 and seeded on the same day. Precipitation sufficient to place the N in contact with the soil occured within a few days.

As little as 0.1 inch of moisture is sufficient to negate losses of N to the atmosphere. The probability of precipitation in late fall or early spring is generally high.

INFLUENCE OF NITRATE-NITROGEN LEVEL OF VARIOUS SOILS OF THE RED RIVER BASIN AND THEIR RESPONSE TO ADDED NITROGEN FERTILIZER - WHEAT FERTILITY RESEARCH 1978

Charles Simkins, Michael O'Leary, and Terrance Courneya

The ability to estimate the available nitrogen level in the soil and adjust this level to the production potential of a given soil under existing climatic conditions is largely the key to economic use of fertilizer on non-legume crops. On most soils in Minnesota, nitrogen is the most limiting plant nutrient for wheat. An inadequate supply can greatly reduce yield and profit. The response of wheat to nitrogen fertilizer is similar to that of other small grain crops except, that normally more nitrogen is required to reach the yield potential of the wheat crops.

The recent introduction and adoption of the nitrate-nitrogen test has been a valuable tool in assisting farmers in adjusting their nitrogen fertilizer use for wheat. There is still considerable need for refinement of the test in Minnesota. The diverse soil types on which wheat is grown vary in their inherent ability to grow crops. Each soil has its won unique yield potential and reaction to applied plant nutrients. It is important that we look at different soils as different individuals and determine more closely their ability to produce. (i.e. their production potential).

Methods and Materials

Trials were established at six locations in the Red River Basin of Minnesota near Thief River Falls, Crookston and Warren, Minnesota. The general profile description of the series are as follows:

POPPLETON-FINE SAND

Very dark grayish brown fine sand overlying grayish brown fine sand, brown mottling in B horizon, fine sandy texture to depth of 50 inches, free carbonates at 45 inches.

FOXHOMME SANDY LOAM

Black sandy loam over very dark brown sandy loam, some pebbles at 11 inches, coarse sand 20 to 24 inches, grayish brown loam at 30 inches, free carbonates at 30 inches.

WHEATVILLE SANDY CLAY LOAM

Black sandy clay loam over very dark gray sandy clay loam, grayish brown clay at 30 inches, free carbonates throughout the profile.

ROLISS LOAM

Surface black loam over olive gray loam, grayish brown clay loam at 18 inches, free carbonates throughout profile.

MAVIE LOAM

Black loam over light brownish gray sandy loam, gravelly sandy loam at 18 inches, light olive gray loam at 30 inches, some rocks and gravel on surface.

FARGO SILTY CLAY

Black silty clay over very dark gray silty clay, olive gray silty clay at 20 inches, lime at 48 inches.

Wheat was seeded at all locations using a grain drill with single disk furrows. The rates of seeding varied from 75 to 90 lbs. of seed per acre. The wheat variety ERA was used in all trials. The general soil fertility properties at the six locations are shown in Table 1.

Table 1. Analysis of Soils Used in Nitrate-Nitrogen Studies - Red River Basin - 1978.

Location and Series		NO_3N-2'	P	K
Crookston -	Wheatville	180	22	231
Skaar	Mavie	139	10	133
Howard	Fargo	246	67	600+
Christiansen	Roliss	98	33	164
Sanders	Foxhomme	134	29	312
Fleshe	Poppleton	113	27	106

Fertilizer materials were applied at seeding time with grain drill attachment. The quantity of fertilizer varied from 100 to 200 lbs. of complete fertilizer (6-24-24, 10-26-26, and 12-30-20). After seeding an application of nitrogen fertilizer equivalent to 60 pounds of N per acre was applied as a top dressing as a randomized block design with 4 replications.

At harvest time yields were determined by harvesting representative samples from each plot. (Four grain drill rows ten feet in distance). The samples were dried, threshed, and yield and protein determinations were made on the grain samples.

Results and Discussions

The yield results are presented in Table 2. Yields given are the average of 4 replications of each location.

Table 2. Yields of ERA Wheat on Nitrogen and No Nitrogen Treated Areas - Red River Basin of Minnesota - 1978.

Location	No Nitrogen	Yield Bu/A 60 lbs. Nitrogen Acre	Increase
Fleshe	35.7	37.5	1.8
Sanders	61.4	66.5	4.9
Skaar	38.8	38.2	-0.6
Christiansen	55.6	53.4	-2.2
Howard	55.7	54.4	-1.3
Crookston	54.5	52.4	-2.1

Non-significant at 5% level

The nitrate-nitrogen level of the soil at all locations was relatively high (range 98 to 246 lbs. NO_3N in top 2 feet). This was the result of previous nitrogen applications and legume summer fallow.

The yield increases due to additional nitrogen applications (60 lbs. N per acre) were not significant at any of the 6 locations. Moisture stress was observed at the Fleshe, Howard, and Crookston locations 10-14 days prior to maturity yields at the Fleshe location were probably adversely affected by an abundant growth of yellow and green foxtail. These yields indicate, however, the ability of the soils of the so called "beach area" of the Red River Basin to produce when properly fertilized and managed. The results of these trials confirms early findings in respect to response of grain yields to nitrogen fertilizer applications and nitrate-nitrogen levels in the top two feet of soil.

The protein content of the harvested wheat is shown in Table 3. The protein percentage at each location is an average of 4 applications with and without added nitrogen fertilizer.

Table 3. Protein Content of ERA Wheat as Influenced by Nitrate-Nitrogen Content of Soil and Applied Nitrogen Fertilizer - Red River Basin, Minnesota - 1978.

Location	Protein % No Nitrogen	Protein % 60 lbs. Nitrogen Acre	Increase
Fleshe	14.9	15.2	0.3
Sanders	13.5	14.6	1.1
Skaar	14.0	15.0	1.0
Christiansen	15.2	15.0	- .2
Howard	14.9	15.3	0.4
Crookston	14.9	15.0	0.1

Non-significant at 5% level

The protein content of the harvested grain was relatively high for the wheat variety ERA. The lack of soil moisture near the maturity stage of the wheat was possibly partially responsible for the high protein in the grain.

The average protein content of the grain was increased at all except the Christiansen location. These increases in protein percentage, however, were not statiscally significant at the 5 percent level.

THE YIELD AND PROTEIN CONTENT OF ERA WHEAT AS INFLUENCED BY STARTER FERTILIZER AT SEVERAL FARM LOCATIONS IN PENNINGTON COUNTY, MINNESOTA - 1978

Charles Simkins, Michael O'Leary, and Terrance Courneya

The application of fertilizer at seeding time with an attachment on the grain drill is a common practice in the Red River Basin of Minnesota and North Dakota. Early investigators have shown that the application of phosphorus fertilizer in this manner, particularly on soils low in available phosphorus, was an efficient means of meeting the phosphorus needs of the crop. As a general guide for low testing soils it was recommended that 40 lbs. of P_2O_5 per acre be applied with the seed at planting time. Doubling these rates was required for the same response when the fertilizer was broadcast and worked into the soil.

With time, the phosphorus reserves of most soils producing wheat have reached rather high levels in the Red River Basin. Agriculturists question the need for applying phosphorus fertilizer with the grain drill at planting time. It is generally agreed that if fertilizer could be omitted at planting time without loss of yield or quality, there would be several opportunities for economic savings.

Methods and Materials

Trials were established at 4 locations in Pennington County, Minnesota. Wheat producers prepared seed beds, applied nitrogen fertilizer and seeded wheat with grain drills in their customary manner. The starter fertilizer applied at seeding time with the grain drill varied from location to location but contained more than 20 lbs. of P_2O_5 and 20 lbs. of K_2O at all locations. The quantity used by each producer is shown in Table 2.

During seeding the fertilizer attachment on the grain drill was shut down, so that strips the width of the grain drill were seeded without starter fertilizer.

Previous to seeding soil samples were taken for chemical analysis. These chemical properties are shown in Table 1.

Table 1. Some Chemical Properties of Soils in Trials of Starter Versus No Starter Fertilizer - Pennington County - 1978.

	Pounds/Acre		
Location	NO_3N-2'	P	K
Sanders	134	29	312
Skaar	139	10	133
Fleshe	113	27	106
Christianson	98	33	164

At harvest time plant samples were harvested from those strips which received starter fertilizer and those strips which received no starter fertilizer. Four samples were collected from each treatment at each location. The samples consisted of 4 drill rows 12 feet in length. Yield and protein determination were made on threshed samples.

Results and Discussion

The nitrate-nitrogen content of the soil on which the trials were conducted was relatively high. Nitrogen fertilizer had either been applied the previous fall or a legume-summer fallow program had been practiced. This lessened the possibility that nitrogen fertilizer would be a big factor in increasing yields. The influence which starter fertilizer exerted on wheat yields are shown in Table 2.

Table 2. The Effect of Starter Fertilizer on Yield of ERA Wheat, Pennington County, Red River Basin, Minnesota - 1978.

	Starter Used				Yield Bu/A		Bu/A
Location	Lbs./A	N	P_2O_5	K_2O	No Starter	Starter	Increase
Sanders	150	6	24	24	61.4	64.6	3.2
Skaar	150	12	30	20	38.8	44.4	5.6
Fleshe	200	6	24	24	36.5	44.8	8.3*
Christiansen	100	10	26	26	51.9	53.4	1.5

*Significant at 5% level

Yields of wheat were increased by starter fertilizer at the 4 locations. The increases in yield ranged from 1.5 to 8.3 bushels per acre. The only location where a statiscally significant increase was obtained was at the Fleshe location.

The influence of the starter fertilizer was quite visible at both the Fleshe and Skaar locations. The heighth and vigor of the plants on the starter treated areas were inferior to those on the non-starter treated areas shortly after emergence of the plants. There was evidence of delay in germination and emergence of the wheat seedlings. Later the starter treated areas recovered and after several weeks the growth and vigor of the wheat plants were superior to those on the non-starter treated areas. At harvest time there was evidence of earlier maturing and greater stooling of wheat plants at the Skaar and Fleshe locations.

There was little visual evidence of increased plant growth at the Christiansen and Sanders location.

The effect of starter fertilizer on the percent protein content of the grain is shown in Table 3.

Table 3. The Effect of Starter Fertilizer on the Protein Content of ERA Wheat - Pennington County, Minnesota - 1978.

Location	Lbs./A	Starter Used N - P_2O_5 - K_2O	Protein % No Starter	Protein % Starter	% Increase
Sanders	150	6 - 24 - 24	13.5	13.9	0.4
Skaar	150	12 - 30 - 20	14.0	15.1	1.1*
Fleshe	200	6 - 24 - 24	14.6	15.1	0.5*
Christiansen	100	10 - 26 - 26	13.8	13.7	---

*Significant at 5% level

The percent protein content of the wheat grain was increased at 3 of the 4 locations. The increases were statistically significant at the Skaar and Fleshe locations. The protein content of the grain at all locations was relatively high for the variety of wheat ERA.

Summary

Wheat yields and protein content of ERA wheat were increased by starter fertilizer at 3 of 4 locations in the Red River Basin of Minnesota. Those fields in which the greatest increase in yields were realized were either relatively low in available phosphorus or potassium.

DTPA SOIL EXTRACT ANALYSIS FOR METALS

Comparative Studies between Inductively Coupled Plasma Emission and Atomic Absorption Spectroscopy

Robert Munter and John Grava

Research Analytical Laboratory and the Soil Testing Laboratory
Department of Soil Science

The DTPA soil extraction method developed by Lindsay and Norvell[1] has been widely used for the determination of plant "available" Cu, Zn, Fe and Mn in soils. This method is currently used for the "zinc test" by the Soil Testing Laboratory. Although the DTPA method was originally developed for Cu, Zn, Fe and Mn, it has also been used for the determination of heavy metals in soils receiving industrial waste and for environmental monitoring of soils for plant "available" metals.

The most common method for measurement of metals in the DTPA extract has been atomic absorption spectrophotometry (AA). Soils and DTPA extracts submitted after January 1977 to the Research Analytical Laboratory for extractable metals (Cu, Zn, Fe, Mn, Cd, Ni, Pb, Cr, Hg) have been determined by the new method of inductively coupled plasma atomic emission spectroscopy (ICP-AES). Preliminary work showed the two spectroscopy methods to be comparable but since such large numbers of research samples are submitted to this laboratory for this determination it was important to further compare the two methods on DTPA extracts from a wide variety of soils and soil like materials.

Table I shows a comparison between analysis by flame atomic absorption in the Soil Testing Laboratory using a Perkin-Elmer model 406, and ICP emission spectroscopy in the Research Analytical Laboratory using an Applied Research Laboratories' plasma spectrometer model 137. Determinations were made on twenty-eight soil samples that were used in a micronutrient sample exchange study by the North Central Regional (NCR-13) Soil Testing Committee 1978, with the Soil Testing Laboratory participating. The agreement between the two departmental laboratories with each using different spectroscopy methods is excellent excepting Fe at high concentrations. Which method is more correct at these levels is not known. In regard to fertility testing this problem is not important since agreement is very good at low iron concentrations. The upper limit for plant response to iron as reported by Lindsay and Norvell is 4.5 ppm Fe in the soil as extracted by DTPA.

Table II shows a comparison between AA and ICP analysis performed in the Research Analytical Laboratory on the same DTPA extracting solution. The AA used was a Perkin Elmer model 303. Background correction was used for Ni, Pb and Cd. The thirty-two Minnesota soil samples used in this study were subsamples of a collection of representative soil series collected by the Soil Survey staff of the USDA Soil Conservation Service. These samples were collected for a sulfur project as part of a thesis study[2] by George Rehm under Dr. A. Caldwell.

The commercial soil group are laboratory "check samples" obtained from Urbana Laboratories, Urbana Illinois. The river sediment samples are dredge material that were used in an SEA-AR USDA study in this department. The scrubber sludge sample was obtained from the Northern States Power plant at Becker Minnesota. The fly ash sample is the National Bureau of Standards' SRM 1633 standard reference material.

Table III is a summary of statistics from tables I and II.

[1]Lindsay, W.L. and Norvell, W.A. 1969. Development of a DTPA micronutrient test. Agron. Abstr. p84. Lindsay, W.L. and Norvell, W.A. 1978. Development of a DTPA soil test for zinc, iron, manganese and copper. Soil Science Soc. Am. J. 42:421-428.

[2]Sulfur oxidation and supplying power of some Minnesota soils. MS. thesis 1965.

TABLE I

COMPARATIVE ANALYSIS OF DTPA SOIL EXTRACTS[1]
BY ATOMIC ABSORPTION (AA) IN THE SOIL TESTING LABORATORY
AND ICP ATOMIC EMISSION SPECTROSCOPY IN THE RESEARCH ANALYTICAL LABORATORY

(concentrations as ppm in air dry soil)

	Cu		Zn		Fe		Mn	
	ICP RAL	AA STL	ICP RAL	AA STL	ICP RAL	AA STL	ICP RAL	AA STL
31	0.30	0.30	0.20	0.20	1.2	1.0	8.1	6.9
7	0.24	0.23	0.34	0.30	1.4	1.8	8.1	6.9
32	0.49	0.50	0.34	0.35	5.0	4.8	16.7	16.2
11	0.90	0.90	1.95	2.15	6.3	6.0	9.1	8.4
30	0.56	0.59	0.30	0.30	6.7	7.0	1.3	<2.0
33	0.68	0.68	0.49	0.40	6.9	6.8	27.5	26.8
22	0.83	0.91	2.10	2.10	7.4	7.2	13.0	12.2
27	0.76	0.78	0.99	0.95	8.7	8.8	10.3	10.3
21	0.99	1.03	1.82	1.85	9.1	9.0	20.7	20.3
10	0.35	0.29	0.74	0.70	10.3	9.0	12.2	11.2
12	0.86	0.92	0.98	1.05	11.9	11.4	16.0	16.4
29	0.30	0.27	1.93	1.75	11.8	11.6	3.4	3.0
16	0.16	0.16	0.30	0.30	13.7	13.2	2.4	2.3
20	0.99	0.99	1.95	1.95	14.7	14.6	9.2	7.9
8	1.37	1.34	0.28	0.35	18.7	16.8	7.7	7.1
9	0.57	0.49	0.40	0.40	18.6	16.8	10.0	8.6
15	1.63	1.65	1.53	1.40	19.4	18.8	10.6	9.8
5	0.22	0.16	0.42	0.40	22.0	19.8	3.4	3.3
28	0.53	0.60	15.3	14.7	31.2	31.2	38.0	36.0
4	0.21	0.13	0.48	0.40	36.6	33.4	0.5	<2.0
1	1.81	1.81	0.99	0.90	48.9	44.0	19.4	19.1
14	1.76	1.85	0.81	0.80	59.0	62.0	4.6	4.6
2	0.57	0.52	3.24	3.70	60.4	54.0	36.4	36.2
13	1.84	1.88	2.00	1.95	83.2	86.0	8.7	8.3
3	2.95	2.91	6.08	6.25	120	98.0	1.5	<2.0
6	0.70	0.72	12.3	12.0	213	185	66.0	58.0
25	0.97	1.16	8.10	8.40	673	596	23.7	24.7
26	3.09	3.01	6.87	6.95	707	621	18.5	19.4
Mean	0.95	0.96	2.62	2.60	80	71	16.1	15.4
s	0.77	0.77	3.78	3.71	178	157	14.0	13.2
r	0.997		0.999		1.000		0.996	

NOTE: Samples are categorized according to increasing iron concentrations.

[1]ICP and AA determinations were made on solutions from different extractions except for Fe where the same solution was used for both methods.

TABLE II

COMPARATIVE ANALYSIS OF DTPA EXTRACTS OF SOILS, SEDIMENTS, SCRUBBER SLUDGE AND FLY ASH BY ICP ATOMIC EMISSION AND ATOMIC ABSORPTION (AA) SPECTROSCOPY IN THE RESEARCH ANALYTICAL LABORATORY

(concentrations as ppm in air dry material)

	Cu		Zn		Fe		Mn		Cd		Pb		Ni		Cr	
	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA
MINNESOTA SOILS																
Bearden	1.24	1.50	0.98	1.04	6.6	6.0	50	54	0.10	0.12	0.74	0.80	1.24	1.32	<.02	<.04
Ulen	0.54	0.52	0.64	0.56	7.2	6.0	20	20	0.06	<.04	0.58	0.60	0.70	0.72	0.04	<.04
Hegne	1.76	1.98	1.76	1.98	9.6	9.0	29	34	0.10	<.06	1.30	1.40	1.16	1.20	0.06	<.04
Flom	2.28	2.24	1.80	1.88	16	16	44	49	0.26	0.22	2.18	2.60	2.96	3.24	0.04	<.04
Downs	0.96	1.02	0.88	0.94	22	20	34	34	0.08	<.04	0.76	0.60	0.84	0.80	0.02	<.04
Webster S*	0.97	1.14	2.18	2.34	28	28	42	44	0.08	0.10	1.06	1.00	1.48	1.60	<.02	<.04
Kasson	1.02	1.08	1.00	0.98	32	32	45	49	0.08	0.10	0.88	0.80	1.14	1.28	0.04	<.04
Hayden	0.96	0.98	1.78	1.80	34	30	85	88	0.10	0.06	0.80	0.40	1.70	1.60	0.04	<.04
Fargo	3.28	3.58	2.62	2.74	34	34	136	140	0.36	0.38	1.26	1.20	4.78	4.68	<.02	<.04
Tama	0.92	1.08	1.28	1.52	40	38	60	65	0.08	0.08	0.64	0.80	1.58	1.60	<.02	<.04
Waukegan	0.62	0.78	0.84	1.08	44	36	39	42	0.06	0.08	0.48	0.60	0.68	0.48	<.02	<.04
Aastad	1.40	1.54	1.58	1.76	48	46	95	99	0.14	0.14	0.62	1.00	3.06	3.12	<.02	<.04
MEAN	1.32	1.45	1.45	1.55	26.8	25.1	57	60	0.14	0.14	1.02	1.02	1.88	1.92	-	-
Hiwood	0.05	0.07	0.78	0.90	47	46	16	16	<.02	<.04	0.06	<.20	0.08	0.08	0.02	<.04
Lester	0.76	0.81	3.16	3.20	50	42	125	133	0.14	0.08	0.92	0.40	1.60	1.60	0.04	<.04
Chetek	0.63	0.70	0.58	0.60	51	43	14	15	0.06	<.06	0.56	0.40	0.16	0.16	0.04	<.04
Zimmerman	0.17	0.10	0.94	0.92	57	54	19	20	0.06	<.04	0.80	0.40	0.16	-	0.08	<.04
Blue Earth	1.71	1.92	6.08	6.70	58	56	82	80	0.18	0.22	1.22	1.20	2.24	2.00	<.02	<.04
Parnell	0.11	0.03	2.12	1.60	63	67	10	12	<.02	0.04	<.02	<.20	<.02	0.36	<.02	<.04
Webster R*	2.06	2.14	1.38	1.38	67	56	64	65	0.14	0.14	1.76	1.60	2.80	2.74	0.06	<.04
Hubbard	0.44	0.40	1.26	1.16	71	60	63	66	0.12	0.06	0.96	0.20	0.72	0.72	0.08	<.04
Kilkeny	2.10	2.30	1.30	1.44	74	74	88	94	0.12	0.08	1.44	1.60	1.56	-	0.04	<.04
Esterville	0.58	0.60	1.88	1.90	75	63	94	98	0.08	0.10	0.66	0.40	1.10	1.00	0.02	<.04
Nicollet	1.07	1.22	2.30	2.44	80	80	142	143	0.22	0.18	0.86	0.80	3.28	3.58	<.02	<.04
Dorset	1.56	1.84	3.62	3.94	91	72	67	73	0.12	0.08	0.40	0.40	0.68	0.68	<.02	<.04
Rocksbury	1.28	1.48	2.08	2.28	94	93	32	36	0.08	0.06	1.48	1.80	1.68	1.92	0.08	0.06
MEAN	0.96	1.05	2.11	2.19	68	62	63	66	0.13	0.11	1.01	0.84	1.43	1.45	-	-

NOTE: Samples are categorized according to increasing iron concentrations.

*Steele and Redwood counties

Table Continued

TABLE II CONTINUED

	Cu		Zn		Fe		Mn		Cd		Pb		Ni		Cr	
	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA
Kenyon	1.39	1.52	3.04	3.20	110	106	134	138	0.14	0.16	1.40	1.20	3.16	3.14	0.02	<.04
Fayette	1.07	1.22	3.14	2.96	120	114	189	195	0.14	0.10	1.58	1.20	2.08	1.84	0.04	<.04
Milaca	0.39	0.32	5.66	5.26	164	149	79	85	0.12	0.06	1.04	0.60	0.50	0.48	0.12	0.06
Brainard	0.62	0.54	1.87	1.78	192	163	146	156	0.06	<.04	1.24	0.80	1.02	0.96	0.18	0.10
MEAN	0.87	0.90	3.43	3.30	148	133	137	144	-	-	1.32	0.95	1.69	1.61	-	-
Ontanogan	2.12	2.24	5.12	4.76	212	206	64	75	0.10	0.16	1.68	1.60	0.80	0.80	0.06	<.04
Zim	0.76	0.78	1.23	1.26	266	252	10	12	0.08	0.08	2.04	1.80	0.74	0.80	0.10	<.04
Isanti	0.01	0.06	0.08	0.08	544	458	4	5	<.02	0.04	0.12	<.20	0.48	0.32	0.08	<.04
MEAN	0.96	1.03	2.14	2.03	341	305	26	31	-	-	-	-	0.67	0.64	-	-
COMMERCIAL SOIL CHECKS (ILLINOIS)																
Ca	2.82	2.82	2.44	3.06	252	228	45	47	0.14	0.06	6.54	6.20	1.58	1.32	0.08	<.04
106	0.65	0.68	0.43	0.57	47	39	46	48	0.06	0.06	1.14	1.00	0.20	0.20	0.04	<.04
107	2.34	2.42	2.22	2.23	102	88	62	69	0.16	0.10	2.98	3.00	1.50	1.44	0.04	<.04
114	0.78	0.78	0.89	0.82	151	110	59	63	0.06	0.06	2.38	2.00	0.32	0.28	0.10	<.04
201	1.52	1.58	2.02	2.22	70	53	47	51	0.14	0.14	1.64	1.40	0.90	0.88	0.06	<.04
205	3.28	3.34	3.10	3.36	298	296	117	123	2.58	2.61	3.04	3.00	2.76	2.96	0.02	<.02
MEAN	1.90	1.94	1.85	2.06	153	136	63	67	0.52	0.51	2.95	2.77	1.21	1.19	-	-
RIVER SEDIMENT (DREDGE MATERIAL)																
New York	60.2	60.8	88.2	93.4	151	143	60	65	2.64	2.86	61.8	59.6	1.02	1.00	0.04	<.04
Ohio	11.7	11.3	12.2	14.3	171	173	36	40	1.62	1.82	11.8	12.4	1.68	1.66	0.02	<.04
Michigan	62.0	61.0	61.2	61.2	189	182	52	55	2.02	2.18	18.5	17.8	6.78	6.82	0.08	<.04
MEAN	44.6	44.4	53.9	56.3	170	166	50	54	2.09	2.29	30.7	29.9	3.16	3.16	-	-
POWER PLANT SCRUBBER SLUDGE AND FLY ASH																
Sludge	1.63	1.44	3.00	2.98	41.2	37.6	7.2	7.6	0.16	0.14	0.62	0.20	0.26	0.14	0.08	<.04
Ash (NBS)	7.34	7.40	0.21	0.22	133	131	0.0	0.0	0.16	0.16	1.62	1.20	0.30	0.48	0.90	0.86

TABLE III

SUMMARY OF STATISTICS OF ICP AND AA DATA FROM TABLES I AND II

(concentrations as ppm in air dry soil)

		Cu		Zn		Fe		Mn		Cd		Pb		Ni	
		ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA
MEANS															
Minnesota Soil	n=33	1.09	1.18	2.03	2.07	73.0	67.6	66.3	69.9	0.13	0.12	1.05	0.97	1.53	1.53
Illinois Soil	n= 6	1.90	1.94	1.85	2.06	153.0	136.0	62.5	66.9	0.52	0.51	2.95	2.77	1.21	1.19
River Sediment	n= 3	44.6	44.4	53.9	56.3	170.0	166.0	49.5	53.5	2.09	2.29	30.7	29.9	3.16	3.16
NCR-13 Soil	n=28	0.95	0.96	2.62	2.61	79.5	71.3	16.1	15.4	ND		ND		ND	
STANDARD DEVIATIONS															
Minnesota Soil	n=33	0.74	0.81	1.44	1.45	61.5	57.5	47.1	48.5	0.07	0.07	0.49	0.56	1.11	1.14
Illinois Soil	n= 6	1.09	1.10	1.00	1.14	102.0	103.0	27.6	28.9	1.01	1.03	1.91	1.87	0.95	1.00
River Sediment	n= 3	28.5	28.6	38.5	39.8	19.0	20.4	12.2	12.5	0.51	0.53	27.1	25.8	3.15	3.18
NCR-13 Soil	n=28	0.77	0.77	3.78	3.71	178	157.0	14.0	13.0	ND		ND		ND	

CORRELATION COEFFICIENTS

		Cu	Zn	Fe	Mn	Cd	Pb	Ni
Minnesota Soil	n=33	0.994	0.989	0.995	0.999	0.882	0.873	0.993
Illinois Soil	n= 6	1.000	0.983	0.991	0.999	0.999	0.997	0.990
River Sediment	n= 3	1.000	0.998	0.963	0.998	0.999	1.000	1.000
NCR-13 Soil	n=28	0.997	0.999	1.000	0.996	ND	ND	ND

LINEAR REGRESSION COEFFICIENTS (y=a+bx) y=ICP x=AA

		Cu	Zn	Fe	Mn	Cd	Pb	Ni
Minnesota Soil	n=33	y=-.02+0.905x	y=-.008+0.982x	y=1.00+1.07 x	y=1.49+0.970x	y=0.03+0.818x	y=0.37+0.727x	y=0.05+0.970x
Illinois Soil	n= 6	y=-.02+0.989x	y= .09 +0.863x	*y= 21+0.975x	y= .97+0.952x	y=0.03+0.977x	y=0.14+1.08 x	y=0.11+0.932x
River Sediment	n= 3	y= .44+0.996x	y=-.57 +0.967x	y= 22+0.897x	y= 2.6+0.976x	y=-.13+0.972x	y=-.74+1.05 x	y=0.03+0.989x
NCR-13 Soil	n=28	y=0.00+0.99 x	y= .03 +1.02 x	y=-1.5+1.14 x	y= .40+1.08 x	ND	ND	ND

*Curve for iron is best defined by a three degree polynonomial giving an intercept of 1.22

Progress Report on Foliar Fertilizers on Soybeans

W.D. Poole[1], G.E. Ham[2], G.W. Randall[3], W.W. Nelson[4] and S.D. Evans[5]

During the 1978 growing season the foliar fertilizer treatments shown in Table 1 were applied to two high yielding soybean varieties at Lamberton, Morris, Rosemount and Waseca. Vickerey variety is the phytophthora resistant sister line of Corsoy variety that was released in 1978. The soybeans were planted in 14-inch rows on May 8-12. Soil tests indicated that no soil fertilizer was needed.

The standard foliar fertilizer of comparison was the Iowa State University-TVA (Tennessee Valley Authority) formulation that produced the 22 and 23 bushel yield increases reported by Iowa State University in 1975. The time and rate of applications are given in Table 1. The commercial products were applied according to the label except for treatment 11 in which Eco-Gro was applied at the same time and rate of nitrogen as treatments 2 and 5 rather than at the recommended rate of one (1) quart per acre. All treatments were applied with 0.1% Tween 80 as a wetting agent.

Samples for seed yield were obtained by harvesting a measured area from each plot with a plot combine. Seed from the plots were dried, cleaned and weighed to determine seed yields. No significant yield increase was obtained from any foliar fertilizer treatment at any location. These results indicate that further research is necessary before the process of foliar fertilization can be understood in order to produce consistent and economical yield increases. At the present time we consider the concept of foliar fertilization of soybeans to be experimental and the practice is not recommended for routine use in commercial soybean production.

Table 1. Influence of various commercial foliar fertilizers on 1978 soybean seed yields.

Treatment	Number Applications		Fertilizer Applied[e]	Lamberton		Morris		Rosemount		Waseca		4-Location Average
	Flowering	Pod-fill	N+P+K+S	Hodgson '78	Vickerey	Evans	Hodgson '78	Evans	Hodgson '78	Hodgson '78	Vickerey	Hodgson '78
			lbs/acre	bu/acre								
1 Control	-	-	-	51	57	43	44	54	60	56	56	53
2 Folian	1		12+4+4+0.5	51	53	46	44	54	59	53	55	52
4 Folian	-	1	12+4+4+0.5	50	53	38	44	53	59	55	55	52
3 Folian	1	1	24+8+8+1	50	54	47	45	55	60	54	56	52
5 NPKS[a]	1	-	12+4+4+0.5	51	54	41	45	56	61	55	57	53
6 NPKS[a]	-	1	12+4+4+0.5	51	57	45	46	57	59	55	55	53
7 NPKS[a]	-	2	24+8+8+1	53	55	40	46	54	61	55	57	54
8 NPKS[a]	-	4	48+16+16+2	50	52	44	43	57	62	55	56	53
9 Seaborne + F[b]	1	-	0.14+0.02+ 0.03+0	53	55	45	41	52	59	54	56	52
10 Eco-gro[c]	1	-	0.19+0.1+0.1+0	52	54	42	44	55	60	55	56	53
11 Eco-gro[d]	1	-	12+6+6+0	50	52	40	43	56	59	54	55	52
12 10-34-0+urea+ KS	-	3	36+12+12+1.5	53	54	44	46	54	62	54	56	54
SE				2.6		3.1		2.0		1.4		
CV(%)				8.4		12.3		6.2		4.2		
F-Test				1.4NS		1.6NS		<1.0NS		<1.0NS		

[a]Iowa State materials; [b]$N-P_2O_5-K_2O$, 6-3-3-0 @ 1 quart/acre; [c]$N-P_2O_5-K_2O-S$, 8-4-4-0 @ 1 quart/acre; [d]15.5 gallons/acre; [e]$N+P_2O_5+K_2O+S$

Response of Soybean Genotypes to Foliar Fertilization

W.D. Poole, G.E. Ham and G.W. Randall

In order to evaluate the influence of soybean genotype on the response to foliar fertilization, 9 commercial soybean varieties, 11 experimental soybean lines (that have the potential of becoming named varieties) and 6 semideterminate-indeterminate isoline pairs received Folian commercial foliar fertilizer. The rate of application was 12+4+4+0.5 pounds per acre of $N+P_2O_5+K_2O+S$ during the early podfilling stage of growth at three field locations (not all soybeans were grown at every location because of maturity differences). All treatments were applied with 0.1% Tween 80 as a wetting agent. The soybeans were planted in 14-inch rows on May 8-12. Soil tests indicated that no soil fertilizer was needed. The seed yield of one experimental line was increased 7 bushels per acre at Becker; otherwise, no significant yield increases were obtained (Table 1). The failure to produce consistent and economical yield increases indicates the need for further research before the process of foliar fertilization is used routinely in commercial soybean production.

Table 1. Influence of foliar fertilization on the seed yield of soybean genotypes in 1978

Soybean Line	Becker		Rosemount		Waseca	
	No Folian	Folian[a]	No Folian	Folian[a]	No Folian	Folian[a]
	bu/acre					
Clay[b]			50	52		
Coles					54	55
Evans	58	59	54	52		
Grande			52	55		
Harcor					55	55
Harlon			57	56		
Hodgson '78	64	67	58	58	59	59
Swift	59	55	55	58		
Vickerey					60	59
M-68-176	65	69				
M-68-333					54	57
M-69-36			59	61		
M-69-122					50	52
M-69-239					51	53
M-70-9					50	49
M-70-74	56	55	54	54		
M-70-77	58	65	58	57		
M-70-127	60	57	57	53		
M-70-153	60	62	58	57		
M-70-330	60	63	58	57		
12-12-1					50	53
12-12-2					52	50
12-22-1			58	59		
12-22-2			60	59		
12-25-1			52	52		
12-25-2			53	53		
13-47-1					57	56
13-47-2					54	54
13-82-1			56	56		
13-82-12			53	55		
13-84-1			56	55		
13-84-2			55	54		
SE	2.3		2.4		3.7	
CV (%)	6.6		7.5		11.6	
F-test	1.5NS		<1.0NS		< 1.0NS	

[a]Applied at the rate of 100 lbs/acre during pod filling; total nutrient elements applied 12-4-4-0.5 ($N+P_2O_5+K_2O+S$); [b]M-genotypes obtained from J.W. Lambert. 12- and 13- genotypes obtained from D.E. Green, Iowa State University.

NITROGEN FERTILIZATION OF SUGARBEETS IN WEST-CENTRAL MINNESOTA - 1978

R. P. Schoper and O. M. Gunderson

Accurate prediction of nitrogen needs for sugarbeets is of prime economic importance to the beet growers of west-central Minnesota. Sugarbeets do not have a built-in mechanism which automatically triggers sugar accumulation at a certain point in the growing season. Therefore, roots increase in sugar content only after a shortage of a primary growth factor exists such as heat units, water or essential nutrients. Of these growth factors, the control of an essential element such as nitrogen has proven to be the most effective.

Research was initiated in 1976 to study the problem of predicting fertilizer nitrogen requirements for sugarbeets in west-central Minnesota. The objectives of this study are: a) to determine the optimum sampling depth for use of the nitrate-nitrogen soil test in predicting fertilizer nitrogen needs, b) to correlate and calibrate soil nitrate-nitrogen levels to fertilizer nitrogen response by sugarbeets and c) to observe the influence of soil nitrate-nitrogen levels and fertilizer nitrogen rates on the nitrate-nitrogen content of sugarbeet petioles at various points in the growing season.

Materials and Methods: Twelve locations were selected in west-central Minnesota for nitrogen correlation-calibration studies in 1978. Five experiments consisting of nitrogen fertilizer rates of 0, 50, 100, 150, and 200 pounds per acre, arranged in a 5 x 5 Latin Square design, were applied as ammonium nitrate in October of 1977. The representative soils were Marna silty clay and Colvin silty clay loam in Renville County, Hamerly loam in Chippewa County, and Svea loam in Swift County. Seven additional experiments consisted of four paired comparisons of nitrogen fertilizer versus a no-nitrogen control. These 400 foot strips were established by farmers utilizing the nitrogen fertilizer rate and form which was used on the remainder of the field.

Soil cores were taken to a 5 foot depth for the nitrogen rate experiments and to a 3 foot depth for the strip trials. Increments of 0-6", 6-12", 12-24", 24-36", 36-48" and 48-60" were analyzed for nitrate-nitrogen. In addition, soil analyses were made on a composite sample of the 0-6" depth for organic matter, available phosphorus, exchangeable potassium, and zinc.

Young-mature petioles were sampled 5 times in 2-week intervals beginning on July 17 to monitor nitrate-nitrogen levels in the sugarbeet tissue. Emission spectographic analyses were also run to ascertain the level of other essential nutrients in the plant tissue.

Plots were harvested with a 4-row Farmhand lifter during the last week of September. Sub-samples were collected and transported to the Minn-Dak Farmers Cooperative where the sugarbeets were processed through the tare laboratory and analyzed for percentage sugar, nitrate, conductivity, and purity.

Results and Discussion: Above average early season moisture followed by dry conditions in late summer resulted in beet yields near the record-breaking year of 1977.[1/] In the 1978 nitrogen rate studies (Tables 1-6), on soils with soil nitrate levels (0-2') ranging from 66 to 91 pounds per acre, the trend was for increased sugar yields with the use of 50 pounds nitrogen per acre and in one case 100 pounds nitrogen per acre. It is noteworthy, that excess use of nitrogen fertilizer reduced the percentage sugar, decreased purity and reduced sugar yield when compared to moderate nitrogen application rates. Similar results were obtained from the strip trials (Table 7) with one exception. At the Olson farm sugar yield was reduced with the addition of nitrogen fertilizer even though the soil nitrate level was low.

Results from the analysis of young mature petioles for nitrate-nitrogen content is presently unavailable and will be reported at a later date.

3-Year Summary: Several observations can be drawn from the 19 nitrogen experiments conducted since 1976.

1) The nitrate-nitrogen soil test is a useful tool in protecting the beet grower against excessive use of nitrogen fertilizer on soils testing high in soil nitrates, greater than 150 pounds per acre 2 feet. The calibration of proper nitrogen fertilizer rate at soil nitrate levels less than 150 pounds is less clear. Variable results are likely due to a combination of factors including soil type, soil organic matter level, soil drainage, plant population, sugarbeet variety, time and depth of sampling for soil nitrates, past cropping history, and the greatest variable of all, the weather.

2) Sampling soils to a 2 foot depth for soil nitrates appears to be reasonably accurate, however, ample evidence exists indicating that sampling to a 3 foot depth would improve the accuracy of the test.

3) Basing nitrogen fertilizer recommendations on yield goal can lead to a large error if improperly used. For example, in 1977 and 1978 it is well documented that average beet yields in excess of 22 tons are possible. However, the grower should not be misled into believing he needs to apply large amounts of nitrogen fertilizer to take advantage of a high tonnage year. If adequate moisture is available to produce high tonnages, an increased rate of nitrogen release from soil organic matter will also be realized. Excessive use of nitrogen fertilizer can lead to a lower sugar percentage and purity in both average and above average tonnage situations.

Recommendations: Based on the nitrogen fertilization studies conducted in west-central Minnesota since 1976, a general guide has been formulated for nitrogen fertilizer use and is presented in Table 8.

Acknowledgements: Sincere appreciation is extended to the Sugarbeet Research and Education Board and to the University Agricultural Extension Service for financing and supporting this research project.

1/ See "1977 Sugarbeet Research and Extension Reports," pp. 106-111.

Recognition should be given to our farmer-cooperators, whose interest and aid made these experiments a success. Wayne Schwitter should receive special recognition for his donation of a 4-row Farmhand lifter to the University of Minnesota.

Special recognition should also be given to Jerome Lensing, Mike O'Leary, George Nelson, Peter Groves, and James Coffman in the Soil Science Department, University of Minnesota, for their untiring efforts and attention to the field phase of this project.

Table 1. Soil nitrate-nitrogen levels at the experimental locations in the fall of 1977.

Soil Depth	L. Stamer Renville Co	P. Frieborg Renville Co	E. Schwitter Chippewa Co	H. Peterson Chippewa Co	V. Arnold Swift Co
inches			lbs NO_3-N/A		
0-6	15	24	26	9	14
6-12	23	41	25	13	14
12-24	37	26	12	44	50
24-36	38	11	24	54	21
36-48	29	6	8	20	9
48-60	15	7	6	8	8

Table 2. Effect of various rates of nitrogen on sugarbeet root yield, percentage sugar, gross sugar, purity, and recoverable sugar. LeRoy Stamer farm, Renville County - 1978.

Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar
lbs/A	T/A	%	lbs/A	%	lbs/A
0	21.7	14.8	6274	87.4	5483
50	23.5	14.4	6782	86.6	5877
100	23.0	14.3	6567	87.0	5716
150	24.7	13.4	6647	85.8	5703
200	24.8	13.4	6653	85.8	5711
Significance	*	**	NS	**	NS
BLSD (.05)	2.0	0.7	--	0.9	--

Table 3. Effect of various rates of nitrogen on sugarbeet root yield, percentage sugar, gross sugar, purity, and recoverable sugar. Pete Frieborg farm, Renville County - 1978.

Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar
lbs/A	T/A	%	lbs/A	%	lbs/A
0	22.5	15.0	6750	87.0	5878
50	21.2	15.2	6443	86.9	5595
100	24.6	15.0	7290	86.7	6321
150	25.5	14.4	7355	86.0	6327
200	23.5	14.4	6757	86.4	5834
Significance	*	NS	+	NS	+
BLSD (.05)	2.9	--	--	--	--

Table 4. Effect of various rates of nitrogen on sugarbeet root yield, percentage sugar, gross sugar, purity, and recoverable sugar. Eugene Schwitter farm, Chippewa County - 1978.

Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar
lbs/A	T/A	%	lbs/A	%	lbs/A
0	23.6	13.8	6504	85.8	5579
50	25.5	14.0	7163	86.2	6172
100	24.0	14.0	6727	86.2	5799
150	26.3	14.1	7418	86.2	6394
200	25.6	13.9	7140	86.9	6205
Significance	NS	NS	NS	NS	NS
BLSD (.05)	--	--	--	--	--

Table 5. Effect of various rates of nitrogen on sugarbeet root yield, percentage sugar, gross sugar, purity, and recoverable sugar. Harold Peterson farm, Chippewa County - 1978.

Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar
lbs/A	T/A	%	lbs/A	%	lbs/A
0	20.1	15.2	6069	86.3	5238
50	24.4	15.0	7319	86.2	6309
100	22.0	14.5	6381	86.0	5496
150	22.2	14.3	6358	85.9	5468
200	22.0	13.6	6965	85.0	5063
Significance	NS	**	NS	NS	NS
BLSD (.05)	--	0.8	--	--	--

Table 6. Effect of various rates of nitrogen on sugarbeet root yield, percentage sugar, gross sugar, purity, and recoverable sugar. Vernon Arnold, Swift Co. - 1978.

Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar
lbs/A	T/A	%	lbs/A	%	lbs/A
0	25.5	15.0	7628	87.3	6655
50	27.9	14.9	8263	86.9	7177
100	27.3	14.4	7889	87.1	6870
150	26.5	13.9	7325	86.4	6330
200	25.7	13.7	7039	86.2	6060
Significance	NS	**	*	*	**
BLSD (.05)	--	0.4	709	0.7	596

Table 7. Effect of nitrogen on sugarbeet root yield, percentage sugar, gross sugar, purity, and recoverable sugar. 1978.

Cooperator	Nitrate Test (0-2')	Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar
	lbs/A	lbs/A	T/A	%	lbs/A	%	lbs/A
C. Morrow	270	0	17.2	14.7	5047	84.3	4257
		100	16.6	14.3	4716	82.7	3902
J. Berger	60	0	17.5	14.7	5141	84.2	4336
		80	18.0	14.6	5202	83.2	4329
W. Olson	33	0	20.3	14.6	5910	87.4	5170
		75	19.0	14.3	5411	85.9	4646
D. Gibson	58	0	19.5	14.6	5656	87.1	4926
		80	21.4	13.7	5888	87.2	5133
L. Kramer	45	0	16.7	13.3	4444	86.1	3831
		70	16.5	14.2	4667	87.6	4089
B. Skalbeck	48	0	15.1	13.8	4171	86.6	3619
		80	18.5	14.0	5191	86.6	4503
H. Zimmer	70	0	23.9	13.3	6399	87.9	5619
		100	25.3	13.0	6585	86.8	5715

Table 8. Nitrogen recommendations for sugarbeets in west-central Minnesota based on previous cropping history.

Previous Crop	Amount of Nitrogen (N) To Apply When the Organic Matter Level Is: Low to Medium	High
	lbs/A	
Corn	100	80
Small grain, Soybeans	80	60
Black fallow, Alfalfa, Clover	20	0

**Nitrogen recommendations for sugarbeets in west-central Minnesota based on soil nitrate-nitrogen level.

- 0-2' - Subtract the soil test nitrate-nitrogen value from 150 pounds per acre.
- 0-3' - Subtract the soil test nitrate-nitrogen value from 180 pounds per acre.

Nitrogen X Variety Interaction Trial on Sugarbeets

In Chippewa County - 1978

Larry Smith, Robert Schoper and Jerome Lensing

In order to produce the highest possible yield of gross sugar per acre, nitrogen fertilizer is generally needed on sugarbeets. However, if excess nitrogen is found in the profile or applied, it increases the level of impurities, which decreases the processors extraction rate and lowers the percent sucrose in the root. A trial designed to study the effects of high nitrogen rates on sugarbeet varieties was initiated at Clara City in 1978.

EXPERIMENTAL PROCEDURES

Sugarbeets were planted on May 5, in a split-plot design replicated 6 times with nitrogen rates as main plots and sugarbeet varieties as the split plots. The nitrogen rate was determined by the sum of the soil NO_3-nitrogen test (0-2') and applied ammonium nitrate to a total of 150, 250, and 350 pounds nitrogen per acre. The sugarbeet varieties used were Beta Seed 1443, 1345, and 1934; American Crystal ACH-17 and 30; and Great Western R-1. The soil contained 114 lb/A NO_3-nitrogen (0-2'), 35 lbs/A phosphorus and 309 lb/A potassium. Eptam was spring applied at 2.5 lb/A. The beets were harvested October 5 with a Farmhand 4-row lifter. Quality factors were determined at the American Crystal research facility at Moorhead, Minnesota.

RESULTS

Increasing nitrogen rates significantly reduced percent sugar, lbs gross and recoverable sugar per acre and percent recoverable sugar. (Table 1) ACH-17 had a significantly lower sugar percentage than the other sugarbeet varieties.

Increasing nitrogen rates significantly reduced the ppm of K and significantly increase the ppm of Na and amino-N in the sugarbeet brei. (Table 2) The impurity index was significantly increased with additional nitrogen. There was a significant difference in the ppm of Na in the sugarbeet varieties.

The data in this trial represents 1 year of study. Results may vary from year to year and conclusions drawn from 1 year of work may not hold true in another year. This trial will be repeated in 1979.

Table 1. Effect of variety and nitrogen rates on sugarbeet yield, percentage sugar, gross sugar, and recoverable sugar. Wayne Schwitter, Chippewa Co. - 1978.

Treatment	Yield	Sugar	Gross Sugar	Recoverable Sugar	
Variety	Tons/A	%	lb/A	lb/A	%
Beta 1443	28.8	14.6	8421	7266	86.1
Beta 1345	26.2	14.9	7788	6714	86.2
Beta 1934	27.7	14.6	8062	6896	85.4
GW R-1	27.2	14.4	7823	6733	86.0
ACH - 17	26.0	13.9	7235	6195	85.6
ACH - 30	26.4	14.8	7803	6734	86.3
Signif.	NS	**	+	+	NS
BLSD(.05)	-	.4	-	-	-
N Rate					
150#N/A	26.8	15.0	8060	7025	87.2
250#N/A	27.3	14.7	8018	6920	86.4
350#N/A	27.0	13.9	7490	6317	84.2
Signif.	NS	**	*	**	**
BLSD(.05)	-	.26	555	482	.8
Interaction					
1443 x 150 N/A	29.3	15.3	8925	7815	87.7
1345 x "	27.4	14.7	8079	7014	86.7
1934 x "	28.0	15.2	8496	7387	87.0
R-1 x "	25.9	15.0	7787	6785	87.3
ACH-17 x "	24.0	14.6	7008	6072	86.7
ACH-30 x "	26.0	15.5	8065	7077	87.7
1443 x 250 N/A	28.7	14.6	8397	7225	86.0
1345 x "	26.3	15.5	8068	7044	87.7
1934 x "	28.3	14.7	8323	7148	86.0
R-1 x "	27.0	14.4	7803	6705	86.0
ACH-17 x "	27.3	13.9	7585	6500	85.7
ACH-30 x "	26.5	15.0	7919	6900	87.3
1443 x 350 N/A	28.3	14.0	7941	6758	84.7
1345 x "	24.8	14.6	7216	6048	84.3
1934 x "	26.7	13.8	7366	6153	83.3
R-1 x "	28.7	13.7	7879	6708	84.7
ACH-17 x "	26.7	13.3	7113	6014	84.3
ACH-30 x "	26.6	14.0	7425	6224	84.0
Signif.	NS	+	NS	NS	NS
C.V.	8.9	3.0	9.7	10.5	1.5

Table 2. Effect of variety and nitrogen rates on impurity index and ppm content of Na, K, and Amino-nitrogen in sugarbeet brei. Wayne Schwitter, Chippewa Co. - 1978.

Treatment	ppm on beets			Impurity Index
Variety	Na	K	Amino N	
Beta 1443	672	1168	861	923
Beta 1345	640	1109	925	928
Beta 1934	710	1165	898	938
GW R-1	574	1054	920	900
ACH - 17	689	771	856	958
ACH - 30	740	1095	861	917
Signif	**	+	NS	NS
BLSD(.05)	100	-	-	-
N Rate				
150#N/A	578	1168	838	859
250#N/A	705	1148	848	913
350#N/A	731	1061	973	1043
Signif.	**	*	**	*
BLSD(.05)	61	87	68	51
Interaction				
1443 x 150 #N/A	620	1190	795	832
1345 x "	551	1151	867	890
1934 x "	616	1156	864	874
GWR-1 x "	491	1125	883	859
ACH-17 x "	612	1207	819	887
ACH-30 x "	577	1177	803	813
1443 x 250 #N/A	724	1182	867	934
1345 x "	612	1151	851	846
1934 x "	723	1315	843	942
GWR-1 x "	638	1018	924	939
ACH-17 x "	715	1117	842	958
ACH-30 x "	818	1104	763	861
1443 x 350 #N/A	672	1138	922	1002
1345 x "	758	1024	1057	1048
1934 x "	792	1194	986	1099
GW R-1 x "	594	1018	954	1001
ACH-17 x "	741	988	906	1028
ACH-30 x "	826	1005	1017	1078
Signif.	NS	NS	NS	NS
C.V.	14.4	11.0	12.0	8.9

Fertilizer trials on Sunflowers - 1978

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G. W. Randall

Experimental work on sunflower fertility has been quite limited. In 1961 R. G. Robinson, U of Mn Agronomy Department, and colleagues reported that sunflowers yielded more on fertile soils and had earlier flowering and maturity. In 1973 Robinson suggested, on the basis of his trials in Northwest Minnesota, 40 pounds per acre of phosphate for low testing soils and 20 pounds for medium tests. Nitrogen rates suggested varied from 0 to 90 pounds per acre, depending on previous crop, soil organic matter, nitrate test and moisture expectations. Dr. Robinson's field trials have been the chief basis for fertilizer recommendations by Extension Specialists.

In 1978 nitrogen trials were established by branch stations personnel on farmers' fields or at the station. These farms were near Lamberton, Norman Co. (also P variable) and 2 farms near Waseca, as well as on the Morris station land. Nitrogen treatments per acre applied prior to planting were 0, 30, 60, 90, 120 and 150 pounds of nitrogen per acre replicated 6 times. Blanket phosphorus and potassium treatments were made across all nitrogen plots as needed. Soil nitrate tests to 5 feet were taken, emission spectrometer readings and Kjeldahl-N determinations were made on leaves.

Yields and nitrogen in leaves are shown in the following tables:

Table 1. Yields of sunflowers from nitrogen at 5 locations - 1978.

Treatment N lbs/A	Norman Co. Ueland	Lamberton	Morris Sta.	Waseca Frodl	Waseca Marzahn
	lbs/acre				
0	1939	2032	2088	1980	2553
30	2234	1952	2114	2098	2505
60	2211	2002	2098	2095	2459
90	2263	1916	2106	2074	2510
120	1958	2262	2175	2438	2610
150	2264	2042	2140	2084	2520
Significance	ns	ns	ns	*	ns
BLSD (5%)	-	-	-	270	-
C.V.	13.4	9.7	4.8	9.8	12.5
Nitrate (0-2) lbs/A	74	73	71	57	59

Table 2. Percent nitrogen in sunflower leaves at Morris and Waseca and percent oil content from Norman County trials, 1978.

Treatment N lbs/A	Norman Co. % oil	Norman Co.	Morris %N			Waseca	
		leaf tops	leaf tops	5th leaf	9th leaf	5th leaf	5th leaf
	Ueland	Ueland	Sta.	Sta.	Sta.	Frodl	Marzahn
0	45,07	3.27	3.75	4.23	4.28	3.23	3.98
30	45.10	3.31	3.75	4.14	4.27	3.22	3.97
60	43.56	3.50	3.97	4.50	4.52	3.32	4.06
90	43.32	3.58	3.94	4.52	4.56	3.70	4.16
120	44.30	3.55	4.09	4.57	4.57	3.56	4.06
150	44.40	3.64	4.07	4.63	4.71	3.76	4.29
Significance	ns	ns	*	**	**	*	*
BLSD (5%)	-	-	.28	.19	.16	.47	.24
C.V.	3.7	2.6	4.2	2.8	2.4	.0	4.4

Table 3. Sunflower yields from phosphorus and oil content, Norman Co. 1978.

P_2O_5 lbs/A Broadcast	Yield lbs/A	Oil Content %
0	1815	46.32
30	2265	44.71
60	2151	44.32
90	1886	44.17
120	1975	44.55
150	2300	44.52
Significance	**	ns
BLSD (5%)	301	-
C.V.	9.3	3.3

Soil test lbs/A, P=5 lbs, K=275 lbs, pH. 8.4, 40 lbs N over all plots.

Summary

No conclusions will be drawn on the basis of this one year trial. The field trials will be continued in 1979.

On the very low phosphorus test in Norman County there was a highly significant response to phosphorus, and evidence of a nitrogen respons on one plot in Waseca County.

WILD RICE FERTILIZATION RESEARCH - 1978

A PROGRESS REPORT
January 4, 1979

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Research was continued during 1978 on fertilization, nutrient requirement and water quality. Soil, water and air temperatures, and quality of paddy water were monitored during the growing season to obtain information on the environment in which wild rice grows. Nitrogen rate studies were conducted on a mineral soil at Grand Rapids with two varieties in first production year, and with three varieties in third production year. Three fertilization experiments were established on peat with a first year stand in Aitkin County to study N, P, K rates, and the effectiveness of foliar fertilization. Tissue samples were collected for plant analysis to learn more about nutrient uptake by the plant.

A. WEATHER AND PLANT DEVELOPMENT

The average air temperature (table 1) was nearly 5°F above normal in May. During the main part of the growing season, air temperature was nearly normal. Heavy rainfall on August 22-23 made harvesting in the Aitkin area difficult.

Soil, water and air temperatures were measured at two locations by 3-point automatic sensing and recording thermographs (Fig. 1,2). The measurement of soil temperature at the Aitkin County location was discontinued after mid-May because of instrument malfunction. The air and water temperatures fluctuated much more than the soil temperature.

Plants emerged on May 8 in Aitkin County and on May 15 at Grand Rapids (Fig. 3,4,5). The jointing stage was reached by Netum on June 29, 45 days after emergence, and by K2 about a week later, on July 6. Netum was harvested at Grand Rapids on August 23, 100 days after emergence, and the K2 variety was harvested a week later. In Aitkin County, K2 wild rice was ready for harvest 108 days after emergence.

Table 1. Average air temperature as measured at three U.S. weather stations.[1/]

Station Year	Month April	May	June	July	August	5 Month Average	GDD T_b=40
	-----	-----	average air temperature, °F	-----	-----	-----	
Fosston, Polk Co.							
Normal[2/]	41.0	54.6	63.6	69.4	67.5	59.2	2955
1974	41.0	50.5	63.4	71.6	62.8	57.9	2744
1975	34.8	55.7	61.9	70.5	64.6	57.5	2852
1976	46.6	54.9	66.8	68.8	70.9	61.6	3315
1977	49.1	66.4	64.6	70.3	60.6	62.2	3446
1978	41.7	59.2	63.4	67.8	67.7	60.0	3060
Grand Rapids, N.C. School							
Normal	39.9	52.7	62.0	67.4	65.1	57.4	2681
1974	41.6	49.4	62.7	70.7	62.8	57.4	2670
1975	34.7	57.0	62.2	71.5	65.2	58.1	2951
1976	47.1	54.4	66.1	68.2	67.4	60.6	3166
1977	48.2	63.8	64.0	69.2	60.2	61.1	3284
1978	41.3	57.9	62.8	66.5	66.0	58.9	2892
Aitkin							
1974	42.9	49.8	63.1	71.1	63.3	58.0	2770
1975	39.0M[3/]	59.4M	64.4M	72.1	66.2M	60.2	3141
1976	47.5	54.8	66.8	69.3M	68.1	61.3	3267
1977	48.3M	64.4M	65.4M	70.3M	61.0	61.9	3446
1978	40.7M	57.5M	64.1M	67.0M	66.9	59.2	2938

1/ Source: Climatological Data, Minnesota, Vol. 80, 81, 82, 83, 84 (1974-78), U.S. Dept. of Commerce.

2/ Normals for the period 1931-60.

3/ M = less than 10 days record missing.

FIG. 1 MEAN AIR, WATER, AND SOIL TEMPERATURES GRAND RAPIDS - 1978

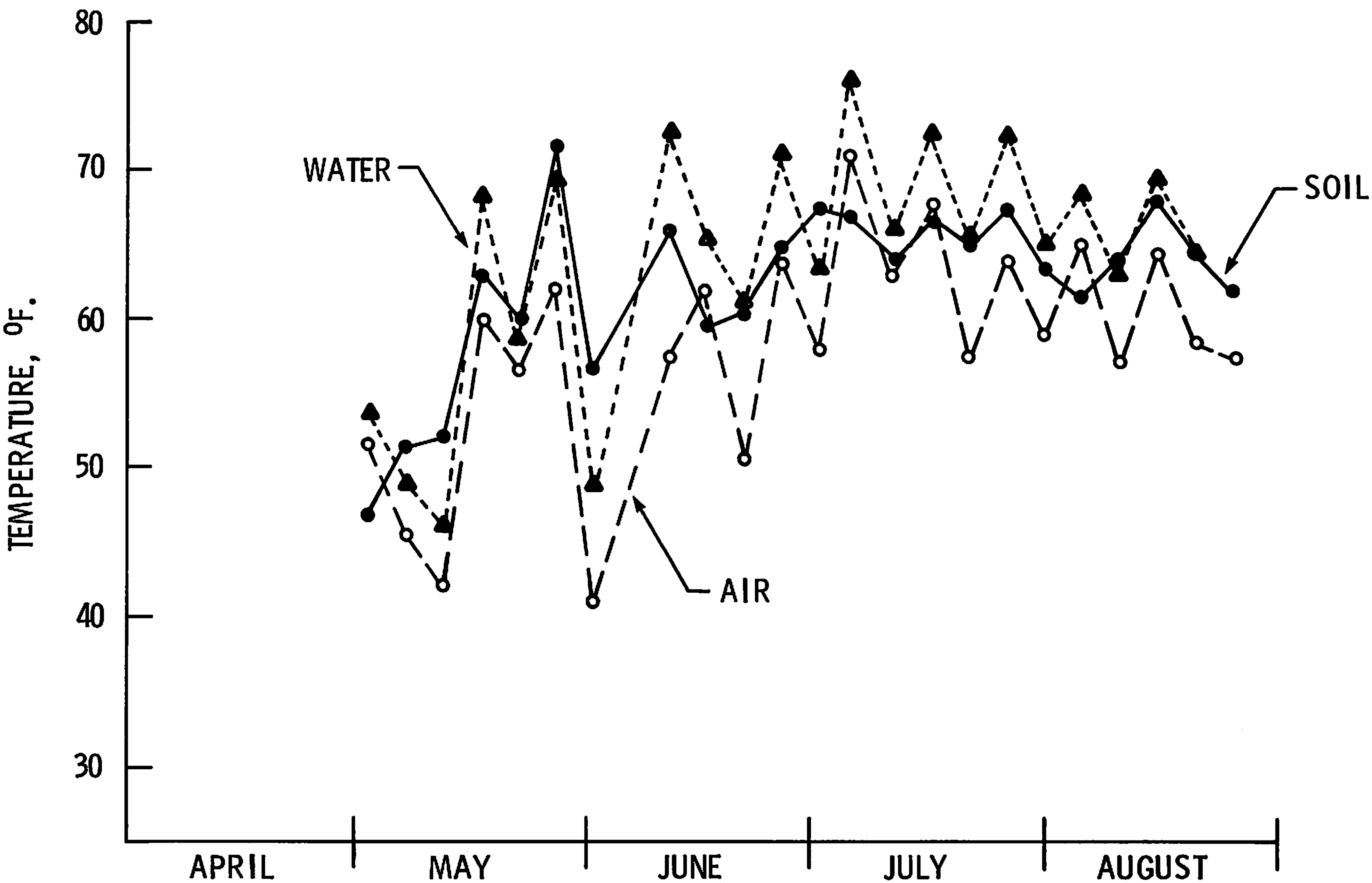

FIG. 2 MEAN AIR, WATER, AND SOIL TEMPERATURES KOSBAU BROS., AITKIN COUNTY - 1978

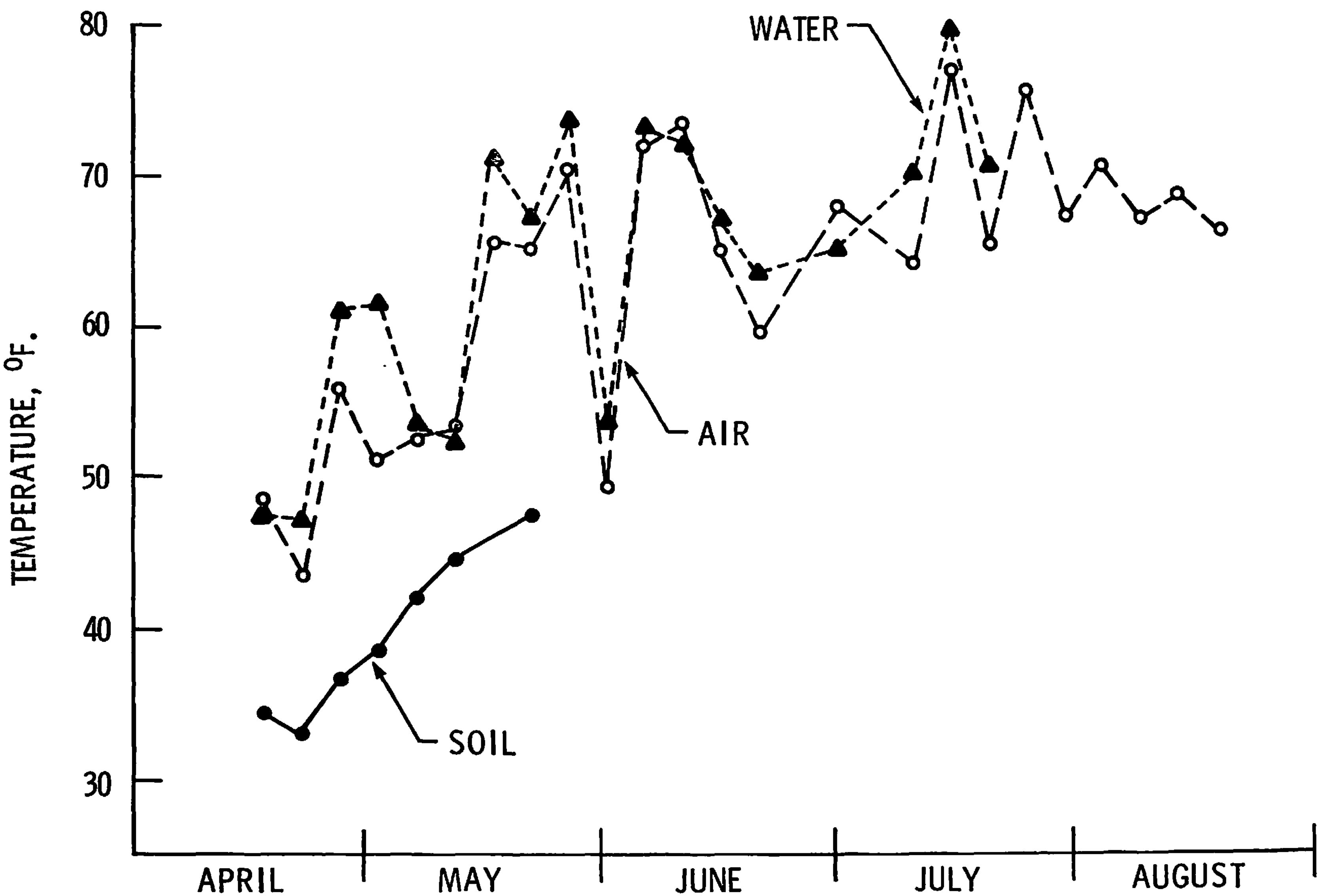

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FIG. 3

WILD RICE DEVELOPMENT
NETUM VARIETY, GRAND RAPIDS, 1978

Phase	STAGES OF DEVELOPMENT	DAYS	DATE
VEGETATIVE GROWTH PHASE	EMERGENCE	0	MAY
	FLOATING LEAF	9	
	2ND AERIAL LEAF	19	JUNE
	EARLY TILLERING	29	
REPRODUCTIVE GROWTH PHASE	JOINTING	45	
	EARLY FLOWERING	64	JULY
	LATE FLOWERING	80	AUGUST
	MATURITY	100	

FIG. 4

WILD RICE DEVELOPMENT
K2 VARIETY, GRAND RAPIDS, 1978

Phase	STAGES OF DEVELOPMENT	DAYS	DATE
VEGETATIVE GROWTH PHASE	EMERGENCE	0	MAY
	FLOATING LEAF	9	MAY
	2ND AERIAL LEAF	19	JUNE
	EARLY TILLERING	29	JUNE
	TILLERING	45	JUNE
REPRODUCTIVE GROWTH PHASE	JOINTING	53	JULY
	EARLY FLOWERING	64	JULY
	MID FLOWERING	80	AUGUST
	LATE FLOWERING	86	AUGUST
	MATURITY	106	AUGUST

FIG. 5

WILD RICE DEVELOPMENT
K2 VARIETY, KOSBAU BROS., AITKIN CO., 1978

	STAGES OF DEVELOPMENT	DAYS	DATE
VEGETATIVE GROWTH PHASE	EMERGENCE	0	MAY
	FLOATING LEAF	17	MAY
	2ND AERIAL LEAF	31	JUNE
	EARLY TILLERING	37	JUNE
REPRODUCTIVE GROWTH PHASE	JOINTING	55	JULY
	BOOT	63	JULY
	EARLY FLOWERING	71	JULY
	MID FLOWERING	79	JULY
	EARLY GRAIN FORMATION	93	AUGUST
	MATURITY	108	AUGUST

B. CHEMICAL CHARACTERISTICS OF PADDY WATER

The quality of paddy water is of interest to the grower as well as to state and federal agencies. The grower may be concerned, for example, with the concentration of sulfate in the water. Plant response to fertilization may be related to nutrient levels found in the water. Public control agencies may want to know levels of nitrogen and phosphorus present in the water when it is released during draining of paddies.

Water samples were collected from several sites at three different paddy locations during the 1978 growing season. At Grand Rapids, samples were collected from two experimental paddies used for N rate studies on a mineral soil. Source of water is the Prairie River. Water was also sampled at two sites within Kosbau Bros. paddies in Aitkin County. Paddies at this location derived water from the Little Willow River via a diversion ditch. One sampling site was located at the beginning of the diversion ditch, near the river; the other site was within a paddy in which three fertilization trials were conducted. The third sampling location was in the Gunvalson and Imle paddies near Gully. These paddies derived water from the Clearwater River.

Water samples were collected and stored in 250 ml polyethylene bottles. After the determination of pH and conductivity, a preservative was added (2 ml of mercuric chloride solution, made by dissolving 40 mg $HgCl_2$/L, to 250 ml of sample). Chemical analyses were made by the Research Analytical Laboratory, University of Minnesota. Information on location, sampling dates and chemical composition of water are given in tables 2, 3, and 4.

Table 2. Chemical composition of water collected from wild rice paddies during 1978 growing season. Location: Grand Rapids

Sample Number	Sampling Date	Location	pH	Cond. milli-mhos/cm	Alkalinity as $CaCO_3$ mg/L	Hardness $CaCO_3$ mg/L	Total Kjeldahl N ppm	Ammonium N ppm	Nitrate & nitrite N ppm	Total P ppm	Soluble P ppm	Sulfate S ppm	Ca ppm	Mg ppm	K ppm
6	5/10	PR	6.6	.12	52	52.8	0.7	0.04	<.1	0.11	0.02	<2.0	14.4	4.1	1.9
7	"	EP #1	6.8	.10	42	42.6	0.7	0.08	<.1	0.12	0.02	2.0+	11.3	3.5	1.4
8	"	EP #6	6.7	.11	42	44.9	1.0	0.08	<.1	0.01	0.01	<2.0	11.9	3.7	1.5
13	5/18	EP #1	6.4	.14			1.1			0.12					1.7
14	"	EP #6	6.5	.13			1.1			0.07					1.4
15	"	PR	6.6	.15			0.8			0.05					1.2
20	5/30	PR	6.2	.14			0.2			<0.01					1.3
21	"	EP #1	6.5	.11			0.2			<0.01					1.0
22	"	EP #6	6.6	.13			0.2			<0.01					1.2
26	6/8	EP #1	6.0	.10			0.8			0.16					1.5
27	"	EP #6	6.3	.13			0.7			0.06					1.3
28	"	PR	6.5	.13			0.6			0.04					1.1
31	6/14	EP #1	7.1*	.10			1.7			0.21					1.2
32	"	EP #6	7.3*	.09			0.8			0.06					1.0
33	"	PR	7.1*	.12			0.7			0.04					1.1
38	6/28	EP #1	7.0				2.1			0.05					1.0
39	"	EP #6	7.3				1.9			0.02					1.7
40	"	PR	7.3				1.9			0.07					1.8
45	7/11	EP #1	7.3	.06			0.9			0.11					0.4
46	"	EP #6	7.0	.13			0.9			0.03					1.2
47	"	PR	6.9	.14			1.8			0.03					1.3
52	8/23	EP #1		.12	30	48.3	0.9	<0.1	<0.1	0.08	0.07	1.3	11.50	4.93	2.96
53	"	EP #6		.11	46	47.9	0.7	0.2	<0.1	0.10	0.05	1.8	12.46	3.97	2.96
54	"	PR		.16	70	75.7	0.8	<0.1	<0.1	0.23	0.06	2.8	20.51	5.70	.72

* pH tested in lab - late afternoon 6/14
+ ppm sulfate-S x 3 = ppm sulfate (SO_4)

Abbreviations and description of sampling sites at Grand Rapids

PR	Prairie River
EP #1	Experimental Paddy #1, 3rd year stand
EP #6	Experimental Paddy #6, 1st year stand

Table 3. Chemical composition of water collected from wild rice paddies during 1978 growing season. Location: Kosbau Bros., Aitkin Co.

Sample Number	Sampling Date	Location	pH	Cond. milli-mhos/cm	Alkalinity as $CaCO_3$ mg/L	Hardness $CaCO_3$ mg/L	Total Kjeldahl N ppm	Ammonium N ppm	Nitrate & nitrite N ppm	Total P ppm	Soluble P ppm	Sulfate S ppm	Ca ppm	Mg ppm	K ppm
1	4/17	DD	7.3	.12	49	52.9	0.8	0.03	<0.1	<0.01	<0.01	2.2+	13.1	4.9	1.2
2	"	EP	5.4	.08		10.8	3.6	1.92	0.7	2.19	2.19	2.2	2.5	1.1	8.6
4	5/3	DD	7.1	.18	70	79.0	0.9	0.04	<0.1	0.09	0.03	<2.	19.6	7.3	1.1
5	"	EP	4.6	.11		18.7	3.9	0.76	0.2	2.64	2.38	<2.	4.2	2.0	13.8
9	5/10	DD	6.6	.17			1.2			<0.01					0.9
10	"	EP	4.5	.11			3.8			3.08					13.5
16	5/18	DD	6.5	.18			1.3			0.04					0.8
17	"	EP	4.6	.11			3.9			2.68					13.7
23	5/31	DD	6.6	.14			1.4			0.02					1.0
24	"	EP	4.7	.10			4.7			2.68					9.9
25	"	EP	4.9	.10			4.8			2.87					9.9
29	6/8	DD	6.4	.16			1.0			0.06					0.8
30	"	EP	4.4	.10			4.6			3.09					12.6
34	6/14	DD*	6.9	.15			1.0			0.08					0.6
35	"	EP*	4.7	.10			4.4			3.42					11.4
41	6/28	DD	6.5				1.3			0.08					0.7
42	"	EP	4.2				7.7			3.67					19.0
43	7/10	DD	6.1	.15	54	79.0	2.7	<0.1	<0.1	0.09	<0.01	<1.	20.3	6.4	1.1
44	"	EP	4.5	.06		17.4	5.1	0.1	<0.1	2.08	1.84	3.2	2.2	2.1	6.6
48	7/18	EP	5.1	.05		22.0	8.1	0.1	<0.1	2.20	1.66	3.9	3.6	2.1	5.4
49	"	DD	6.4	.20		98.4	3.4	0.1	<0.1	0.37	0.04	1.9	25.3	7.5	1.2

* pH tested in lab - late afternoon 6/14
+ ppm sulfate-S x 3 = ppm sulfate (SO_4)

Abbreviations and description of sampling sites

DD = Diversion ditch at bridge near Little Willow River

EP = Experimental paddy

Table 4. Chemical composition of water collected from wild rice paddies during 1978 growing season. Location: Gunvalson and Imle, Gully

Sample Number	Sampling Date	Location	pH	Cond. milli-mhos/cm	Alkalinity as $CaCO_3$ mg/L	Hardness $CaCO_3$ mg/L	Total Kjeldahl N ppm	Ammonium N ppm	Nitrate & nitrite N ppm	Total P ppm	Soluble P ppm	Sulfate S ppm	Ca ppm	Mg ppm	K ppm
3	5/3	PP	7.0	.42	124	172.0	2.3	0.04	<.1	0.36	0.12	20.8+	45.5	14.0	9.8
11	5/17	CR	7.2	.50	228	249.0	0.8	0.06	<.1	0.12	0.01	15.8	64.0	21.6	2.6
12	"	PP	6.9	.52	166	225.0	1.6	0.09	<.1	0.36	0.36	25.0	59.3	18.8	14.3
18	5/24	CR	7.2	.46			0.3			<0.01					2.1
19	"	PP		.57			1.5			0.69					13.1
36	6/26	PP	6.8				2.2			1.51					6.8
37	"	CR	7.1				1.2			0.06					2.7
50*	7/19	PP	6.5	.13	39	45.2	2.0	0.5	0.2	1.18	0.97	4.0	11.1	3.9	10.0
51	"	CR	6.4	.44	204	242.0	1.8	<0.1	<0.1	0.28	0.09	8.7	58.9	22.6	2.4

* Paddy recently drained, almost dry
+ ppm sulfate-S x 3 = ppm sulfate (SO_4)

Abbreviations and description of sampling sites
PP = Production paddy
CR = Clearwater River

C. NITROGEN RATE AND VARIETY STUDIES ON MINERAL SOIL

Two experiments were conducted on a mineral soil at the North Central Experiment Station, Grand Rapids. Experiment 1 (first year stand) was established in the fall of 1977 with two early maturing varieties: Netum and K2. Experiment 2 (third year stand) had been established in the spring of 1976 with K2, M3 and Johnson varieties.

First Year Stand[1/]

The experimental paddy No. 6 was in fallow during 1977 and was fumigated with methyl bromide in the fall. Four rates of nitrogen were used in this experiment: 0, 20, 40 and 80 pounds per acre. Urea (46-0-0) was applied by hand and incorporated into the soil by rototilling. Phosphorus and potassium were not applied because of relatively high soil tests. Two early maturing varieties, Netum and K2, were grown. A split-plot design was used in this experiment, with the N rates as main plots and varieties as subplots. Each plot, containing one N rate and both varieties, occupied a 12 x 15 ft. area. Each N treatment was replicated five times. The wild rice was planted in rows that were one foot apart on November 8. Plant population, at harvest, was one plant per square foot. Water level was maintained at about 8-12 inches. Ten plants were selected at random from each plot at jointing stage, and five plants at late flowering for weight measurements and plant analysis. The jointing stage was reached by Netum (Fig. 3) on June 29 and by K2 (Fig. 4) by July 6. An 80 sq. ft. area from each plot was hand-harvested for yield determination. Netum was harvested on August 23 and K2 six days later.

The K2 variety outyielded Netum by 143 pounds per acre (table 5). The grain yield of both varieties was increased by nitrogen fertilization. Maximum yields were produced with 40 pounds of N per acre.

Dry matter production was not affected by N fertilization, but K2 plants were slightly heavier than Netum at jointing and late flowering (table 6).

Nitrogen concentration of 2nd leaf at jointing was not affected by N treatments and no varietal differences were detected (table 7). Total uptake of N by the plant was related to the amount of nitrogen applied (table 8).

[1/] This experiment was conducted in cooperation with Mr. Gary Linkert, Department of Agronomy and Plant Genetics.

Table 5. Effect of nitrogen application on the yield of two wild rice varieties, Grand Rapids, 1st year stand, 1978.

Variety	N Rate, lb/Acre 0	20	40	80	Average (variety)
	Grain Yield, lb/Acre				
K2	895[1)]	947	1038	1045	981
Netum	778	767	935	872	838
Average (Rate)	836	857	986	959	

1) 7% moisture

(a) Variety — Grain yield, lb/Acre

Variety	Grain yield, lb/Acre
K2	981 b
Netum	838 a
Significance	**
BLSD (0.05)	85

(b) N Rate, lb/Acre

N Rate, lb/Acre	
0	836 a
20	857 ab
40	986 c
80	959 bc
Significance	*
BLSD (0.05)	118
C.V.	14

Table 6. Effect of nitrogen application on plant weight of two varieties at jointing and late flowering, Grand Rapids, 1st year stand, 1978.

Development stage and variety	N Rate, lb/Acre 0	20	40	80	Average (variety)
	Dry matter, grams per plant				
(a) Jointing					
Netum	3.70	3.72	4.43	3.91	3.94
K2	5.09	4.47	4.79	5.20	4.89
Average (rate)	4.40	4.10	4.61	4.56	
(b) Late Flowering					
Netum	15.57	19.13	18.64	20.16	18.38
K2	20.85	18.63	20.97	21.79	20.56
Average (rate)	18.21	18.88	19.81	20.98	

Table 7. Effect of nitrogen application on N concentration in 2nd leaf at jointing, Grand Rapids, 1st year stand, 1978.

Variety	N Rate, lb/Acre 0	20	40	80	Average (variety)
	N % in dry matter				
K2	4.44	4.10	4.40	4.32	4.32
Netum	4.23	4.36	4.50	4.32	4.35
Average (rate)	4.34	4.23	4.45	4.32	

Table 8. Effect of nitrogen application on total uptake of N by the wild rice plant at late flowering, Grand Rapids, 1st year stand, 1978.

Variety	N Rate, lb/Acre 0	20	40	80	Average (variety)
	N in milligrams per plant				
K2	237	258	293	321	277
Netum	231	294	300	304	282
Average (rate)	234	276	297	313	

Third Year Stand

The nitrogen-variety experiment, established in the spring of 1976, was continued in 1978. Three wild rice varieties were grown: the relatively early maturing K2 and M3, and the later maturing Johnson. Three N rates were used: 0, 40, 80 pounds per acre. To minimize cross-pollination, the Johnson wild rice was placed between the two earlier maturing varieties and each variety was grown in a 48 x 72 foot area separated from adjoining variety by a 10 ft. wide alley. Individual plots were 12 x 14 ft. in size. Nitrogen treatments were replicated five times. Straw was disked and rototilled into the soil. Urea was applied on May 2 and rototilled into the soil. Phosphorus and potassium were not applied because of relatively high soil test levels (P 72, K 308, pH 6.0; nitrate-N 16 lb/A 0-6 inch depth). The plant density of M3 was excessive and required manual thinning. At early tillering, average plant density of K2 was 4, while M3 and Johnson had six plants per square foot. There was heavy infestation of broadleaf weeds, especially in the K2 area. On July 5, 2,4-D (¼ lb/acre) was sprayed to control weeds.

Fertilization with nitrogen resulted in striking height and color differences. Plants in N0 plots were shorter and lighter in color than those receiving either N40 or N80 treatments. There was moderate lodging in the N80 treatment plots.

Blackbird control was ineffective and heavy yield losses occurred. Nearly 80% of grain was lost, particularly in M3 plots. The yield ranged from 211 - 233 lb/acre for K2, 120 - 190 lb/acre for Johnson, and 152 - 189 lb/acre for M3.

Visual differences in plant height and color, observed during the growing season, also were reflected by weight and plant analysis data (tables 9, 10 and 11). The application of 40 or 80 lb/acre of nitrogen resulted in the production of more dry matter and increased the total N uptake by the plant compared to the control.

Table 9. Effect of nitrogen application on plant weight of three varieties at jointing and late flowering, Grand Rapids, 3rd year stand, 1978.

Development stage and variety	N Rate, lb/Acre 0	40	80	Average (variety)
	----------Dry matter, grams per plant----------			
(a) Jointing				
K2	1.69	2.64	3.12	2.48
Johnson	2.58	3.36	4.38	3.44
M3	2.80	2.93	3.36	3.03
Average (rate)	2.36	2.98	3.62	
(b) Late Flowering				
K2	6.68	9.53	11.75	9.32
Johnson	6.53	6.55	10.66	7.91
M3	9.23	9.29	15.78	11.43
Average (rate)	7.48	8.46	12.73	

Table 10. Effect of nitrogen application on N concentration in 2nd leaf at jointing, Grand Rapids, 3rd year stand, 1978.

N Rate lb/Acre	Variety K2	M3	Johnson	Average (rate)
	-----------------N % in dry matter-----------------			
0	2.46	2.62	2.29	2.46
40	2.74	2.77	1.94	2.48
80	2.84	2.95	2.39	2.73
Average (variety)	2.68	2.78	2.21	

Table 11. Effect of nitrogen application on total uptake of N by the wild rice plant at late flowering, Grand Rapids, 3rd year stand, 1978.

N Rate lb/Acre	Variety K2	M3	Johnson	Average (rate)
	-------------N in milligrams per plant-------------			
0	68	98	58	75
40	105	123	87	105
80	142	208	112	154
Average (variety)	105	143	86	

D. FERTILIZATION STUDIES ON PEAT

Three fertilizer experiments were conducted in a Kosbau Bros. paddy in Aitkin County. During 1977, rye was grown, receiving 12 + 72 + 72 lb/acre of N, P_2O_5 and K_2O. Fertilizer was applied by hand to 12 x 12 foot plot areas on October 19, 1977. K2 wild rice was seeded, and the seed and fertilizer were incorporated into the soil by rototilling. Wild rice started to emerge on May 8 and by July 2 had reached the jointing stage (Fig. 5). Some lodging occurred throughout the experimental area, and in some areas, the stand was spotty and thin with heavy infestation of cattails. Average plant density was two plants per square foot. The paddy was drained on July 22. A 4 x 4 foot area was hand-harvested from each plot for yield measurement on August 24. No color or height differences were observed during growing season and there was a general lack of response to fertilizer treatments. The grain yield ranged from 300 to 500 lb/acre.

Table 12. Soil test values of experimental areas, Kosbau Bros., Aitkin Co.

Area	Soil Test Results for 0-6 inch Depth			
	pH	Extractable P pp2m	Exchangeable K pp2m	NO_3-N lb/A
NK trial	3.9	18	145	3
NP trial	4.0	19	240	3
Foliar-Fertilization	4.2	21	116	2

Samples collected on 10/19/77.

NK RATE TRIAL

Exchangeable potassium in the experimental area was 145 pp2m, considered to be a medium level (table 12). Nitrogen treatments consisted of the following rates: 0, 20, 60 pounds per acre. Potassium was applied at rates of 0, 60 and 200 pounds of K_2O per acre. All plots received 40 pounds of P_2O_5 per acre. Fertilizer treatments were replicated six times. Urea, muriate of potash and concentrated superphosphate were applied by hand during the fall of 1977 and incorporated into the soil by rototilling.

The yield of wild rice ranged from 349 to 431 pounds per acre (table 13). Neither nitrogen nor potassium treatments had any effect on the yield.

Table 13. Effect of nitrogen and potassium application on grain yield of wild rice, Kosbau Bros., 1978.

K Rate K_2O lb/acre	N rate, lb/acre 0	N rate, lb/acre 20	N rate, lb/acre 60	Average (K rate)
	Grain yield, lb/acre			
0	342[1)]	358	431	377
60	425	392	365	394
200	369	379	342	363
Average (N rate)	379	376	379	

1) 7% moisture

Significance ns

NP RATE TRIAL

Extractable phosphorus in the experimental area was 19 pp2m, indicating medium relative level (table 12). Nitrogen was applied at rates of 0, 20, 40 lb/acre, and phosphorus treatments included 0, 40 and 80 pounds of P_2O_5 per acre. All plots received 60 lb/acre of K_2O. Fertilizer treatments were replicated six times. Urea, concentrated superphosphate and muriate of potash were applied by hand in the fall and incorporated into the soil by rototilling.

Grain yields ranged from 298 to 494 pounds per acre (table 14). Although the application of phosphorus, combined with either the N0 or the N20 treatments, tended to increase the yield by nearly 100 lb/acre, the differences were not statistically significant.

Table 14. Effect of nitrogen and phosphorus application on grain yield of wild rice, Kosbau Bros., 1978.

P Rate	N rate, lb/acre			Average
P_2O_5 lb/acre	0	20	40	(P rate)
	Grain yield, lb/acre			
0	374[1)]	298	491	388
40	485	467	468	473
80	469	461	494	475
Average (N rate)	443	409	484	

1) 7% moisture

Significance ns

FOLIAR FERTILIZATION TRIAL

Foliar fertilization studies initiated in 1976 were continued. In the fall of 1977, a new experiment was established in an area adjoining NK and NP trials. Soil application of fertilizer (20 + 40 + 60) was made during the fall and incorporated into the soil. Fertilizer solution was sprayed on 12 x 12 foot plot areas with a backpack sprayer at a rate of 26.4 gallons per acre or 250 pounds per acre. Spraying pressure was maintained at 30 psi by using a carbon dioxide cylinder. The formulation, fertilizer materials used and costs were reported, in detail, in the 1976 Wild Rice Research Progress Report. In 1978, foliar fertilizer applications were made on the following dates:

1st spraying, 7/10 - at boot stage,
2nd spraying, 7/26 - mid-flowering,
3rd spraying, 8/9 - early grain formation.

No "leaf burn" damage was observed in this trial.

The grain yield in this experiment ranged from 380 to 492 pounds per acre. Fertilizer, either by soil or foliar application, had no effect on the grain yield (table 15).

Table 15. Effect of foliar and soil application of fertilizer on grain yield of wild rice, Kosbau Bros., 1978.

Foliar Application	Total Plant Nutrients Applied, lb/Acre				Soil Application		
Number	N	P_2O_5	K_2O	S	None	20+40+60	Average (Foliar)
					-----Grain yield, lb/Acre-----		
None	none				492[1)]	419	456
1 x	15 +	6 +	9 +	1.3	-	389	389
2 x	30 +	12 +	18 +	2.6	-	389	389
3 x	45 +	18 +	27 +	3.9	380	388	384
Average (soil)					436	396	

1) 7% moisture, average of 6 replications; Significance ns

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