Soil Series 117

A Report on Field Research in Soil Science

The 1987 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, Soil Scientists at the branch stations of Crookston, Lamberton, Morris, and Waseca; Becker and Staples experimental sites; and Soil and Crop area agents. Associated personnel from the Soil Conservation Service, and the Soil and Water Research group of the ARS-USDA, the Tennessee Valley Authority, the Departments of Agriculture and Natural Resources also contributed information.

Sincere appreciation is expressed for materials, financial assistance or program support from several organizations including: Potash and Phosphorus Institute of North America, Cenex, Farmland, Howe Incorporated, Minnesota Crop Improvement Association, American Soybean Association, Golf Course Superintendents Association, Sugarbeet Research and Education Board of Minnesota and North Dakota, Minnesota Soybean Research and Promotion Board, Minnesota Limestone Producers Association, Minnesota Plant Food and Chemicals Association, Minnesota Soil and Water Conservation Committee, Pioneer Hybrid International, Inc., U.S. Borax and Chemical Corporation, Shaklee Corporation, Dow Chemical, Terra Chemical, Allied Chemical Corporation, Shell Development, Monsanto, BASF Wyandotte Corporation, Ciba Geigy Corporation, Minnesota Soil Conservation Service, Minnesota Dept. for Energy and Economic Development, Minnesota Wheat Council, Minnesota Soybean Council, Malting Barley Improvement Association, The Red River Valley Potato Growers Association, The Iron Range Resources Commission, The Minnesota State Planning Agency, Minnesota Water Planning Board, The Water Resources Research Center of the Graduate School, The Staples Vo-Tech Institute, Tennessee Valley Authority-National Fertilizer Development Center, The North Central Forest Experiment Station, SKW Trostberg AG., The Sulfer Institute, Fluid Fertilizer Foundation, Potash Corporation of Saskatchewan, Corklin Company Inc., Minnesota Food Processors Association, Harris Laboratories Inc., American Crystal Sugar Quality Laboratory, A and L Midwest Agricultural Laboratories Inc., Minnesota Valley Testing Laboratories Inc., Holden Farms, Pillsbury-Green Giant, Birdseye-General Foods, and Ferti-Flo Fertilizer.

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

Some of the results are from 1986 experiments and should be regarded on this basis. Since most data are from only 1986 studies, conclusions may not be conclusive and thus are not for further publication without the written consent of the individual researchers involved.

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Table of Contents

page

Agricultural Year Precipitation, September 1985 - August 1986.....1

The Lamberton Moisture Year.....5

The Waseca Moisture Year.....9

Air and Soil Temperature Variations.....13

Soil Freezing Depth and Duration.....14

Becker

Management of UAN on the Coarse Textured Irrigated Soils of Minnesota for Efficient Corn Production.....16

Influence of Nitrogen Application Time and Nitrification Inhibitor Rate on Sweet Corn Production on an Irrigated Sand.....23

Crookston

1986 Weather.....30

The Effects of Sulfur Application on Sugarbeet.....31

Starter Phosphorus Fertilizer on Sugarbeet.....32

The Effect of Nitrogen Rate and Plant Population on Sugarbeet.....33

Timing of Nitrogen Application on Sugarbeet.....34

Foliar Nitrogen Application on Sugarbeet-Timing and Rate.....35

High Phosphorus and Potassium Rates on Continuous Spring Wheat.....39

Intensive Fertilizer Management on Spring Wheat.....41

Micronutrients on Spring Wheat.....44

Yield and Root Rot Responses of Spring Wheat to Chloride Fertilization.....45

Survey of Soil Chloride Status in the Red River Valley.....46

Residual Soil N, Fertilizer N, and Inoculation Effects on Soybean Production in Northwestern Minnesota.....47

Use of Acid Based Fertilizers for more Efficient Soybean Production in Northwestern Minnesota.....49

Evaluation of the Efficiency of Band Placement of P Fertilizer for Corn, Soybean and Wheat....52

Lamberton

The Erosion-Productivity Study at the Southwest Experiment Station....58

Twenty Seven Years of Field Experimentation With Nitrogen Source, Placement, and Time of Application to a Webster Loam at the Southwest Experiment Station....62

Morris

West Central Experiment Station Weather Summary 1986....66

Residual Effect of Heavy Applications of Animal Manures on Corn Growth and Yield and on Soil Properties....67

Manure Rate Study....69

Continuous Corn Silage....71

Investigations of Tillage, N Rate and Corn Hybrid on a Pachic Udic Haploboroll....73

Soil Test Lab Comparison....76

Effects of Liquid Starter Rate, Placement and Analysis on Corn Growth and Yield....81

Soybean Tillage Study....85

Alfalfa Fertility-Management Study....89

Method of foliar Nitrogen Application on Three Spring Wheat Varieties....93

Topdressing Urea on Spring Wheat....95

Staples

Management of Boron for Crop Production on Irrigated Sandy Soils in Minnesota....96

Corn - Soybean Rotation....101

Lupine Bean Study....106

Triticale-Rye Study....113

Waseca

Weather Data 1986....115

Rotation Nitrogen Study....116

Split Application of N for Corn on a Webster Soil....123

Nitrogen Sources for Corn with Conservation Tillage in Southern Minnesota....130

Nitrogen Loss to Tile Lines as Affected by Tillage....138

Starter Fertilizer Placement Effects on Corn Production....141

Soil Test Comparison Study....145

Conservation Tillage for Corn and Soybean Production....149

Tillage Systems for Corn and Soybean Crop Sequences....156

Alfalfa

Liming Materials and Rates of Application for Alfalfa Production on an Acid Sandy Soil....159

Cauliflower

Leaf Tipburn in Cauliflower as Influenced by Genotype and Foliar-Applied Calcium Sprays....161

Compost

Evaluation of 'Agri-Brand' Compost as a Fertilizer Source for Processing Sweet Corn and Snap Beans....165

Corn

Decline Rates of Soil Test P and K in a Corn-Soybean Rotation....171

Nitrogen Sources and Rates for Continuous Corn in Goodhue County....174

Influence of Crop History and Manure Use on Nitrogen Rates for Corn Production in Southeastern Minnesota....177

Fertilizer Placement

Evaluation of the Relationship Between Tillage and Placement of P and K in a Corn-Soybean Rotation....181

Effect of Potassium Placement on Corn Production in a High Yield Environment in Southeast Minnesota....191

Peas

Influence of Seed Inoculation, Nitrogen Source, and Nitrogen Rate on Productivity of Processing Peas....199

Potatoes

Nitrogen Fertilizer Rate and Timing Studies on Irrigated Potatoes....207

Strawberry

Variation in Foliar Nutrient Composition of Strawberry as Influenced by Genotype and Location....211

Sulfur

Sulfur Management for Corn Production on Irrigated Sandy Soils....215

The Effect of Sulfur Fertilization on Yield and Forage Quality of Corn and Alfalfa....218

Tillage

The Effect of Tillage on Corn and Soybean Production in Southeastern Minnesota....229

The Effect of Tillage System on Stand Establishment, Presence of Weeds, Growth, Grain Yield, and Protein Content of Winter and Spring Wheat, and Barley....243

The Effect of Tillage System, Variety, and Fungicide Application on Winter and Spring Wheat, Barley, and Soybean Production....254

Corn - Tillage Residue Management....268

Tillage and Diffuse Source Phosphorus Pollution in the Clearwater River Watershed, Minnesota, 1986....275

The Effect of Tillage on Soil Nitrogen with Corn and Soybean Production in Southeastern Minnesota....284

AGRICULTURAL YEAR PRECIPITATION, September 1985 - August 1986

J.A. Zandlo, State Climatology Office

Precipitation for 1986 again generally continued at above 1951-80 normal rates. The pattern of distribution for the 1986 Agricultural year is presented here in map form as Figure 1. For the Agricultural year ending August 1986, unofficial precipitation totals ranged from 16.23 inches in Kittson county to 52.11 inches in Kandiyohi county. The largest departures from normal were concentrated in the west to east central portions of the state. Portions of Kandiyohi, Meeker, Stearns, Pope, Sherburne, and Pine county received more than 44 inches of precipitation. Conversely, small portions of the northwest and north central regions of the state were actually a few inches below normal for the Agricultural year.

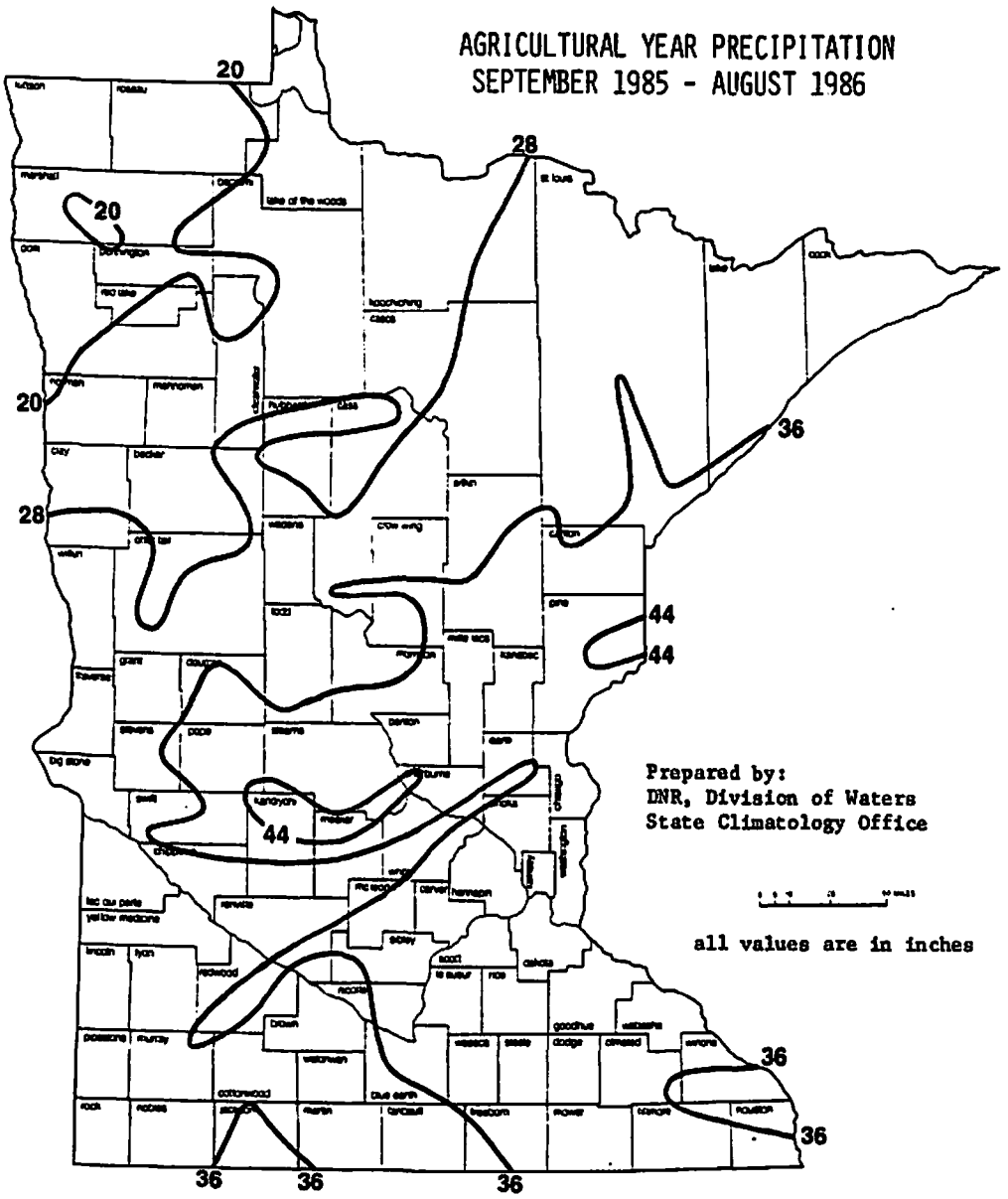
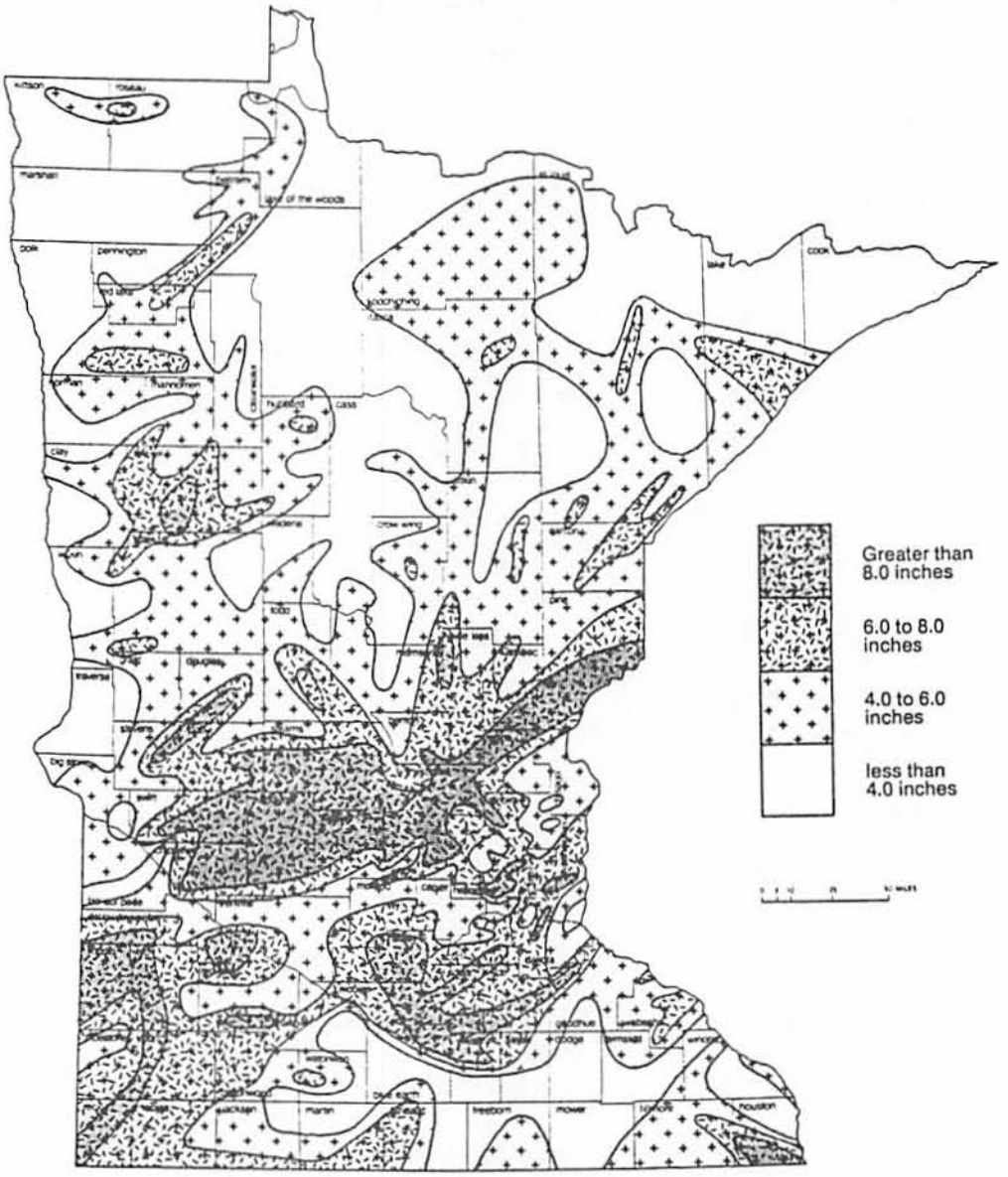


Figure 1. Agricultural precipitation September 1985-August 1986.

While most months since September 1985 were just marginally above normal in most areas of the state, some months were record breakers. September 1985, included in the Agricultural year precipitation totals, was a wet month in portions of Minnesota but September 1986 was even wetter with many all-time September precipitation records broken. The other month with notable excesses over normal was April 1986 which was as much as three times normal in some portions of the state. During the closing months of 1986, October through December, the nearly continuous string of above normal precipitation months starting in late 1985 came to an end.

At mid-year, a new 50 inch plus 12 month precipitation total had been recorded by a long term National Weather Service climate station in Minnesota. New London recorded 50.58 inches of precipitation for the period August 1985 through July 1986. 50 inches or more precipitation in a twelve month period for areas of Minnesota outside of the southeast corner has only been observed at Duluth with 52.35 inches in 1882 and at Isle with 53.04 and Long Prarie with 50.68 both in 1972. Many other points in Minnesota experienced new 12 month record levels of precipitation at some time during 1986.



Prepared by: DNR, Division of Waters, State Climatology Office

Figure 2. Average annual departure from normal precipitation for 1982-1986(5 years).

1986 caps a record breaking 10 year period of wetness for much of the state. Many of the long term climate stations of the National Weather Service had never experienced a wetter 10 year period than the one which ended with December 1986. The 10 year total at Caledonia, 387.82 inches, has the further distinction of being the highest 10 year total ever observed in the state of Minnesota! In order to more readily depict the magnitude and distribution of the continuing tendency for excessive precipitation across Minnesota, two special maps, Fig. 2 and 3, have been prepared; 'Average Annual Departure from Normal Precipitation for 1982-1986 (5 Years)' and 'Average Annual Departure from Normal Precipitation 1977-1986 (10 Years)'.

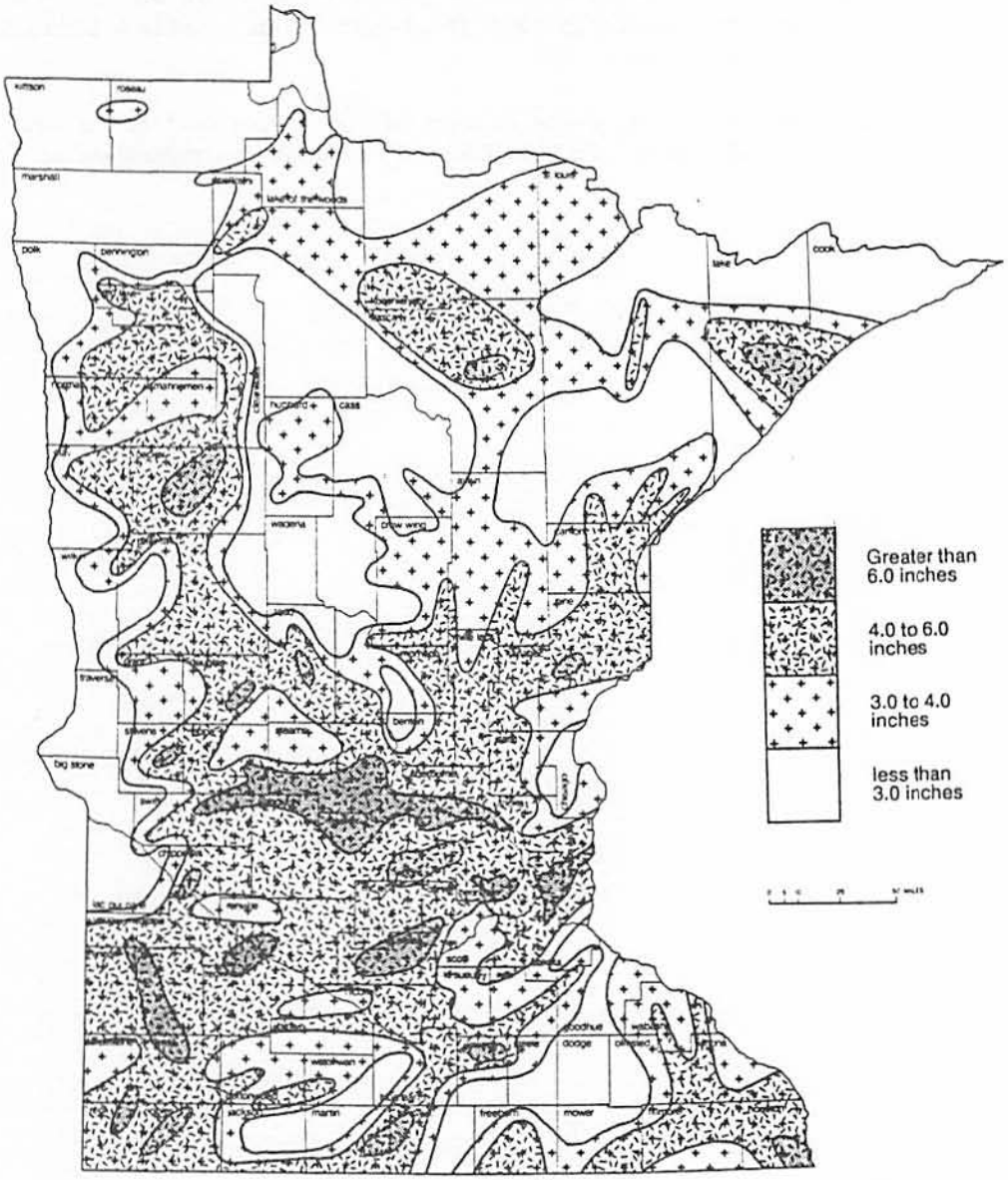


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Figure 3. Average annual departure from normal precipitation for 1977-1986 (10 years).

The 5 year departure map shows a broad but broken swath of very large departures extending from the southwest corner through the midsection and into the east central portions of the state. In a rough sense, departures more than 4 inches may be thought as a 'once in 25 years' condition, while amounts greater than 6 inches can be thought as 'once in 40 years' condition. Such an interpretation implies that many people are unlikely to have witnessed such long term wetness at any time in their lives. In fact, the last time such levels of wetness have been so generally distributed across the state appears to have been in the first decade of this century.

The 10 year departure map is not qualitatively different from the 5 year map. However, the most extreme departures do not seem so heavily concentrated in the middle of the state. Portions of the northern sections of the state exhibit departure levels as high as anywhere else in the state. On this map values greater than about 3 inches might be regarded as 'once in 25 years' events, while 4 inches is the threshold for once 'once in 40 years' events.

Note that the interpretation of the shading levels in terms of 'return periods' is the same for both maps. That is, a given type of shading will imply the same frequency of occurence regardless of which map is being examined.

THE LAMBERTON MOISTURE YEAR

D.G. Baker, D.L. Ruschy, W.W. Nelson, and T. Strasser

As noted in the previous section Minnesota has been the beneficiary of above normal precipitation for a relatively lengthy period. For Lamberton it has been five of the last five years and seven of the last 10 years. This represents an unusual period as may be seen by inspection of Fig. 4. (Fig. 4 represents the agricultural year of September-August rather than the more usual calendar year total). This current "wet" period may be considered as making up for the 12 year period of 1966-1977 when the annual precipitation was below average in nine of the 12 years.

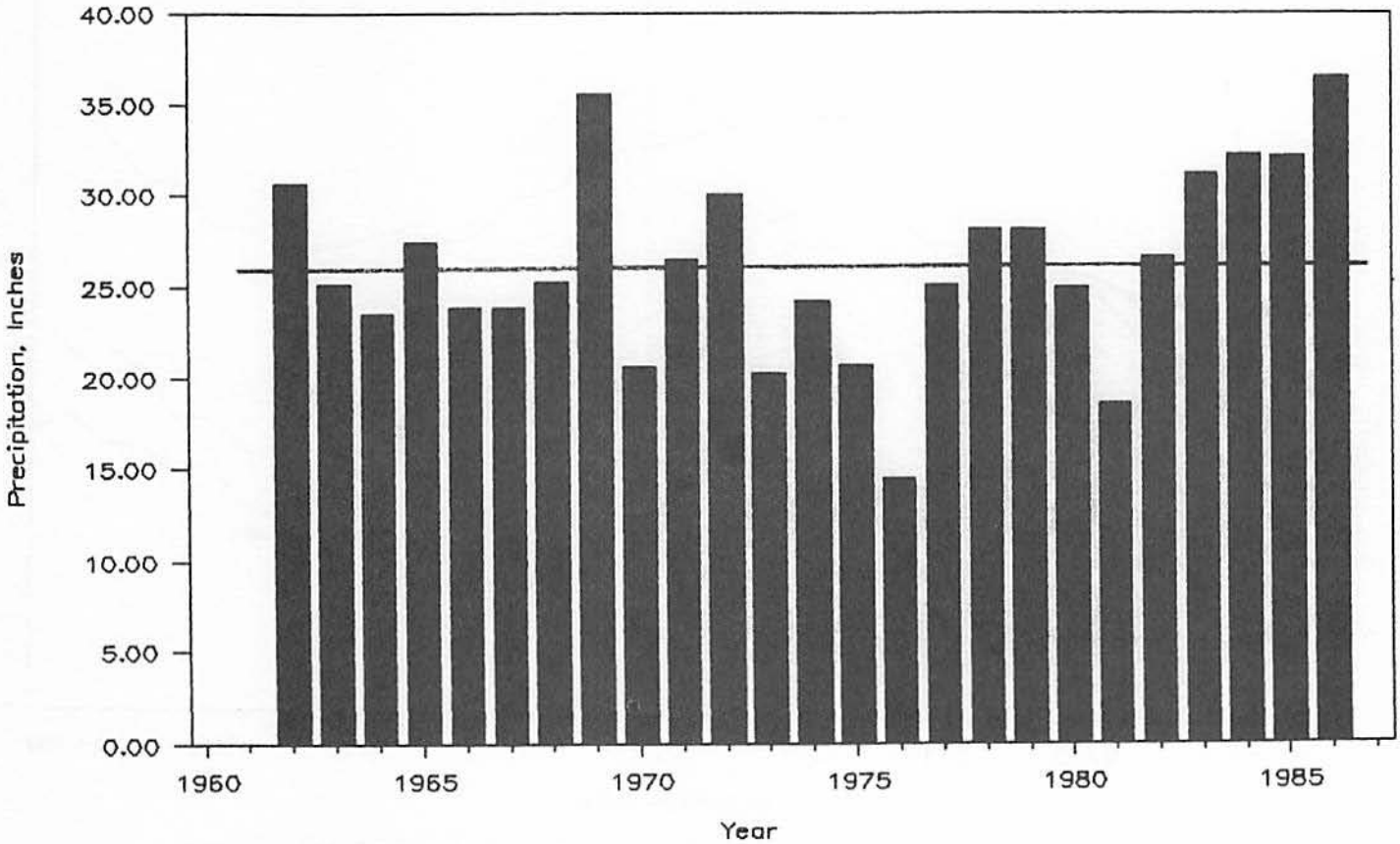


Figure 4. Total agricultural year precipitation at the Southwest Agricultural Experiment Station, Lamberton, 1962 - 1986. The annual average for 1962 - 1985 is 25.77 inches.

There is a phrase that goes "we'll pay for this bye and bye". Which is simply a statement of the fact that there is a general average for the precipitation. Although the current high precipitation may vary considerably from the average for a period of time, there will reach a point when a reversal occurs. Unfortunately the time of the reversal cannot be predicted. But it can be said without fear of contradiction that a change in our precipitation pattern can be expected. The above-average agricultural year precipitation occurring during the last several years in Minnesota, and indeed over a large area of northern United States from the Great Lakes westward to the Rockies, cannot be expected to continue. It may well be a very good thing that we are learning about and have begun practicing conservation tillage now before the reversal in precipitation begins.

The above average precipitation is of course reflected in the soil moisture. Indeed it has altered the average soil moisture picture considerably from what it was. This is evident in Fig. 5, which shows the total plant available soil moisture in a 5-foot soil profile under corn. The lowest line is the 1964-1981 average, the middle one is the 1964-1986 average, and the top one represents the 1982-1986 average. The greatest and most significant change has been the increase in the late July and August soil moisture content. In the past years this has been the period when the soil moisture reserves have been drawn upon so heavily in order to make-up for the large plant requirements and the usually limited precipitation of that period.

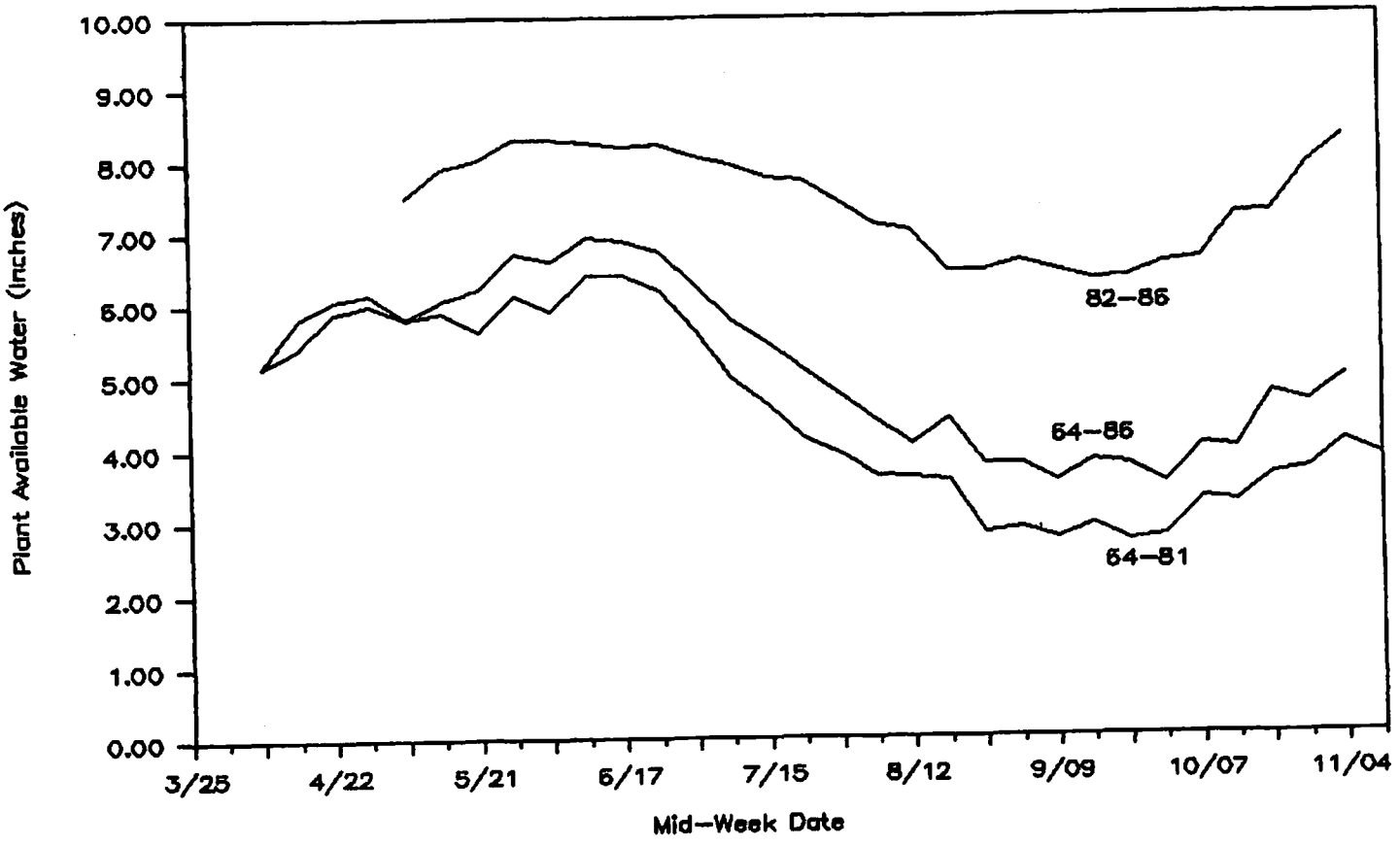


Figure 5. Plant available soil moisture in a 5-foot column of soil under continuous corn at the Southwest Agricultural Experiment Station.

An extremely interesting picture of soil moisture usage is presented is Fig. 6. This shows the average amount of water in each foot of the five-foot soil profile during the 23-year period 1964-1986. Several things are worthy of note. One is the timing of the high and low amounts of soil moisture. The maximum is reached at all depths within about a three week period varying from the week of June 10 to June 24. However, due to plant moisture requirements and plant and root development the mimimum soil moisture within the profile has about a seven week spread. This is shown in greater detail in Table 1.

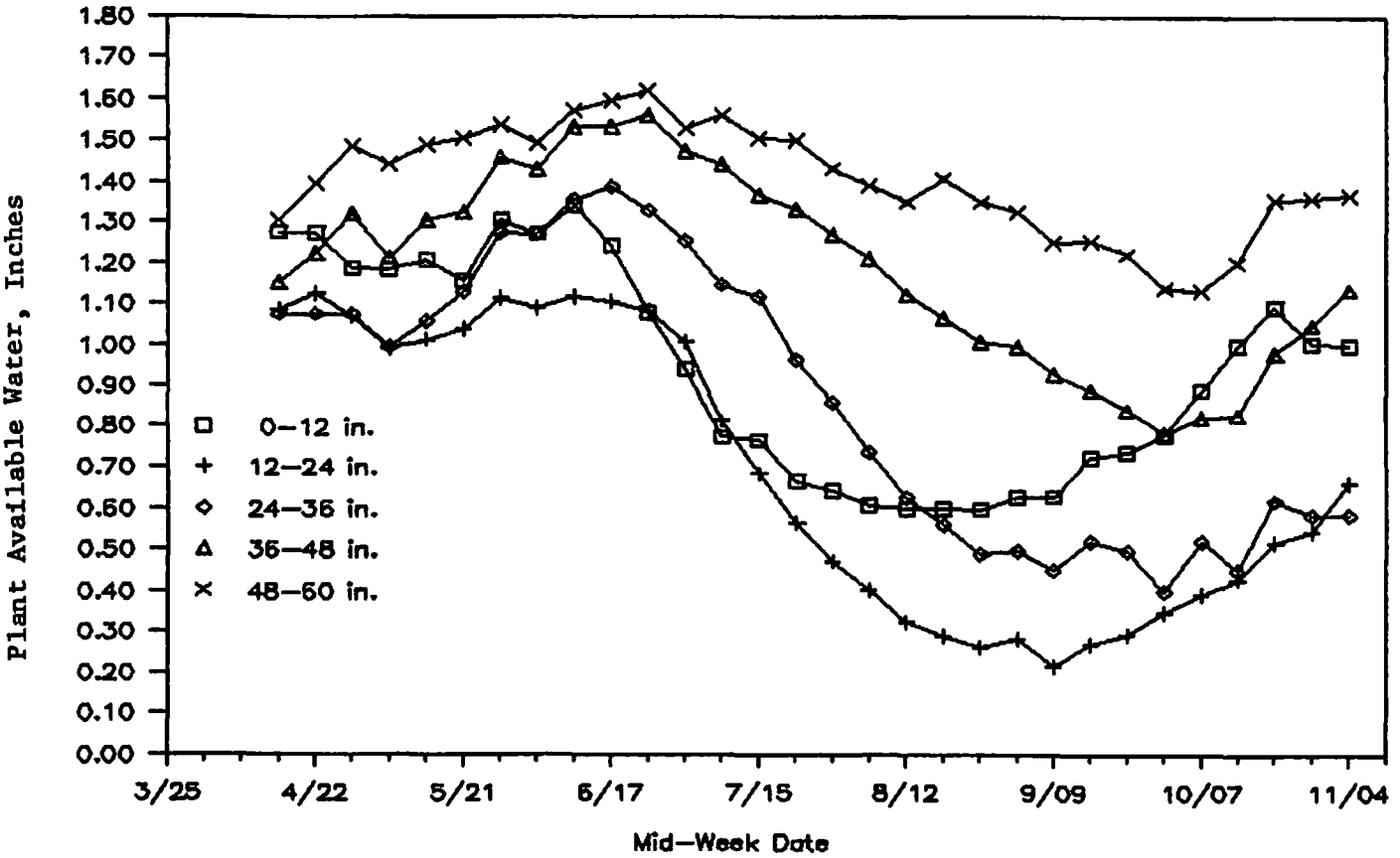


Figure 6. Average amount of plant available soil moisture in each foot of soil under continuous corn at the Southwest Agricultural Experiment Station, Lamberton, 1964 - 1986.

Table 1. The average date of the occurrence of the soil moisture maximum and minimum contents in each foot of soil at Lamberton, 1964-1986.

Depth	Maximum soil moisture	Minimum soil moisture
0-12 in.	June 10	August 17
12-24	June 10	September 9
24-36	June 17	September 23
36-48	June 17	September 30
48-60	June 24	October 7

The amounts of plant available soil water in each foot of soil at the times of maximum and minimum contents are listed in Table 2. The difference between the maximums and minimums is alos shown and represents the water supplied to the crop. This amount plus the precipitation between the period represents then the total water consumed by the crop. This assumes no runoff or downward drainage through the soil profile.

Table 2. The average amount of plant available soil water in each foot of soil at the time of the maximum and minimum contents (see Table 1) at Lamberton, 1964-1986.

Depth	Soil Water at maximum	Soil Water at minimum	Difference
0-12 in.	1.33 in.	0.60 in.	0.73 in.
12-24	1.10	0.22	0.88
24-36	1.38	0.40	0.98
36-48	1.74	0.78	0.96
48-60	1.61	1.14	0.47
Total	7.16	3.14	4.02

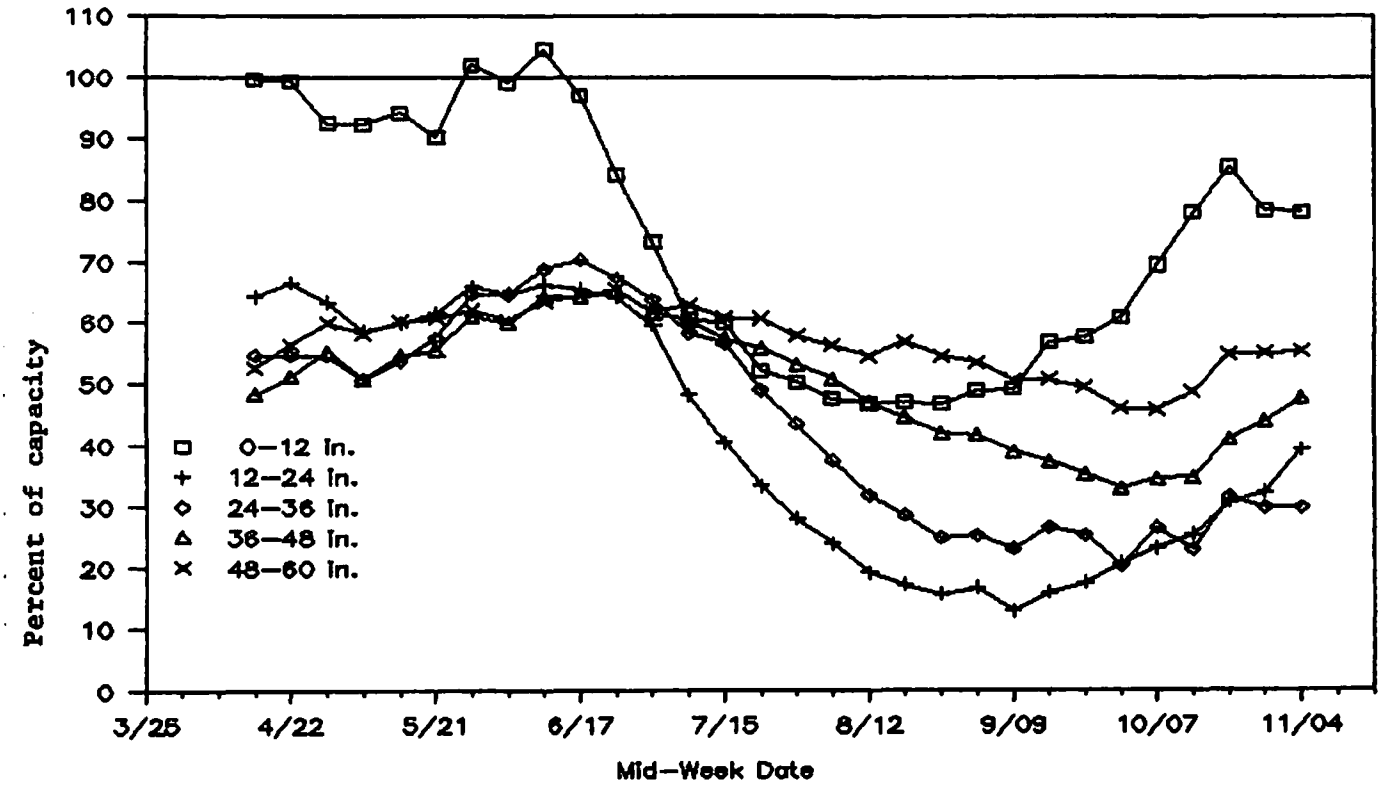


Figure 7. Average amount of plant available soil moisture in each foot of soil expressed as a percentage of the field capacity, Southwest Agricultural Experiment Station, Lamberton, 1964 - 1986.

The moisture profiles for each foot of the Lamberton sampling site are shown in another way in Fig. 7. In this case each foot is expressed as the percent of field capacity. In general it is the 12-24 inch and 24-36 inch depths that are the closest to being depleted of their plant available moisture supplies. This is indicative of the quantity of roots at these depths. It is also shown that the first foot is often above field capacity (above 100%) in mid-June.

THE WASECA MOISTURE YEAR

D.G. Baker, D.L. Ruschy, G.W. Randall, and P. Kelly

Waseca, like Lamberton, has been the object of increased precipitation, though perhaps not quite to the same degree. This is apparent in Fig. 8 in which is shown the totals for each agricultural year. The current 30-year normal, 1951-1980, equals 30.62 inches. We have defined the agricultural year as September through August, because this more nearly represents the water year for most crops.

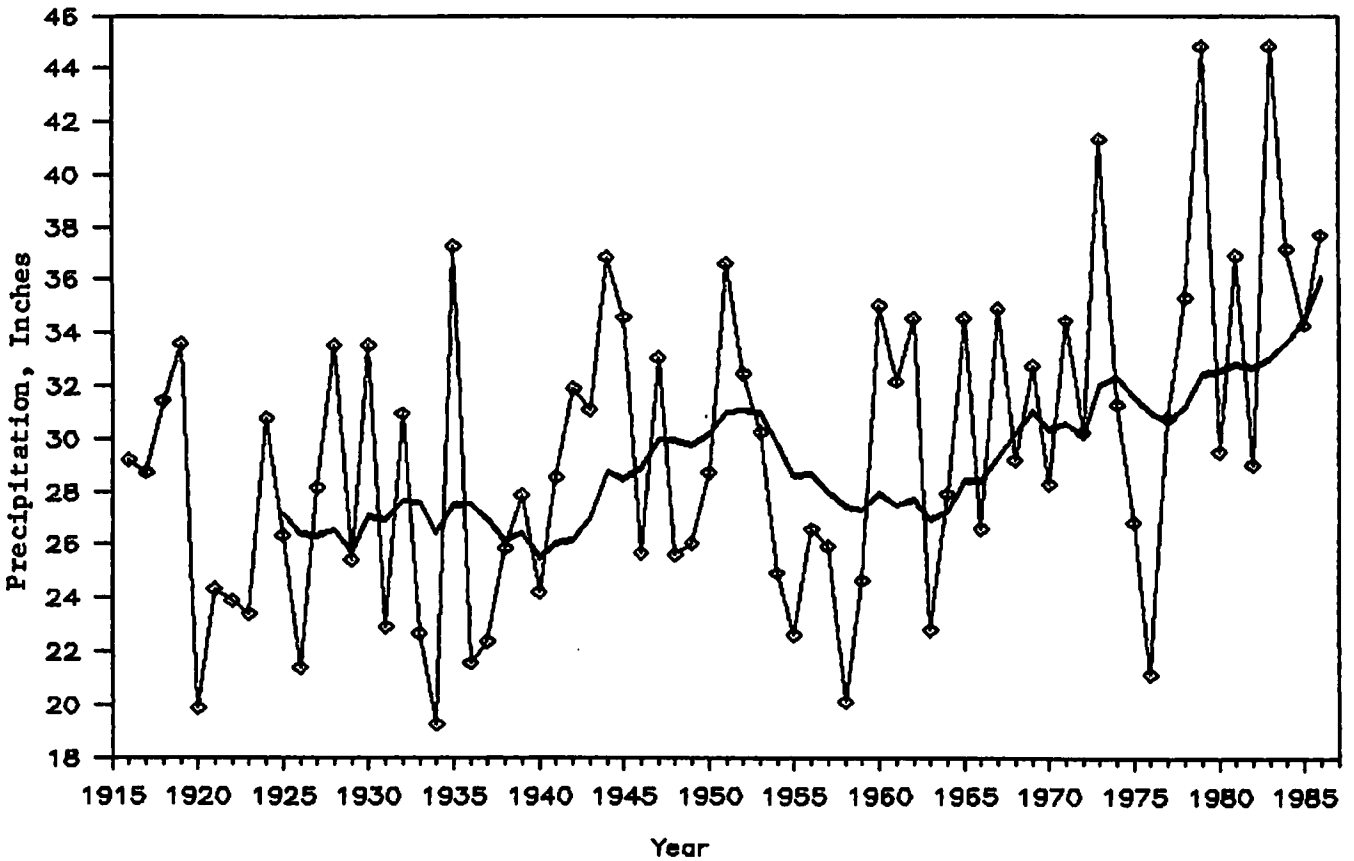


Figure 8. Annual total precipitation for the agricultural year (Sept. thru Aug.) for the period Sept. 1915 - Aug. 1986 at the Southern Agricultural Experiment Station, Waseca. The smoothed line is a 10-year running mean plotted at the end of the 10-year period.

Also shown in Fig. 8 is a 10-year running mean of the agricultural year precipitation. This line smoothes the large variation that is typical of our climate and permits trends to be more readily apparent. The rising trend of the precipitation throughout the period becomes most obvious with the running mean. The increase in the 10-year mean from the early 1960's to the present is an increase of about 8 inches. A truly remarkable increase.

The time of occurrence of the maximum and minimum soil moisture amounts in each foot of the soil is not as regular as at the Lamberton station. This is shown in Fig. 9 and Table 3. In fact the timing of the

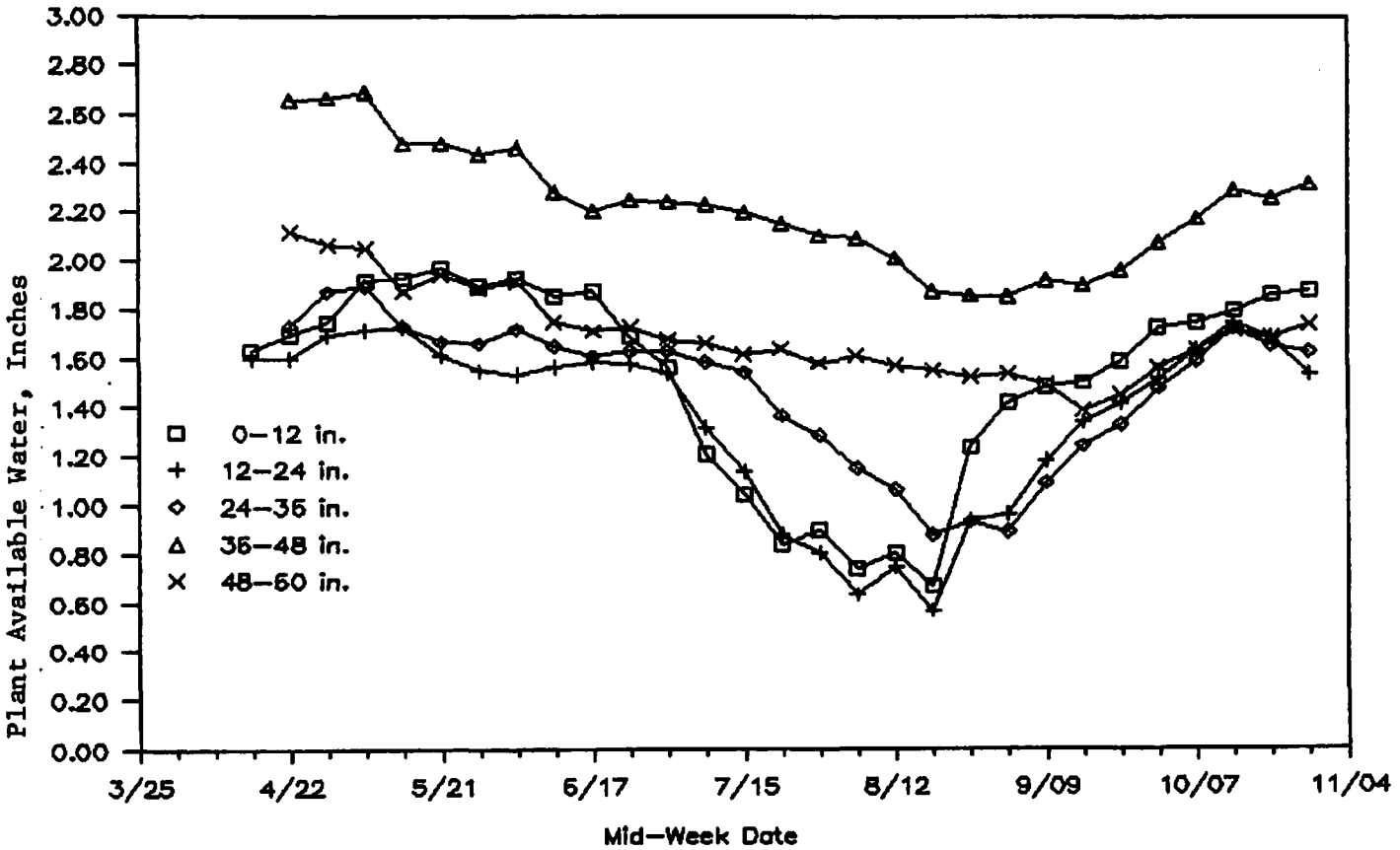


Figure 9. Average amount of plant available soil moisture in each foot of soil under continuous corn at the Southern Agricultural Experiment Station, Waseca, 1977 - 1986.

Table 3. The average date of the occurrence of the soil moisture maximum and minimum contents in each foot of soil at Waseca, 1977-1986.

Depth	Maximum soil moisture	Minimum soil moisture
0-12 in.	May 21	August 19
12-24	May 14	August 19
24-36	May 7	August 19
36-48	May 7	September 2
48-60	April 22	September 16

maximum is most curious with the shallowest depth showing the latest date of ocurrence. This might be an artifact of the relatively brief period of the record. The time when the minimum occurs ranges from August 19 in the first three feet of soil and on September 2 and 16 for the fourth and fifth foot of soil, respectively. This is about as would be expected and agrees fairly well with the longer record at Lamberton.

Fig. 10 is similar to Fig. 7, but it represents the soil moisture situation for the Southern station at Waseca. It is perhaps more evident in this figure than in Fig. 9 that the major withdrawals of moisture occur in the first three feet. Due to the generally higher total precipitation at Waseca than at Lamberton, there is less need for the corn to pull water from the fourth and fifth foot of the soil. Indeed the roots may in general not reach as deep as they do at Lamberton because of the higher moisture content. From Table 5 it appears that on the average nearly an inch or more of water is obtained from the soil at Waseca than at Lamberton. That is, the average total at Waseca is 4.99 inches compared to the 4.02 inches at Lamberton.

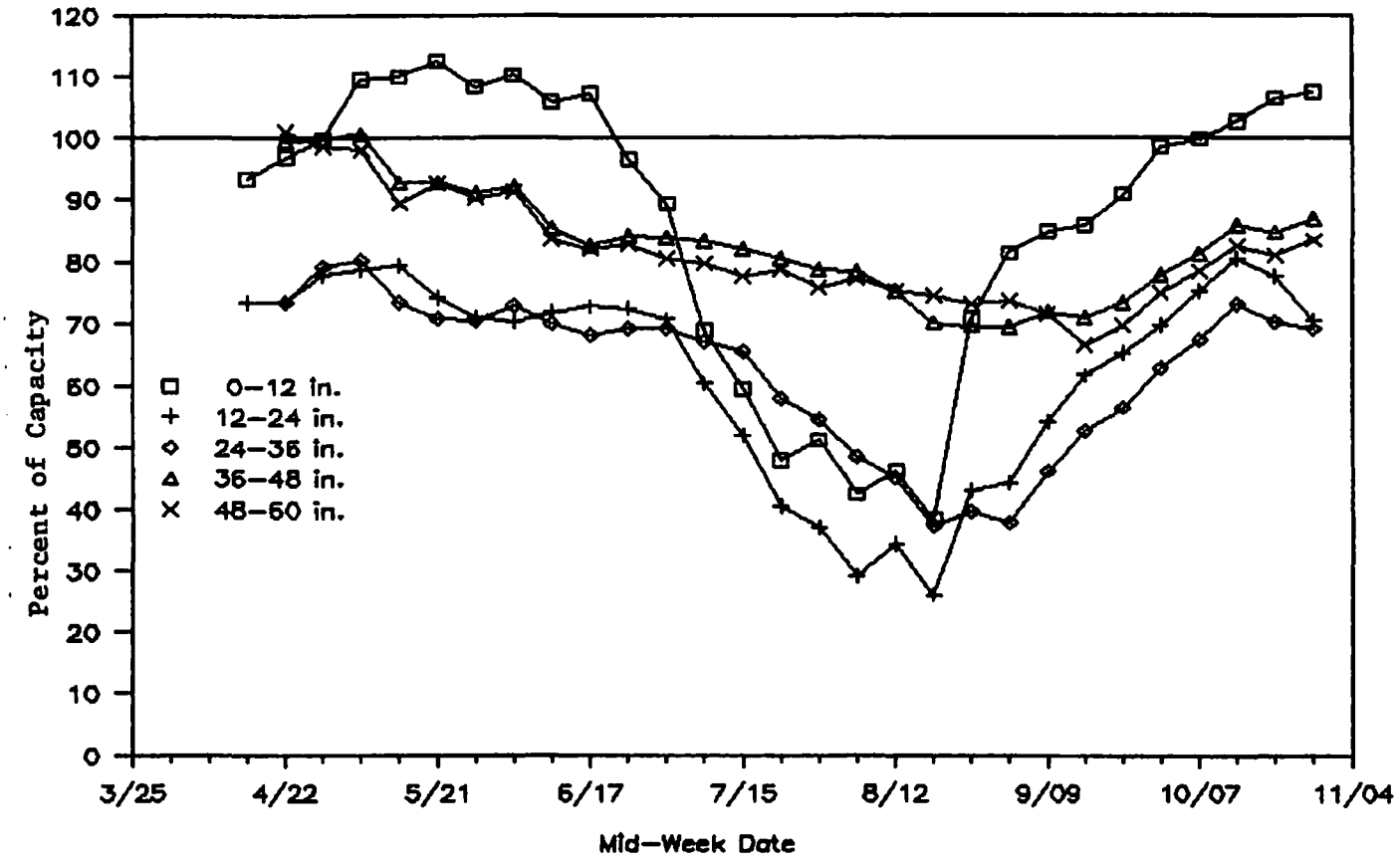


Figure 10. Average amount of plant available soil moisture in each foot of soil expressed as a percentage of the field capacity, Southern Agricultural Experiment Station, Waseca, 1977 - 1986.

Table 5. The average amount of plant available soil water in each foot of soil at the time of the maximum and minimum contents (see Table 4) at Waseca, 1977-1986.

Depth	Soil Water at maximum	Soil Water at minimum	Difference
0-12 in.	1.94 in	0.65 in.	1.29
12-24	1.70	0.52	1.18
24-36	1.86	0.86	1.00
36-48	2.66	1.84	0.82
48-60	2.10	1.40	0.70
TOTAL:	10.26	5.27	4.99

Fig. 10, as already noted, is the soil moisture content in each foot of soil expressed as a percent of the total plant available water that can be held in the soil. The graph indicates that on the average the spring and autumn contents in the first foot are above field capacity. This excess water is available for recharge of the lower depths. The fact that the surplus in the first foot is reached by October 7, so soon after the recent crop season may explain the rather curious timing of the maximum soil moisture amounts in the spring that are listed in Table 4. That is, during the latter part of the autumn and over winter the water will move down to the deeper depths. Thus, the shallow depths, 0-6 inch, for example, can accept a spring recharge and reach their maximum content at a later date than at the deeper depths.

AIR AND SOIL TEMPERATURE VARIATIONS

D.G. Baker and D.L. Ruschy

At the St. Paul campus microclimate station a plot has been devoted to alfalfa. Both soil temperatures at several depths under the alfalfa and air temperatures have been taken at hourly intervals during the growing season. In the course of a study on the effect of the environment upon alfalfa several rather interesting things have been observed. Fig. 11 is an example of one of these occasions during the 1984 season.

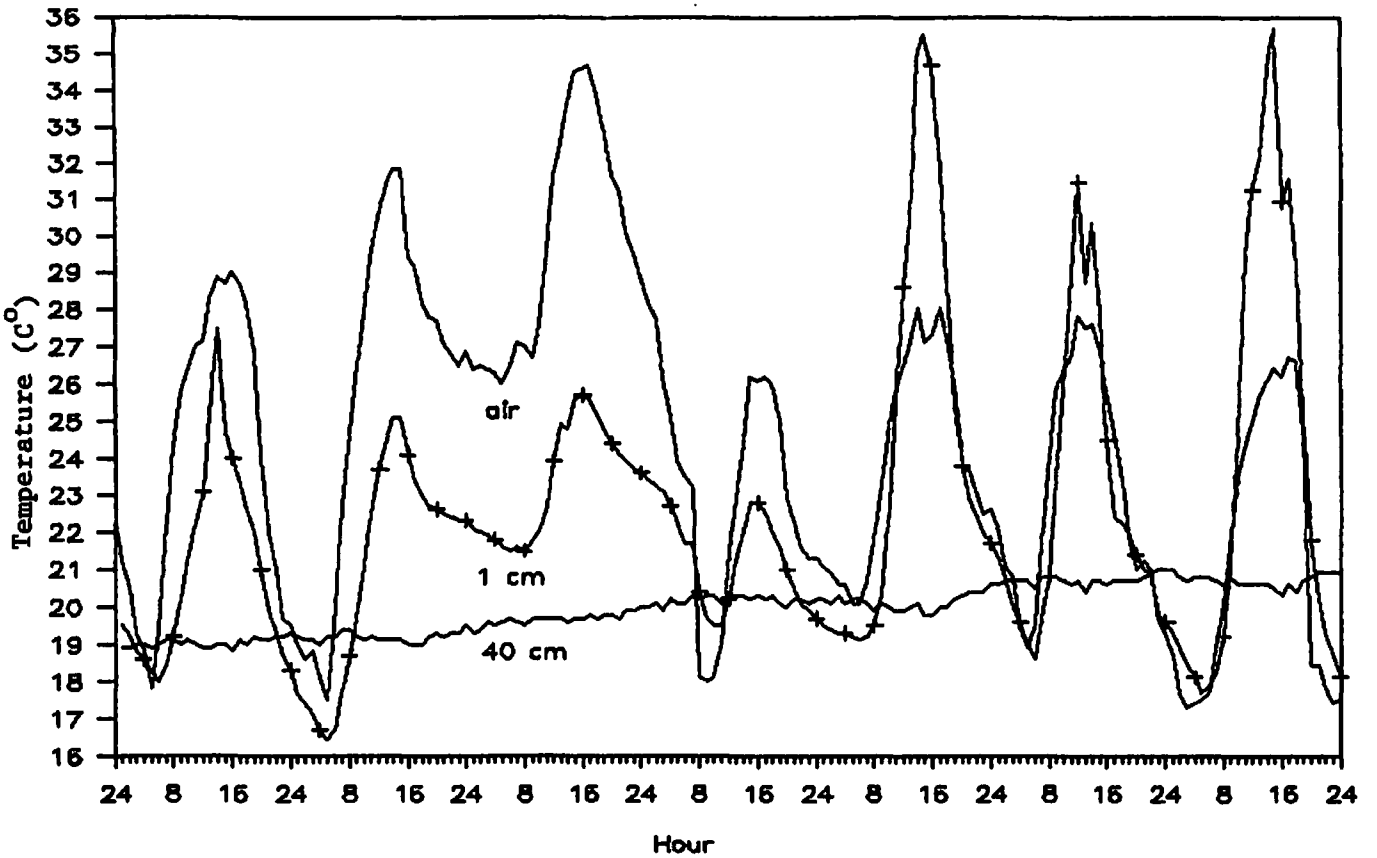


Figure 11. Air and soil temperatures, at 1 cm (0.4 in.) and 40 cm (16 in.) in alfalfa at St. Paul, July 20 - 26, 1984. The time in hours of the day is shown at the bottom; 24 marks the end of each day. Note that from July 20 - 22 the 1 cm soil temperature exceeds the air temperature but a reversal occurs beginning on July 23.

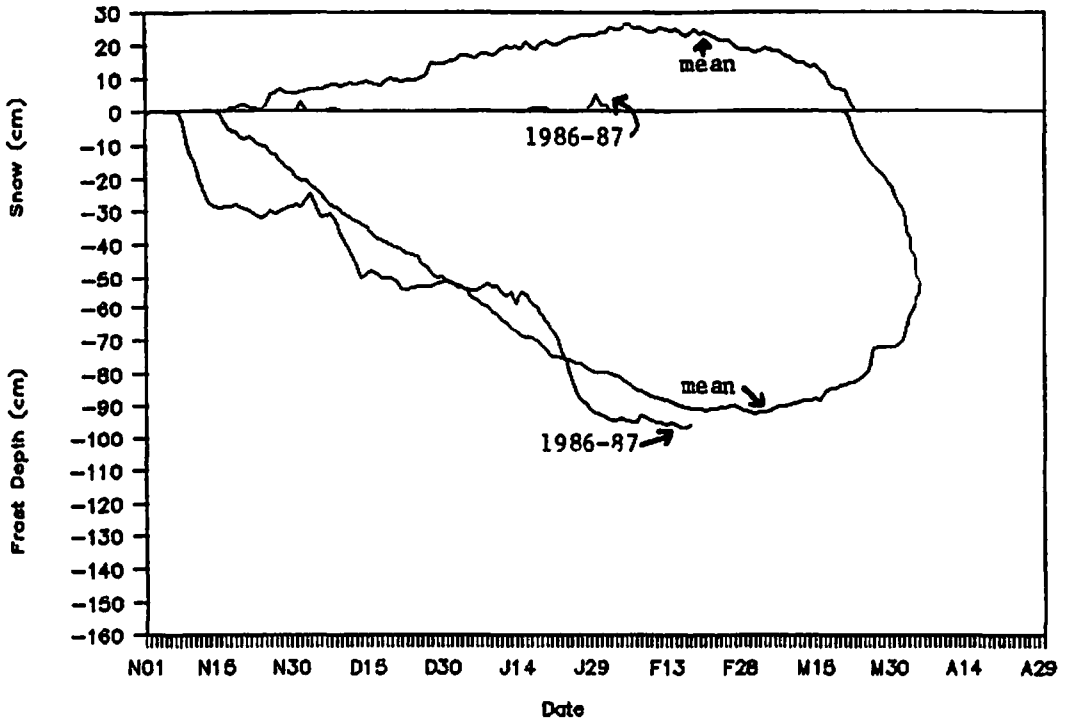
The second 1/10th bloom cutting of the alfalfa was made on July 24. Late on July 22 a cold front passed the station resulting in cooler air for the next several days. With the passage of the cold front on July 22 0.40 inch of rain was measured and the wind shifted from SW to a northerly wind which brought in the cooler air. All of this is pretty well evident in the temperature record. Due to the protection provided by the alfalfa cover (before it was cut) the soil temperature at 1 cm was considerably lower and less variable than the air temperature. However, once the alfalfa was cut and removed the 1 cm soil temperature greatly exceeded the air temperature. The air temperatures are now considerably reduced as a result of the introduction of the cold air, but even with the cold air it can be seen that the soil is absorbing lots of heat. This is reflected in the fact that the 1 cm soil temperature is now much higher than the air temperature. The daily heat wave has essentially no effect upon the daily variation of the soil temperature at 40 cm. This is true even in the absence of the alfalfa cover.

SOIL FREEZING DEPTH AND DURATION

D.B. Wall and D.G. Baker

Over 25 years of snow depth, soil temperature, and air temperature measurements have been made at the St. Paul microclimate station. These measurements have provided data from which the mean snow depth, frost depth, and cumulative freezing index throughout the winter could be determined. The averages are illustrated in Fig. 12. The cumulative freezing index (in °C) was calculated by summing the daily freezing indices (0°C minus the daily mean temperature) throughout the winter. The frost depth is under a plot bare of vegetation. On the average the soil begins to freeze on November 17 and gradually freezes to an average maximum depth of 94 cm (37 in) on March 3. The maximum freezing depth has varied between 27 and 175 cm (80 in) over the last 22 years. This variation is primarily due to differences in snow depth and air temperature, with snow depth being the most important variable influencing frost depth. The accumulated snow depth on the non-vegetated surface is greatest on the average in late February (26 cm or 10 in).

The 1986-1987 winter (through February) has had very unusual climatic conditions, with virtually no snow cover and temperatures much higher than normal. The 1986-1987 snow depth and cumulative freezing index are also shown in Fig. 12. The cumulative freezing index by Feb. 15, 1987, was 315 °C compared to mean of 785 °C on this date. While the 1986-1987 winter temperatures through mid-February have been much warmer than normal, the mid-February frost depth is about equal to the mean frost depth. The lack of snow cover this winter is the primary reason that the frost depth has penetrated past the mean frost depth even though temepratures were much higher than normal. This indicates that an average winter snow cover by mid-February has nearly the same effect on frost penetration as does a reduction of the cumulative freezing index by 470°C, a 60% reduction as experienced this winter.



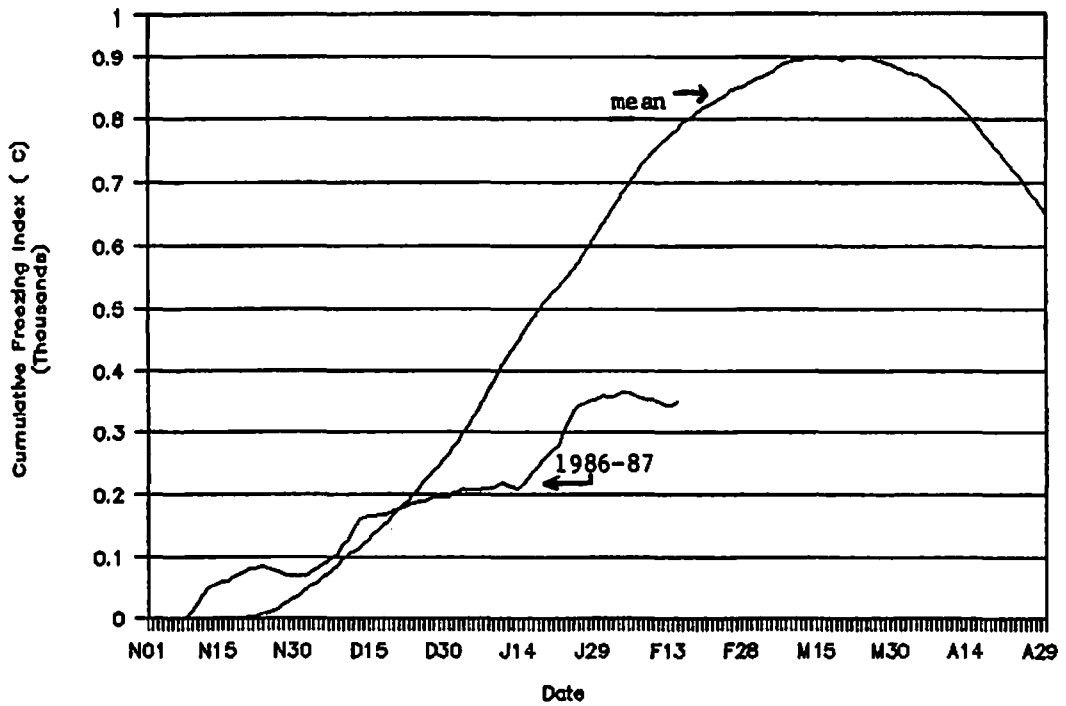


Fig. 12 (Top) Mean snow depth and frost depth (1964-84) compared to the snow and frost depth (1986-87). The soil is bare of vegetation. (Bottom) Mean cumulative freezing index for 1964-84 compared to the index for 1986-87. Note how much lower the 1986-87 cumulative freezing index is than the mean cumulative freezing index.

MANAGEMENT OF UAN ON THE COARSE TEXTURED IRRIGATED SOIL OF MINNESOTA FOR EFFICIENT CORN PRODUCTION BECKER, MN 1986

G.L. Malzer and T. Graff

Nitrogen (N) fertilizer management decisions are major considerations that all producers must address. These management decisions include many aspects of N fertilization including rates, forms, methods and time of applications, equipment, and additives. Although these factors are important for all corn producers, they become especially important for the producers on the coarse textured irrigated soils. Since these soils are highly responsive to fertilizer N, and highly susceptible to N loss, poor management can result in significant yield reductions, reduced profits, and increased nitrate contamination of ground water. The use of nitrification inhibitors in the management programs should also be considered as a management tool to minimize the N loss and add flexibility to the overall N management program. Although most nitrification inhibitors are applied with anhydrous ammonia, they can also be applied with other fertilizer products such as urea, or urea-ammonium nitrate solution (UAN). The objectives of these experiments are to evaluate several aspects of UAN management including: timing of application, method of application, split vs. single applications and the contribution of nitrification inhibitors in these possible management combinations.

Experimental Procedures

Two separate experiments were established at the Sand Plain Research Farm near Becker, Minnesota in 1985; this is the second year of these experiments.

Experiment 1 consisted of 25 treatments with four replications arranged in a randomized complete block design. Treatment variables included factorial combinations of six N rates of UAN (100, 134, 168, 202, 235, and 269 kg/ha) and four methods of application (2/3 of N rate early 1/3 late, all late, 2/3 early with DCD 1/3 late, and 2/3 early with N-Serve 1/3 late), plus a zero N control. Early N treatments were applied at the 4-5 leaf growth stage (May 29) while late applications were made at the 8-9 leaf growth stage (June 12). All treatments were injected into the soil on 76 cm centers approximately 8 cm deep and 18 cm away from the row. Nitrification inhibitors were mixed with the UAN prior to application and were applied at rates of 7.84 kg/ha for DCD and 0.56 kg/ha a.i. for N-Serve.

Experiment 2 consisted of 24 treatments with four replications in a randomized complete block design. Treatment variables included factorial combinations of three rates of N as UAN (100, 168, and 235 kg/ha), two methods of application (broadcast vs. injected), and two times of applications (4-leaf and 8-leaf growth stages). Nitrification inhibitor (DCD and N-Serve similar to above) treatments were included to provide comparisons for all injected N treatments at the four-leaf growth stage. Four additional treatments were included with a new test inhibitor (ACP 2500), applied with UAN at the rate of 0.28 kg/ha a.i.. N rates of 100 and 168 kg/ha either injected or broadcast with the UAN at the 4-leaf stage of plant growth.

Experiment 1 and 2: Prior to planting, broadcast applications of potassium-magnesium sulfate (336 kg/ha 0-0-22), and (280 kg/ha 0-14-42) were made and incorporated by plowing. Corn (Pioneer 3906 - 95 day relative maturity) was planted on April 30th in 0.76 m rows at a population of 75,800 seeds/ha. Starter fertilizer was applied at the rate of 185 kg/ha 8-10-30, side banded at planting. A tank mix of Atrazine (2.24 kg/ha) and Dual (1.68 kg/ha) was applied on May 2nd for weed control.

Leaf samples from opposite and below the ear at mid-silking were obtained on July 14th, dried and anlyzed for N. Total dry matter production and grain yields were determined on September 16 and 18th by hand harvesting 9.29 m^2 of plot area. Ears were separated from the stalks, field weights obtained, and samples removed for moisture and N determination. Grain yields were adjusted to 15.5% moisture.

The irrigation program was started on June 18th and continued through September 2nd with a total of 20.2 cm being applied through irrigation. An additional 55.37 cm of water was obtained during the growing season as rainfall.

General Results:

The 1986 growing season provided excellent conditions for high yields. The growing season precipitation was slightly lower in 1986 than was experienced at this location in 1985 and was characterized by being relatively dry during the months of May and June with no single excessive rainfall event at any time during the growing season. With these weather conditions significant nitrate leaching would not be expected to occur. Likewise, the impacts of nitrogen management techniques such as time of application, placement and use of nitrification inhibitors would be expected to have a minimal influence on grain yield and N utilization. The results for experiment 1 are presented in tables 1 and 2 and the experiment 2 results are presented in tables 3 and 4.

Experiment 1: Yield increases in excess of 110 bu/A (6.9 mt/ha) could be associated with fertilizer N application. The optimum rate of N application was 150 lbs/A (168 kg/ha), similar to what was obtained in 1985. A significant rate by method of application interaction suggests that high N rates applied as one single late application was inferior to split applications with or without a nitrification inhibitor. Nitrification inhibitors applied at the lowest N rate tended to reduce yields, but at rates closer to the optimum, this trend was negated. Single N applications late in the season significantly reduced stover and total dry matter production. Nitrification inhibitors and single late applications significantly increased the N concentrations in the grain. Nitrification inhibitors increased the N removal in the grain and total N removal when compared to treatments that did not have a nitrification inhibitor. This significant increase in N removal did not result in a consistant significant increase in grain yield, although some positive trends were noted with N-Serve.

Experiment 2: The apparent optimum N rate was the same in expt. 2 as that which was obtained in expt. 1, at 150 lbs/A (168 kg/ha). Injected applications of UAN with a nitrification inhibitor had no influence on grain yield or N removal, although significant increases in leaf N concentrations were obtained at silking when a nitrification inhibitor was used. Time of N application had no influence on grain yield or N removal suggesting that early season N leaching losses were minimal. Increased concentration of N in both the grain and the stover were obtained when the UAN was injected rather than broadcast. Injection also resulted in increased total N uptake by the crop. Since leaching losses were apparently minimal the decreased efficiency associated with the broadcast applications could be due to either volitalization, increased immobilization of N in the soil or positional unavailability. Although it is not possible to differentiate these processes in this experiment, previous experimental results at this location under similar experimental conditions would suggest that volitalization losses are minimal.

Table 1. Influence of N rates, nitrification inhibitors and method of application on grain yield, and dry matter production on irrigated corn Becker, MN - 1986.

Treatments					Grain Yields		Dry Matter Production		
N-Rates	Split 1	Inh.	Split 2	Meth.			Grain	Stover	Total
kg/ha	kg/ha		kg/ha		Bu/A	mt/ha	--------mt/ha---------		
Control	----	----	----	---	85.4	5.4	4.52	5.31	9.83
100	67	----	34	1	187.0	11.7	9.92	7.75	17.67
100	----	----	100	2	184.0	11.5	9.74	7.48	17.23
134	90	----	44	1	171.9	10.8	9.12	7.37	16.49
134	----	----	134	2	188.3	11.8	9.99	7.64	17.63
168	112	----	56	1	186.1	11.7	9.86	8.20	18.08
168	----	----	168	2	182.0	11.4	9.65	7.37	17.02
202	134	----	68	1	188.3	11.8	9.99	7.82	17.81
202	----	----	202	2	178.6	11.2	9.48	7.17	16.62
235	157	----	78	1	195.9	12.3	10.39	8.62	19.02
235	----	----	235	2	179.3	11.2	9.50	8.09	17.61
269	179	----	90	1	191.8	12.0	9.97	8.15	18.30
269	----	----	269	2	188.1	11.8	9.97	7.15	17.11
100	67	DCD	34	3	176.9	11.1	9.39	7.46	16.84
100	67	NS	34	4	172.8	10.8	9.16	7.17	16.33
134	90	DCD	44	3	182.6	11.4	9.68	8.00	17.67
134	90	NS	44	4	191.7	12.0	9.97	8.02	18.19
168	112	DCD	56	3	196.0	12.3	10.39	8.20	18.59
168	112	NS	56	4	194.8	12.2	10.33	7.91	18.23
202	134	DCD	68	3	182.1	11.4	9.65	7.44	17.09
202	134	NS	68	4	196.4	12.3	10.42	8.24	18.66
235	157	DCD	78	3	196.0	12.3	10.39	8.51	18.91
235	157	NS	78	4	192.8	12.1	10.21	8.06	18.28
269	179	DCD	90	3	192.1	12.0	10.19	8.11	18.28
269	179	NS	90	4	194.9	12.2	10.33	8.00	18.32
P-Value					99	99	99	99	99
BLSD (.05)					12.6	0.8	0.66	0.82	0.24
Main Effects									
Rates kg/ha									
100					180.2	11.3	9.54	7.45	17.00
134					183.6	11.5	9.72	7.75	17.47
168					189.7	11.9	10.05	7.90	17.96
202					186.3	11.7	9.85	7.66	17.53
235					191.0	12.0	10.12	8.31	18.43
269					191.7	12.0	10.08	7.84	17.98
P-Value					99	99	99	99	99
BLSD (.05)					7.5	0.4	0.38	0.43	0.67
Method	Early	Late							
1	2/3	1/3			186.8	11.7	9.90	7.97	17.87
2	---	3/3			183.4	11.5	9.63	7.45	17.16
3	2/3+DCD	1/3			187.6	11.7	9.94	7.92	17.87
4	2/3+NS	1/3			190.6	11.9	10.08	7.88	17.98
P-Value					70	70	70	99	99
BLSD (.05)								0.35	0.57
Rate X Method					97	97	97	67	96

Table 2. Influence of N rates, nitrification inhibitors and method of application on leaf, grain, and stover N content and total N removal by irrigated corn Becker, MN - 1986.

Treatments					N-Concentration			N-Removal		
N-Rates	Split 1	Inh.	Split 2	Meth.	Leaf	Grain	Stover	Grain	Stover	Total
kg/ha	kg/ha		kg/ha		---------%----------			--------kg/ha--------		
Control	----	----	----	----	1.48	1.10	0.37	49.8	19.8	69.7
100	67	----	34	1	2.53	1.34	0.47	132.6	36.5	169.2
100	----	----	100	2	2.80	1.47	0.58	143.0	43.3	186.3
134	90	----	44	1	2.97	1.43	0.57	130.5	41.7	172.2
134	----	----	134	2	2.95	1.43	0.59	142.6	45.1	187.7
168	112	----	56	1	3.08	1.46	0.57	143.6	46.6	190.2
168	----	----	168	2	2.98	1.55	0.67	149.6	49.6	199.2
202	134	----	68	1	2.99	1.50	0.67	149.9	53.1	203.1
202	----	----	202	2	3.09	1.52	0.69	143.2	49.6	192.8
235	157	----	78	1	2.94	1.50	0.65	156.0	54.9	211.0
235	----	----	235	2	3.04	1.56	0.68	148.2	55.0	203.3
269	179	----	90	1	2.91	1.48	0.64	150.2	52.3	202.6
269	----	----	269	2	2.87	1.51	0.69	150.7	49.8	200.5
100	67	DCD	34	3	2.90	1.39	0.54	130.8	40.5	171.4
100	67	NS	34	4	2.86	1.36	0.54	124.5	38.2	162.8
134	90	DCD	44	3	2.86	1.50	0.60	145.0	47.7	192.8
134	90	NS	44	4	2.75	1.50	0.51	151.7	41.4	193.1
168	112	DCD	56	3	3.07	1.50	0.61	155.8	50.3	206.1
168	112	NS	56	4	3.05	1.52	0.67	157.4	53.0	210.4
202	134	DCD	68	3	2.99	1.57	0.70	150.9	52.4	203.4
202	134	NS	68	4	3.08	1.53	0.66	158.7	54.6	213.4
235	157	DCD	78	3	2.98	1.75	0.67	181.3	57.4	238.8
235	157	NS	78	4	3.18	1.65	0.66	168.4	53.2	221.7
269	179	DCD	90	3	3.16	1.60	0.72	162.9	58.6	221.6
269	179	NS	90	4	2.88	1.63	0.74	168.3	59.1	227.5
P-Value					99	99	99	99	99	99
BLSD (.05)					0.22	0.09	0.87	14.0	9.0	18.7
Main Effects										
Rates										
100					2.77	1.38	0.53	132.7	39.6	172.3
134					2.90	1.46	0.56	142.4	43.9	186.4
168					3.04	1.50	0.63	151.5	49.8	201.4
202					3.03	1.52	0.68	150.6	52.4	203.1
235					3.03	1.61	0.66	163.5	55.1	218.6
269					2.95	1.55	0.69	158.0	54.9	213.0
P-Value					99	99	99	99	99	99
BLSD (.05)					0.12	0.04	0.04	2.0	4.3	9.4
Method	Early	Late								
1	2/3	1/3			2.90	1.45	0.59	143.8	47.4	191.4
2	---	3/3			2.95	1.50	0.65	146.1	48.7	194.9
3	2/3+DCD	1/3			3.00	1.55	0.64	154.4	51.1	205.6
4	2/3+NS	1/3			2.96	1.53	0.63	154.7	49.9	204.8
P-Value					77	99	81	99	72	99
BLSD(.05)						0.04		2.1		8.3
Rate X Method					89	93	33	98	21	93

Table 3. Influence of N rates, nitrification inhibitors, method, and time of application on grain yield and dry matter production on irrigated corn Becker MN. - 1986.

N-Rate	Treatments Method	Inh.	Time	Grain Yields		Dry Matter Production Grain	Stover	Total
kg/ha				Bu/A	mt/ha	---------mt/ha----------		
Control	---------	----	----	86.8	5.4	4.61	5.04	9.63
100	Broadcast	----	1	178.0	11.2	9.43	7.15	16.58
100	Broadcast	----	2	189.4	11.9	9.59	6.90	16.96
100	Injected	----	1	192.6	12.1	10.21	7.68	17.88
100	Injected	----	2	185.3	11.6	9.83	7.32	17.14
100	Injected	DCD	1	189.6	11.9	10.06	7.66	17.72
100	Injected	NS	1	191.3	12.0	10.15	7.93	18.05
168	Broadcast	----	1	192.4	12.1	10.19	8.04	18.23
168	Broadcast	----	2	198.7	12.5	10.53	7.62	18.14
168	Injected	----	1	198.6	12.5	10.53	8.04	18.57
168	Injected	----	2	191.9	12.0	10.17	7.50	17.67
168	Injected	DCD	1	203.6	12.8	10.80	8.09	18.88
168	Injected	NS	1	195.9	12.3	10.39	7.93	18.32
235	Broadcast	----	1	194.7	12.2	10.33	7.80	18.12
235	Broadcast	----	2	191.2	12.0	10.12	7.84	17.96
235	Injected	----	1	193.3	12.1	10.24	8.09	18.32
235	Injected	----	2	199.4	12.5	10.57	7.68	18.23
235	Injected	DCD	1	192.6	12.1	10.21	7.91	18.12
235	Injected	NS	1	197.7	12.4	10.48	8.22	18.70
100	Broadcast	ACP2500	1	178.7	11.2	9.48	7.12	16.60
100	Injected	ACP2500	1	180.6	11.3	9.59	7.35	16.91
168	Broadcast	ACP2500	1	190.4	11.9	10.10	7.91	17.99
168	Injected	ACP2500	1	197.1	12.3	10.46	7.37	17.81
Control	--------	------	--	80.9	5.0	4.28	5.00	9.27
P-Value				99	99	99	99	99
BLSD (.05)				13.8	0.8	0.73	0.77	1.30
Factorial Arrangement (N-Rate X Inhibitor DCD and N-Serve)								
N-Rate								
100				189.7	11.9	10.03	7.63	17.69
168				197.5	12.4	10.46	7.88	18.34
235				195.8	12.3	10.37	7.95	18.34
P-Value				99	99	99	73	57
BLSD (.05)				5.0	0.3	0.26		
Inhibitor								
None				193.5	12.2	10.64	7.70	17.96
DCD				195.2	12.2	10.34	7.88	18.23
N-Serve				195.0	12.2	10.32	8.01	18.34
P-Value				27	27	27	68	64
BLSD (.05)								
N-Rate X Inhibitor				68	68	68	7	38

Table 3 continued on page after next.

Table 4. Influence of N rates, nitrification inhibitors, method, and time of application on leaf, grain, and stover N content and total N removal by irrigated corn Becker MN - 1986.

	Treatments			N-Concentration			N-Removal		
N-Rate	Method	Inh.	Time	Leaf	Grain	Stover	Grain	Stover	Total
kg/ha				---------%----------			---------kg/ha----------		
Control	---------	----	---	1.36	1.15	0.45	50.1	22.8	76.3
100	Broadcast	----	1	2.74	1.35	0.54	127.1	38.3	165.4
100	Broadcast	----	2	2.90	1.44	0.55	144.2	37.7	181.9
100	Injected	----	1	2.71	1.48	0.58	151.2	45.3	196.6
100	Injected	----	2	2.84	1.44	0.55	141.1	40.8	181.9
100	Injected	DCD	1	2.97	1.36	0.58	137.2	44.7	181.9
100	Injected	NS	1	2.87	1.44	0.52	145.8	42.0	187.8
168	Broadcast	----	1	3.09	1.49	0.58	151.8	46.5	198.3
168	Broadcast	----	2	2.76	1.50	0.58	157.4	44.1	201.6
168	Injected	----	1	2.99	1.58	0.67	166.8	54.4	221.3
168	Injected	----	2	2.84	1.54	0.69	156.6	52.0	208.6
168	Injected	DCD	1	3.09	1.57	0.63	169.7	51.4	221.2
168	Injected	NS	1	3.09	1.64	0.70	170.9	55.5	226.4
235	Broadcast	----	1	3.11	1.53	0.64	158.5	49.9	208.5
235	Broadcast	----	2	3.07	1.44	0.68	146.1	53.6	199.7
235	Injected	----	1	2.64	1.58	0.75	162.3	60.5	222.8
235	Injected	----	2	2.75	1.55	0.67	164.3	51.1	215.5
235	Injected	DCD	1	3.15	1.60	0.74	163.0	58.8	221.8
235	Injected	NS	1	3.22	1.53	0.81	159.9	66.8	226.7
100	Broadcast	ACP2500	1	2.66	1.35	0.47	128.3	33.7	162.0
100	Injected	ACP2500	1	2.80	1.40	0.65	134.4	48.1	182.5
168	Broadcast	ACP2500	1	2.80	1.41	0.65	141.8	51.3	193.1
168	Injected	ACP2500	1	2.97	1.49	0.66	155.5	48.4	203.9
Control	---------	----	---	1.48	1.11	0.45	47.9	22.6	70.5
P-Value				99	99	99	99	99	99
BLSD (.05)				0.24	0.12	0.08	15.5	8.7	20.0
Factorial Arrangement (N-Rate X Inhibitor DCD and N-Serve)									
N-Rate									
100				2.84	1.42	0.56	143.8	43.1	178.0
168				3.00	1.58	0.67	165.9	53.3	219.4
235				2.93	1.56	0.74	162.4	59.2	221.6
P-Value				51	99	99	99	99	99
BLSD (.05)					0.05	0.03	7.6	4.4	9.7
Inhibitor									
None				2.79	1.52	0.65	157.0	50.6	207.7
DCD				3.06	1.51	0.65	156.6	51.6	208.3
N-Serve				3.05	1.53	0.67	158.8	54.7	213.5
P-Value				99	21	54	13	75	48
BLSD (.05)				0.12					
N-Rate X Inhibitor				94	82	97	58	70	21

Table 4 continued on next page.

Table 3. continued

Treatments N-Rate	Method	Inh.	Time	Grain Yields		Dry Matter Production Grain	Stover	Total
kg/ha				Bu/A	mt/ha	---------mt/ha----------		
Factorial Arrangement (N-Rate X Method X Time)								
N-Rate								
100				186.3	11.7	9.85	7.25	17.13
168				195.4	12.2	10.34	7.79	18.14
235				194.7	12.2	10.34	7.84	18.14
P-Value				97	97	97	99	97
BLSD (.05)							0.38	
Method								
Broadcast				190.7	11.9	10.10	7.54	17.65
Injected				193.5	12.1	10.23	7.70	17.96
P-Value				65	65	65	70	76
Time								
Early				191.6	12.0	10.14	7.77	17.94
Late				192.6	12.1	10.19	7.45	17.67
P-Value				28	28	28	95	68
Rate X Method				27	27	27	63	56
Rate X Time				6	6	6	27	19
Method X Time				78	78	78	53	76
Rate X Method X Time				87	87	87	12	36

Table 4. continued

	N-Concentration Leaf	Grain	Stover	N-Removal Grain	Stover	Total
	----------%----------			----------kg/ha---------		
Factorial Arrangement (N-Rate X Method X Time)						
N-Rate						
100	2.79	1.42	0.55	140.8	40.5	181.4
168	2.92	1.52	0.63	158.1	49.2	207.4
235	2.89	1.52	0.68	157.8	53.7	211.5
P-Value	97	99	99	99	99	99
BLSD (.05)		0.05	0.03	8.5	4.0	10.4
Method						
Broadcast	2.94	1.45	0.59	147.5	45.0	192.5
Injected	2.79	1.52	0.65	157.0	50.6	207.7
P-Value	99	99	99	99	99	99
Time						
Early	2.87	1.50	0.62	152.9	49.1	202.1
Late	2.85	1.48	0.62	151.5	46.8	198.1
P-Value	39	59	32	29	85	61
Rate X Method	99	5	83	11	35	1
Rate X Time	99	67	25	39	1	28
Method X Time	78	63	86	81	88	90
Rate X Method X Time	47	78	80	94	68	65

INFLUENCE OF NITROGEN APPLICATION TIME AND NITRIFICATION INHIBITOR RATE ON SWEET CORN PRODUCTION ON AN IRRIGATED SAND

C. J. Rosen and H. J. Buchite

With excessive rainfall, coarse-textured soils are subject to leaching of nitrate-N from the root-zone. Because N loss through the growing season can depress yields and contaminate groundwater, the practice of sidedressing and/or use of nitrification inhibitors are important considerations for growers on the central sand plains of Minnesota. Maintaining N in the relatively nonleachable ammonium form through use of a nitrification inhibitor may be one means of reducing nitrate-N leaching and N fertilizer inputs. Another factor to consider is whether hybrids respond differently to ammonium-N compared to nitrate-N. Selecting hybrids that respond to ammonium nutrition may enhance the effectivness of nitrification inhibitors. The objectives of this study were to 1) determine the effects of N fertilizer application time and nitrification inhibitor rate on soil levels of nitrate-N and ammonium-N and 2) compare the response of two sweet corn hybrids to these treatments.

EXPERIMENTAL PROCEDURES

The experiment was conducted at the Sand Plains Research Farm in Becker, MN. Prior to planting and fertilizer application, the soil (Hubbard loamy sand) had the following test values (0-6"): pH, 6.3; Bray P1, 85 lb/A; ammonium acetate extractable K, 185 lb/A; KCl extractable NH_4-N (0-12"), 1.5 ppm; KCl extractable NO_3-N (0-12"), 1.6 ppm. The previous crop at this site was rye. Prior to planting 150 lb/A potassium-magnesium sulfate (0-0-22) was broadcast and incorporated.

Treatments consisted of two hybrids 'Code 5' (early season maturing) and 'Jubilee' (mid-season maturing), 150 lb N/A as anhydrous ammonia either preplant or split applied (75 lb N/A preplant and 75 lb N/A sidedressed) and three rates of N-Serve (0, 0.5, or 1.0 lb ai/A). A split-plot design with four replications was used with timing and inhibitor rate as main plots and hybrid as subplots. Preplant treatments were applied April 30, 1986. Both hybrids were planted May 2 with a banded application of 150 lb/A 0-14-42. Stands were thinned to approximately 24,000 plants/A with spacing set at 30" rows. The sidedress treatments were applied June 13 (10-12 leaf stage). The split N treatments had half the inhibitor applied preplant and the remainder applied with the sidedress. Soil samples were collected in the anhydrous ammonia bands (samples bulked over hybrid) May 30, July 9 and July 31 and stored moist at 4 C until extracted with 2N KCl for nitrate-N and ammonium-N determination. Whole plant samples collected at the 10-12 leaf stage (before sidedress application) and leaf samples opposite and above the ear at mid-silking were dried and ground for subsequent nutrient determination. From May through July, precipitation totalled 12.3". This rainfall was supplemented with 6.7" of water through an overhead irrigation system.

Code 5 was harvested on July 29 and Jubilee was harvested August 4. Total green yield, husked yield and stover yield were obtained by harvesting two 15 ft center rows within each plot. Subsamples of ears, husk, and stover were taken to determine % moisture for N uptake calculations. As a measure of product quality, % kernel moisture and % useable ears (5.5" or greater with unfilled tip removed - COC eligible) were determined.

RESULTS

Both N timing and nitrification inhibitor rates had significant effects on levels of soil ammonium-N (Table 1) and nitrate-N (Table 2). Because samples were taken in the anhydrous ammonia band, values presented are valid for that area and do not represent average levels through the field. At the first sampling date (prior to the sidedress application), ammonium-N levels increased with increasing inhibitor rate and were higher when all N was applied as preplant. Most of the ammonium-N was concentrated in the

top 12" of soil at all sampling dates. By the second and third sampling dates, ammonium-N levels were higher with the split applications compared to the preplant application. The highest inhibitor rate corresponded to the highest ammonium-N levels when N applications were split. Ammonium-N levels decreased dramatically with all preplant treatments. In contrast to ammonium-N, nitrate-N decreased with increasing inhibitor rate at the first and second sampling dates. Timing of N application had no apparent effect on nitrate-N levels at the first sampling date, but split applications tended to result in higher levels at the later sampling dates. These data clearly indicate that N-Serve significantly suppressed nitrification which resulted in relatively high ammonium-N soil levels in N-Serve treated plots.

Unhusked (green) and husked yield of both hybrids increased with increasing inhibitor rate and with split applications of N (Table 1). Because of rainfall events greater than 1" on June 21, July 5 and July 19, nitrate-N loss was apparently sigificant (see Table 2). The main response to inhibitor and sidedress N was probably due to greater N availablity during the later part of the season. Jubilee appeared to respond to a greater extent to split applications than did Code 5. Moisture in kernels at harvest decreased with increasing inhibitor rate when N was applied preplant but increased with inhibitor rate when N applications were split. The reasons for this response are not clear from the present experiment. The effect of inhibitor on COC eligible ears was highly significant for Code 5 but minimal for Jubilee. This response to inhibitor by Code 5 but not Jubilee may be due to differences in hybrid response to ammonium nutrition. Unfortunately, in plots not receiving N-Serve, significantly more nitrate-N may have leached out of the root zone resulting lower N availability. Therefore, it cannot be determined from the present experiment whether the difference between hybrids is specifically due to ammonium nutrition or to greater availability of N in the root zone.

Nitrogen composition of and uptake by the two hybrids are presented in Table 4. Concentrations of N in plants sampled at the 8-10 leaf stage were not significantly affected by inhibitor rate or N timing. Concentrations of N in stover and ears generally increased with inhibitor rate and split applications. Inhibitor appeared to increase N concentrations to a greater extent when N was split applied compared to a preplant application. Husk N composition was not significantly affected by any of the treatments. Total N removed in ears and stover also increased with inhibitor rate and split application. For ear N, this effect was more pronounced with Jubilee than with Code 5. Greater N uptake with inhibitor and split N applications was most likely due to less nitrate-N leaching with these treatments. Mid-silk leaf elemental concentrations are presented in Table 5. All leaf N levels were in the optimum range for sweet corn production. In general, inhibitor increased leaf P and decreased leaf Ca and Mn.

General Comments:

Use of N-Serve, a nitrification inhibitor, on irrigated sandy soils, significantly increased yield and quality of processing sweet corn. This effect was observed even when inhibitor was applied in combination with split applications. Differences in hybrid response to inhibitor were evident in earfill characteristics as measured by COC eligible ears. Although soil ammonium-N levels increased with inhibitor rate, nitrate-N levels were generally low by earfill. The response to inhibitor may have been due to a combination of greater N availability as well as to ammonium nutrition.

The assistance of Tom Graff with inhibitor and nitrogen application is gratefully acknowledged.

Table 1. Influence of timing of N fertilizer application (150 lb/A) and rate of nitrification inhibitor on soil ammonium - N levels at three depths.

		Sampling Date								
		May 30			July 9			July 31		
Timing	NI rate (lb. ai/A)[1]	0-6"	6-12"	12-24"	0-6"	6-12"	12-24"	0-6"	6-12"	12-24"
		ppm								
preplant	0	72.0	30.0	1.1	7.2	5.5	3.6	0.7	0.5	0.3
preplant	0.5	57.4	19.8	1.0	11.3	5.4	1.6	1.0	8.5	0.5
preplant	1.0	58.7	41.9	1.3	5.3	9.7	2.8	0.9	7.7	0.9
split	0	1.2	16.8	0.5	12.5	57.0	5.0	0.6	1.8	0.3
split	0.5	29.4	26.5	0.4	48.2	78.6	4.3	12.6	38.7	2.1
split	1.0	64.6	50.3	0.5	128.6	80.3	22.8	60.7	43.6	3.9
Statistics										
Timing										
preplant		62.7	30.4	1.2	8.0	6.8	2.7	0.9	5.5	0.5
split		31.8	31.2	0.5	63.3	72.0	10.7	24.6	28.0	2.1
Significance		NS	NS	+	**	**	+	*	++	*
NI Rate										
0		36.6	23.2	0.8	9.9	31.2	4.3	0.7	1.1	0.3
0.5		43.4	23.1	0.7	30.0	42.0	2.9	6.8	23.6	1.3
1.0		61.7	46.1	0.9	67.0	45.0	12.8	30.8	25.6	2.4
Significance		NS	NS	NS	**	NS	NS	*	+	++
Linear		NS	+	NS	**	NS	NS	*	++	*
Quad		NS	NS	NS	NS	NS	NS	NS	NS	NS
Time x NI Rate										
Significance		NS	NS	NS	**	NS	NS	*	NS	NS

[1] NI - nitrification inhibitor (N-Serve)
** = <.01, * = .01-.05, ++ = .05-.1, + = .1-.2, NS = >.2

Table 2. Influence of timing of N fertilizer application (150 lb. N/A) and rate of nitrification inhibitor on soil nitrate-N levels at three soil depths.

		Sampling Date								
		May 30			July 9			July 31		
Timing	NI rate (lb. ai/A)[1]	0-6"	6-12"	12-24"	0-6"	6-12"	12-24"	0-6"	6-12"	12-24"
		ppm								
preplant	0	68.0	59.3	5.7	7.2	11.9	7.3	4.9	3.7	1.7
preplant	0.5	34.9	38.6	4.6	4.9	3.7	1.6	5.2	4.1	1.7
preplant	1.0	29.2	30.3	5.3	4.7	3.0	2.4	4.7	3.4	1.8
split	0	58.0	59.0	5.5	10.6	23.0	7.8	7.9	9.9	2.4
split	0.5	31.6	29.4	3.8	5.9	10.9	3.9	11.0	9.0	3.6
split	1.0	38.4	23.4	4.4	3.3	2.5	2.1	7.9	6.7	2.8
Statistics										
Timing										
preplant		44.0	42.7	5.2	5.6	6.2	3.8	4.9	3.7	1.7
split		42.7	37.2	4.6	6.6	12.1	4.6	8.9	8.5	2.9
Significance		NS	NS	NS	NS	**	NS	**	*	**
NI Rate										
0		63.0	59.1	5.6	8.9	17.4	7.5	6.4	6.8	2.1
0.5		33.2	33.9	4.2	5.4	7.3	2.7	8.1	6.5	2.6
1.0		33.8	26.8	4.9	4.0	2.8	2.3	6.3	5.1	2.3
Significance		*	*	NS	**	**	**	+	NS	NS
Linear		*	**	NS	**	**	**	NS	NS	NS
Quad		+	NS	+	NS	+	*	++	NS	+
Time x NI Rate										
Significance		NS	NS	NS	*	++	NS	NS	NS	NS

[1] NI - nitrification inhibitor (N-Serve)
** = <.01, * = .01-.05, ++ = .05-.1, + = .1-.2, NS = >.2

Table 3. Nitrogen fertilizer timing (150 lb. N/A) and nitrification inhibitor rate effects on yield and quality of two sweet corn hyrbrids.

Timing	NI rate (lb. ai/A)[1]	Hybrid	Yield (T/A) Green	Yield (T/A) Husked	% Kernel Moisture	% CCC Eligible
preplant	0	Code 5	5.83	3.80	76.1	72
preplant	0.5	Code 5	6.55	4.27	76.6	87
preplant	1.0	Code 5	6.24	4.13	74.5	82
split	0	Code 5	6.09	3.94	74.1	75
split	0.5	Code 5	6.26	4.20	74.8	90
split	1.0	Code 5	6.80	4.48	76.2	90
preplant	0	Jubilee	6.60	4.28	76.5	91
preplant	0.5	Jubilee	7.27	5.03	75.1	91
preplant	1.0	Jubilee	7.66	5.24	73.0	97
split	0	Jubilee	7.62	5.37	72.1	99
split	0.5	Jubilee	7.93	5.84	74.4	97
split	1.0	Jubilee	8.33	5.87	74.3	97
Statistics						
Main Effects						
Hybrid						
		Code 5	6.30	4.13	75.4	83
		Jubilee	7.57	5.27	74.2	95
Significance			**	**	*	**
Timing						
		preplant	6.69	4.45	75.3	87
		split	7.17	4.95	74.3	91
Significance			++	**	*	+
NI Rate						
	0		6.53	4.35	74.7	84
	0.5		7.00	4.82	75.2	91
	1.0		7.26	4.93	74.5	92
Significance			++	*	NS	+
Linear			**	**	NS	*
Quad			NS	+	NS	+
Interactions						
Hybrid x Timing			++	**	NS	NS
Hybrid x NI Rate			NS	NS	NS	**
Timing x NI Rate			NS	NS	**	NS
Hybrid x NI Rate x Timing			NS	NS	NS	NS

[1] NI - nitrification inhibitor (N-serve)
** = <.01, * = .01-.05, ++ = .05-.1, + = .1-.2, NS = >.2

Table 4. Nitrogen fertilizer timing (150 lb. N/A) and nitrification inhibitor effects on N composition of and uptake by two sweet corn hybrids.

Timing	NI Rate (lb. ai/A)[1]	Hybrid	% N Whole Plant (6-8 leaf)	% N Ear (Harvest)	% N Husk (Harvest)	% N Stover (Harvest)	N Content Ear (lb N/A)	N Content Husk (lb N/A)	N Content Stover (lb N/A)	Total N Uptake lb. N/A
preplant	0	Code 5	4.88	1.49	.83	1.41	25.5	5.2	57.7	88.4
preplant	0.5	Code 5	5.02	1.47	.80	1.39	28.9	6.1	59.3	94.2
preplant	1.0	Code 5	4.97	1.48	.77	1.41	29.5	5.4	57.8	92.7
split	0	Code 5	4.86	1.52	.81	1.44	27.7	5.5	63.6	96.8
split	0.5	Code 5	4.89	1.53	.81	1.66	30.9	5.3	72.8	109.0
split	1.0	Code 5	4.74	1.54	.82	1.83	31.7	6.3	79.7	117.7
preplant	0	Jubilee	4.87	1.51	.75	1.14	29.8	5.8	55.4	91.0
preplant	0.5	Jubilee	5.26	1.56	.71	1.02	36.9	5.4	58.0	100.2
preplant	1.0	Jubilee	4.89	1.50	.75	1.19	39.4	5.9	66.7	112.0
split	0	Jubilee	5.07	1.46	.80	1.23	37.6	5.4	67.1	110.2
split	0.5	Jubilee	5.08	1.56	.87	1.34	45.0	5.8	77.5	128.3
split	1.0	Jubilee	5.22	1.69	.83	1.59	47.8	6.6	80.6	135.0
Statistics										
Main Effects										
Hybrid										
		Code 5	4.89	1.50	.81	1.52	29.0	5.6	65.1	99.8
		Jubilee	5.06	1.55	.78	1.25	39.4	5.8	67.5	112.8
Significance			*	+	NS	**	**	NS	NS	**
Timing										
		Preplant	4.98	1.50	.79	1.26	31.7	5.6	59.1	96.4
		Split	4.97	1.55	.82	1.51	36.8	5.8	73.6	116.2
Significance			NS	**	*	**	**	NS	**	**
NI Rate										
		0	4.92	1.50	.80	1.30	30.2	5.5	61.0	96.6
		0.5	5.06	1.53	.80	1.35	35.4	5.6	66.9	107.9
		1.0	4.95	1.55	.79	1.50	37.1	6.0	71.2	114.3
Significance			+	*	NS	**	**	NS	*	**
Linear			NS	++	NS	**	**	++	**	**
Quad			++	NS	NS	NS	+	NS	NS	NS
Interactions										
Hybrid x Timing			++	NS	++	NS	**	NS	NS	NS
Hybrid x NI Rate			NS	+	NS	NS	++	NS	NS	NS
Timing x NI Rate			NS	**	NS	**	NS	NS	NS	NS
Hybrid x NI Rate x Timing			+	NS	NS	NS	NS	NS	NS	NS

[1] NI - nitrification inhibitor (N-Serve)
** = <.01, * = .01-.05, ++ = .05-.1, + = .1-.2, NS = >.2

Table 5. Influence of timing of N fertilizer application (150 lb. N/A) and rate of nitrification inhibitor on leaf elemental concentration at mid-silking.

Timing	NI Rate (lb. ai/A)[1]	Hybrid	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
			%					ppm				
preplant	0	Code 5	3.41	0.32	2.82	0.51	0.37	102	93	23	8	8
preplant	0.5	Code 5	3.20	0.32	2.71	0.47	0.34	295	50	20	8	7
preplant	1.0	Code 5	3.41	0.35	2.70	0.47	0.35	94	51	21	8	8
split	0	Code 5	3.33	0.33	2.83	0.51	0.35	100	74	22	8	9
split	0.5	Code 5	3.37	0.35	2.72	0.47	0.36	94	46	19	8	10
split	1.0	Code 5	3.51	0.36	2.83	0.47	0.34	98	49	21	8	7
preplant	0	Jubilee	2.82	0.29	2.55	0.51	0.41	77	92	26	7	8
preplant	0.5	Jubilee	2.93	0.30	2.57	0.46	0.35	80	62	26	8	9
preplant	1.0	Jubilee	2.80	0.31	2.46	0.47	0.38	77	48	25	8	8
split	0	Jubilee	2.83	0.30	2.50	0.51	0.39	77	67	24	8	7
split	0.5	Jubilee	3.02	0.32	2.51	0.47	0.36	78	53	25	8	7
split	1.0	Jubilee	3.07	0.33	2.59	0.44	0.34	84	51	27	9	8
Statistics												
Main Effects												
Hybrid												
		Code 5	3.37	0.34	2.77	0.48	0.35	130	60	21	8	8
		Jubilee	2.91	0.31	2.53	0.48	0.37	79	62	26	8	8
Significance			**	**	**	NS	*	+	NS	**	NS	NS
Timing												
		Preplant	3.09	0.32	2.63	0.48	0.37	121	66	24	8	8
		Split	3.19	0.33	2.66	0.48	0.36	88	57	23	8	8
Significance			++	*	NS	NS	NS	NS	*	NS	NS	NS
NI Rate												
		0	3.09	0.31	2.68	0.51	0.38	89	81	24	8	8
		0.5	3.13	0.32	2.63	0.47	0.35	137	53	23	8	8
		1.0	3.20	0.34	2.64	0.46	0.35	88	49	23	8	8
Significance			NS	**	NS	**	+	NS	**	NS	NS	NS
Linear			++	**	NS	**	*	NS	**	NS	NS	NS
Quad			NS	NS	NS	*	+	+	*	++	NS	NS
Interactions												
Hybrid x Timing			NS	NS	NS	NS	NS	NS	NS	NS	NS	*
Hybrid x NI Rate			++	NS	NS	NS	NS	NS	NS	NS	NS	NS
Timing x NI Rate			+	NS	+	NS	NS	NS	*	NS	NS	NS
Hybrid x NI Rate x Timing			NS	NS	NS	NS	NS	NS	NS	++	NS	*

[1] NI - nitrification inhibitor (N-Serve)
** = <.01, * = .01-.05, ++ = .05-.1, + = .1-.2, NS = >.2

1986 WEATHER

J.A. Lamb

The weather for 1986 was closer to the 90-year average when compared to the cool 1985 weather. The mean temperature for 1986 was the same as the 90-year average 39.4°F. Eight of the 12 months had average temperatures that were above the 90-year average. The remaining four months were below the average. Early growing season temperatures were above average which encouraged rapid growth of the spring crops. This extra growth helped compensate for the cool August and September temperatures. The last frost of the spring was May 2, 1986 (31°F) and the first hard killing frost was October 5, 1986 (31°F). Scattered frost occurred September 12, 1986 (32°F) which killed frost-tender crops in the research area of the Station. This made for a 123-day and 156-day growing season.

The 1986 precipitation was 1.5" less than the 90-year average. Eight of the 12 months had precipitation amounts less than the 90-year average. The remaining months were greater. The snow melt occurred somewhat earlier in 1986 and it was thought an early planting season would be possible. The rainfall in April delayed the planting season into mid May. The rains in July helped finish the small grain crop after a drier than normal June. August and October were drier than normal. Even with the normal rainfall in September the fall soil moisture content at the Northwest Experiment Station was low.

Table 1. Weather summary for 1986 with 90-year averages for precipitation and mean temperature.

Month	Precipitation 1986	Precipitation 1890-1979		Mean Temperatures 1986	Mean Temperatures 1890-1979
	--------inches--------			--------degrees F---------	
January	0.34	0.56		9.9	3.7
February	0.51	0.59		8.3	8.1
March	0	0.84		29.3	22.9
April	5.01	1.57		42.0	41.4
May	1.99	2.59		58.4	54.6
June	1.09	3.56		65.9	64.4
July	3.71	3.09		70.0	69.6
August	1.62	2.90		63.9	67.4
September	2.24	2.16		55.0	57.5
October	0.29	1.43		43.0	45.3
November	2.16	0.78		19.5	26.7
December	0.19	0.60		16.5	11.5
Total	19.2	20.67	Mean	39.4	39.4

THE EFFECTS OF SULFUR APPLICATION ON SUGARBEET

J.A. Lamb

OBJECTIVE: Determine if sugarbeets grown in the Red River Valley would respond to sulfur fertilization.

PROCEDURE: This study was located at the Northwest Experiment Station, Crookston, MN. Table 1 shows the soil parameters for this location. Elemental sulfur was applied at rates of 0, 25, and 50 pounds S per acre, spring 1986. The experimental design was a randomized complete block with four replications. Maribo 403 was planted May 15, 1986 and thinned back to 125 plants per 100 ft of row. The experiment was harvested September 24, 1986 and quality determined by American Crystal Sugar Tare Lab, East Grand Forks, MN.

Table 1. Soil parameters NWES sulfur study.

NO_3^--N (0-2')	41 #/A
P ($NaHCO_3$)	7 #/A
K	220 #/A

RESULTS AND DISCUSSION: The yield and quality results are reported in Table 2. The application of sulfur to the soil caused a trend toward decreasing root yields and sugar content. The impurities were increased with increasing S rate as noted by the impurity index and the decrease in pounds of sugar recovered per ton of sugarbeet. As a combination of the decreasing root yield, sugar content, and increasing impurity index, the recoverable sugar per acre was significantly decreased with increasing sulfur application. A yield response would not be expected at this location or on any Red River Valley soils because of the gypsum (calcium sulfate) content.

Table 2. Root yield, sugar content, recoverable sugar, sugar per ton of sugarbeet impurity index for sulfur study NWES, 1986.

Sulfur #/A	Yield Ton/A	Sugar %	Recoverable Sugar #/A	Recoverable Sugar/Ton #/Ton	Index
0	20.5	18.7	7066	344	523
25	19.9	18.3	6682	336	548
50	19.4	18.1	6417	330	597
Statistical Analyses					
Sulfur	NS	NS	++	+	NS
Linear	+	+	*	++	+
CV %	4.8	2.4	4.6	2.7	10.3

*, ++, + and NS are 0.05, 0.10, 0.20, and not significant, signicance levels, respectively.

Please refer to title page of this publication for information regarding application and use of this article.

STARTER PHOSPHORUS FERTILIZER ON SUGARBEET

J.A. Lamb

OBJECTIVE: Determine if sugarbeet will respond to starter fertilizer.

MATERIALS AND METHODS: This study was conducted at the Northwest Experiment Station in 1986. The soil test results are as follows; 40 # NO_3^--N (0-2'), $NaHCO_3$ P 7 #/A, and K 220 #/A. There are eight treatments in this study. Four treatments were ammonium polyphosphate 10-34-0 broadcast and incorporated or row applied at planting at 3 or 6 gallon/A rates. Three treatments were preplant application of Minnesota recommendations alone, or with 3 and 6 gallon/A of row applied 10-34-0. In 1986, the Minnesota recommendations were 80 # N/A and 70 # P_2O_5/A. The final treatment was an unfertilized check. The treatments were arranged in a randomized complete block design with four replications. The study was planted May 15, 1986 using KW3394 sugarbeet variety. Harvest occurred the third week of September with the quality determined by the American Crystal Tare Lab in East Grand Forks, MN.

RESULTS AND DISCUSSION: Table 1 lists the 1986 yield and quality results. Sugar content and recoverable sugar per ton were not affected by the treatments. The addition of fertilizer increased yield and recoverable sugar per acre. The treatments with Minnesota recommendations had larger root yields than those without. The addition of starter fertilizer to the Minnesota recommendation treatments increased yields. The treatments with just starter fertilizer the row application yielded better than the broadcast and the 6 gallon/A yielded better than 3 gallon/A.

The recoverable sugar per acre was effected similar to the root yield by the treatments. The exceptions to this would be the 6 gallon/A broadcast and Minnesota recommendation + 3 gallon/A row. These treatments were lower in relative comparison to the other treatments. This was caused by somewhat lower sugar contents. These responses in root yield and recoverable sugar per acre were caused by the phosphorus applied in the fertilizer. The low soil test P confirms this observation.

Table 1. Treatment means and statistical analyses for yield and quality for sugarbeet starter study, 1986.

	Root		Recoverable		
Treatment	Yield Ton/A	Sugar %	Sugar #/A	Sugar/Ton lb/Ton	Index
Check	15.9	18.5	5421	340	522
3 Gallon Row	18.7	18.6	6426	344	501
6 Gallon Row	19.8	18.7	6856	346	487
3 Gallon Broadcast	17.4	19.0	6137	352	500
6 Gallon Broadcast	16.2	18.6	5543	341	557
MN Rec.	20.3	18.5	6901	339	535
MN Rec. + 3 Gal. Row	20.6	18.3	6819	332	616
MN Rec. + 6 Gal. Row	21.7	18.3	7194	332	619
Statistical Analyses					
Treatment	**	NS	**	NS	++
C.V.%	5.5	2.8	6.2	3.6	11.1

** and ++ are 0.01 and 0.10 significance levels, respectively.

Please refer to title page of this publication for information regarding application and use of this article.

THE EFFECT OF NITROGEN RATE AND PLANT POPULATION ON SUGARBEET

J.A. Lamb

OBJECTIVE: Determine if adjustment in nitrogen fertilization on above-optimum spaced sugarbeet will increase yield and quality.

MATERIALS AND METHODS: A study with nitrogen and plant population variables was established at Crookston with N treatments of 40, 120, and 200 pounds (soil N + fertilizer N) N per acre and plant populations established by overplanting and thinning to the following populations of 100, 150, and 200 plants/100 ft of row. The treatment design was split-plot with N rate as the whole plot and plant population as the subplot. Four replications were planted May 22, 1986 to Maribo 403. Harvest occurred the third week of September. The soil test NO_3^--N was 40 # N/A (0-24").

RESULTS AND DISCUSSION: Root yield was significantly increased with the addition of N even up to the 200 # N/A level. When the population was increased, the root yield decreased. There was no significant interaction. The optimum yield was at 100 sugarbeet plants per 100 foot of row and 200 # N/A. Increased N did significantly decrease the sugar content and population did not have an effect. The recoverable sugar per acre was slightly increased by N but more directly decreased with increasing population. Recoverable sugar per ton was negatively effected by increasing N rate. Plant population did effect recoverable sugar per ton of sugarbeet. The negative N effect was caused by the increased impurities at the higher N levels. The addition of N does compensate for the detrimental effects of above optimum plant populations but does not totally replace the recoverable sugar loss caused by not having an optimum population.

Table 1. Yield and quality as affected by plant population and nitrogen in 1986.

		Root		Recoverable	
N Rate	Population	Yield Ton/A	Sugar %	Sugar #/A	Sugar/Ton #/Ton
40	100	15.4	17.1	4778	310
	150	12.7	17.5	4046	320
	200	10.9	16.9	3305	305
120	100	15.2	17.1	4695	309
	150	13.1	16.7	3951	301
	200	12.5	16.6	3704	297
200	100	15.8	16.3	4496	285
	150	15.6	16.6	4595	295
	200	13.7	16.2	3934	286
N Rate					
	40	13.0	17.1	4043	311
	120	13.6	16.8	4117	302
	200	15.0	16.4	4341	289
Population					
	100	15.5	16.8	4656	301
	150	13.8	16.9	4197	305
	200	12.4	16.5	3648	296
Statistical Analyses					
N Rate		*	**	NS	**
Linear		*	**	+	**
Quadratic		NS	NS	NS	NS
Population		**	NS	**	NS
Linear		**	NS	**	NS
Quadratic		NS	NS	NS	NS
N Rate * Population		NS	NS	NS	NS
C.V.%		12.8	3.6	12.9	5.0

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TIMING OF NITROGEN APPLICATION ON SUGARBEET

J.A. Lamb

OBJECTIVE: Evaluate the effect of application timing of N fertilization on root yield and quality.

MATERIALS AND METHODS: The plots were established at the Northwest Experiment Station, Crookston, MN. Urea Ammonium Nitrate solution (UAN, 28% N) was used to apply N at four dates, May 5, June 4, June 26, and July 18. The applications were knifed with anhydrous ammonia knives spaced 22 inches apart. The total amount of N applied was 80 #/A. The soil test was 41 # NO_3^--N/A (0-2'). This brought the total N to 120 #N/A. Hilleshog Dippe II was originally planted May 5, 1986. Because of crusting problems the experiment was replanted to the same variety May 22 and thinned to 125 plants per 100 feet of row. The treatments, which are reported in Table 1, were arranged in a randomized complete block design with four replications. The sugarbeets were harvested September 25, 1986 and the quality was determined by the American Crystal Sugar Tare Lab, East Grand Forks, MN.

RESULTS AND DISCUSSION: The results for 1986 are contained in Table 1. The addition of N did not significantly effect the sugar content, recoverable sugar per ton of sugarbeet, Na, K, and impurity index. An increase in root yield and recoverable sugar per acre from N fertilization occurred. There were no significant differences in root yield and recoverable sugar per acre caused by the different application treatments. This was different from the results in 1985. In 1985 the later applications of N decreased the sugar and quality of the sugarbeet. The amino N content was significantly affected by the treatments applied. These differences do not follow any logical pattern as far as an explanation.

Table 1. Root yield, sugar content, recoverable sugar, sugar per ton sugarbeet, and impurities for N timing study, NWES, 1986.

Application Date				Root		Recoverable		Impurities			
5/5	6/4	6/26	7/18	Yield	Sugar	Sugar	Sugar/Ton	Na	K	Amino N	Index
--------#N/A---------				Ton/A	%	#/A	lb/Ton	------ppm-------			
0	0	0	0	14.2	17.5	4541	320	248	2105	393	565
20	20	20	20	17.5	17.7	5643	324	288	1960	428	564
40	40	0	0	18.1	17.6	5775	320	240	2033	513	615
40	0	40	0	16.7	18.0	5512	330	233	2108	400	550
40	0	0	40	17.9	17.8	5845	324	238	2200	423	583
0	40	40	0	16.7	17.4	5325	316	245	2248	393	589
0	40	0	40	16.9	17.0	5213	308	290	2093	453	622
0	0	40	40	16.3	17.4	5194	315	270	2195	463	632
80	0	0	0	18.9	17.0	5767	304	275	2260	573	708
0	80	0	0	18.1	17.7	5863	326	245	2058	358	532
0	0	80	0	16.8	17.1	5249	312	295	2108	400	590
0	0	0	80	17.6	17.0	5468	309	283	2073	423	602
Statistical Analyses											
Treatment				NS	NS	NS	NS	NS	NS	**	NS
Check vs Rest				*	NS	++	NS	NS	NS	+	NS
CV %				17.5	3.5	17.9	4.6	22.7	8.0	15.1	13.0

**, *, ++, +, and NS are 0.01, 0.05, 0.10, 0.20, and not significant significance levels, respectively.

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FOLIAR NITROGEN APPLICATION ON SUGARBEET-TIMING AND RATE

J.A. Lamb and J.T. Moraghan

OBJECTIVE: Determine effects of foliar N application on sugarbeet yield and quality after early yellowing under optimum fertilizer rates and under inadequate N conditions.

MATERIALS AND METHODS: A cooperative study was established at the Northwest Experiment Station, Crookston, MN with the foliar and preplant soil treatments listed in Table 1.

Table 1. Treatments for foliar N trial, NWES 1986.

Treatment	Soil Preplant # N/A	Foliar 6/30	Foliar 7/15	Foliar 7/30	Total
		--------#N/A--------			
1	0	0	0	0	0
2	0	0	0	20	20
3	0	0	20	20	40
4	0	20	20	20	60
5	100	0	0	0	0
6	100	0	0	20	20
7	100	0	20	20	40
8	100	20	20	20	60

The soil NO_3^--N (0-2') was 41#/A. Six replications were planted to ACH 164 in a randomized complete block design May 22. The plots were overplanted and thinned back to 125 plants per 100 feet of row. The soil treatments were applied and incorporated October 25, 1985 as urea. The foliar treatments were urea ammonium nitrate (UAN 28%) solution applied at 20# N/A increments on June 28, July 15, and July 30. Petiole and blade samples were taken July 10, July 28, and August 20 for N determination. Roots and tops were hand harvested September 25 with quality determined by American Crystal Tare Lab and N determined at Dr. J.T. Moraghan's laboratory at NDSU.

RESULTS AND DISCUSSION: Yields: Root yields were increased with the application of foliar N (Table 2.). The 20# N/A foliar treatment caused the yield increase with addition amounts not increasing root yield further. The 100# N/A soil N treatment had the greater yields than the 0# N/A treatments. The 20# N/A foliar application increased yields by 2 tons/A at the 0# N/A soil treatment where the 20# N/A foliar at the 100# N/A soil treatment only increased yields 0.7 tons/A.

The sugar content was increased by foliar N at the 0# N/A soil applied level and decreased by foliar N at the 100# N/A soil. This is because the foliar treatment has added too much N to the plant at the 100# N/A level and thus decreasing sugar content. The 0# N/A level is deficient in N and was able to utilize the additional N supplied.

Recoverable sugar per acre was increased with the addition of as little as 20# N/A foliar August 1. Additional N application either to the soil or as a foliar spray did not further increase recoverable sugar per acre. With the current payment program the foliar treatments at the soil N of 100#/A would decrease payments because of the negative effect on sugar per ton of sugarbeets. This negative effect did not occur with the foliar N treatments at the soil N of 0#/A.

Top yields were increased with increasing amounts of nitrogen both foliar and soil applied. The amount of N for maximum top yield does not correlate to the maximum recoverable sugar per acre. This response for top growth is similar to results of other studies.

Impurities: The impurities are reported in Table 3. All three factors measured for impurities were effected by N fertilization. Sodium (Na) and Amino N contents increased with the addition of N both foliar and in the soil preplant. The K content was decreased with increasing soil and foliar N. The overall effect of N on impurities as reflected by the index value, is generally greater with the addition of both foliar and soil N.

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Table 2. Sugarbeet root and top yield, sugar content, recoverable sugar per acre, and recoverable sugar per ton sugarbeet, foliar study, NWES, 1986.

Soil N #/A	Foliar N #/A	Yield Ton/A	Sugar %	Recoverable Sugar #/A	Recoverable Sugar/Ton #/Ton	Top Yield #/A
0	0	12.1	19.0	4297	356	2210
0	20	14.1	19.3	5066	360	3407
0	40	14.3	19.4	5148	359	3527
0	60	13.4	19.3	4811	360	3504
100	0	13.8	19.2	4908	356	3765
100	20	14.5	18.5	4929	340	4230
100	40	14.0	18.7	4770	341	4067
100	60	14.5	18.6	4918	338	4700
	Foliar N #/A					
	0	12.9	19.1	4603	356	2988
	20	14.3	18.9	4997	350	3819
	40	14.2	19.0	4957	350	3797
	60	14.0	18.9	4865	349	4102
	Soil N #/A					
	0	13.5	19.2	4830	359	3162
	100	14.2	18.7	4881	344	4190
Statistical Analyses						
Soil N		*	**	NS	**	**
Foliar N		**	NS	*	NS	**
Soil x Foliar N		++	*	**	*	NS
CV %		7.1	2.3	7.1	2.9	12.6

**, *, ++, and NS are 0.01, 0.05, 0.10, and not significant, significance levels, respectively.

Petiole N: At the first two sampling dates, July 10 and 28, the petiole N level was not significantly effected by the foliar appications (Table 4). Petiole N was greater under the 100# N/A applied to the soil as compared to the 0# N/A. At the August 20 sampling date both soil applied and foliar N treatments increased petiole N. The increasing amount of foliar applied N increased petiole N accordingly.

Table 3. Sugarbeet root impurities, foliar study, NWES, 1986.

Soil N #/A	Foliar N #/A	Impurities Na	K	Amino N	Index
		ppm			
0	0	192	2218	218	436
0	20	205	2223	245	446
0	40	237	2262	288	477
0	60	198	2085	260	435
100	0	218	2055	375	493
100	20	275	2072	430	553
100	40	297	2100	476	580
100	60	293	2052	503	590
	Foliar N #/A				
	0	205	2137	297	465
	20	240	2148	338	500
	40	266	2181	383	529
	60	246	2068	382	513
	Soil N #/A				
	0	208	2197	253	449
	100	271	2070	446	554
Statistical Analyses					
Soil N		**	**	**	**
Foliar N		*	++	**	**
Soil x Foliar N		NS	NS	++	++
CV %		21.5	4.6	11.4	8.2

**, *, ++, and NS are 0.01, 0.05, 0.10, and not significant, significance levels, respectively.

Blade N: The blade N values for July 10 and 28, were increased by the addition of 100# N/A to the soil preplant. The foliar treatments that were applied (60# N/A at July 10 sampling and 40 and 60# N/A at the July 28 sampling) increased blade N content. The August 20 sampling results indicate the blade N contents are affected differently, depending on the soil N level. At the 100# N/A soil level, the 40 and 60 # N/A foliar treatments had greater blade N contents. The 20# N/A foliar did not have an increased blade N content. The blade N content for the 0# N/A, increased with a foliar application but the increase was the same for all foliar levels.

Conclusion:

1) From this data it can be noted that in most cases the N content of the blade will indicate the addition of foliar N fertilizer. The petiole N was not as reliable.

2) The addition of N did effect the impurity level, increasing impurities with increasing N (soil or foliar).

3) For 1986, 20 #N/A applied foliar July 30 or 40# N/A foliar applied as 20# N/A July 15 and July 30, at the 0# N/A soil level and the 0# N/A foliar at the 100 # N/A soil level, would have given the highest return per acre. Remember this is a conclusion from one location and one year's data. This could possibly be different next year.

Table 4. Influence of soil and foliar N application on % N in petioles and blades of sugarbeets, NWES, 1986.

Soil N #/A	Foliar N #/A	Petiole N 7/10	Petiole N 7/28	Petiole N 8/20	Blade N 7/10	Blade N 7/28	Blade N 8/20
		% N					
0	0	2.36	0.92	0.68	4.59	3.27	2.65
0	20	2.41	0.97	0.83	4.66	3.31	3.37
0	40	2.18	1.00	0.80	4.55	3.52	3.22
0	60	2.35	1.09	0.83	4.81	3.57	3.49
100	0	3.24	1.54	0.96	4.96	4.28	3.65
100	20	3.09	1.64	1.03	5.05	4.12	3.51
100	40	3.18	1.75	1.13	4.95	4.47	3.93
100	60	3.31	1.76	1.17	5.08	4.35	3.90
	Foliar N #/A						
	0	2.80	1.23	0.82	4.78	3.78	3.15
	20	2.75	1.31	0.93	4.86	3.72	3.44
	40	2.68	1.38	0.97	4.75	4.00	3.58
	60	2.83	1.43	1.00	4.95	3.96	3.70
	Soil N #/A						
	0	2.33	1.00	0.79	4.65	3.42	3.18
	100	3.21	1.67	1.07	5.01	4.31	3.75
Statistical Analyses							
Soil N		**	**	**	**	**	**
Foliar N		NS	NS	**	**	**	**
Soil * Foliar N		NS	NS	NS	NS	NS	*

**, *, and NS are 0.01, 0.05, and not significant, significance levels, respectively.

HIGH PHOSPHORUS AND POTASSIUM RATES ON CONTINUOUS SPRING WHEAT

J.A. Lamb and R.K. Severson

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

EXPERIMENTAL PROCEDURE: Ten treatments consisting of P and K combinations and applications made to date are shown in Table 1. Treatments applied in the fall of 1985 were broadcast and plowed down. Nitrogen, as urea, was fall applied at 100 lb N/ac and incorporated with a field cultivator on October 29, 1985. Marshall wheat was planted on April 25, 1986 and harvested for grain yields on August 14, 1986. Whole plant samples were taken at soft dough August 7, 1986 for elemental analyses and used to determine forage yields, P, and K uptakes. Soil samples were taken after crop removal to measure the residual effects of the treatments. The plant samples are in the process of being analyzed at the time of this report so will not be reported.

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

Treatment No.	Application Date: Spring 1980 Fall 1985	Fall 1980	Fall 1981	Fall 1982	Fall 1983	Fall 1984
	P_2O_5 (lb/ac) + K_2O (lb/ac)					
1	0 + 0	0 + 0	0 + 0	0 + 0	0 + 0	0 + 0
2	0 + 100	0 + 100	0 + 100	0 + 100	0 + 100	0 + 100
3	50 + 100	50 + 100	50 + 100	50 + 100	50 + 100	50 + 100
4	100 + 100	100 + 100	100 + 100	100 + 100	100 + 100	100 + 100
5	150 + 100	0 + 100	0 + 100	150 + 100	0 + 100	0 + 100
6	100 + 0	100 + 0	100 + 0	100 + 0	100 + 0	100 + 0
7	100 + 50	100 + 50	100 + 50	100 + 50	100 + 50	100 + 50
8	100 + 150	100 + 0	100 + 0	100 + 150	100 + 0	100 + 0
9	150 + 100	0 + 0	0 + 0	0 + 0	0 + 0	0 + 0
10	100 + 150	0 + 0	0 + 0	0 + 0	0 + 0	0 + 0

RESULTS AND DISCUSSION: Table 2 reports the grain yield, test weight, and protein. The significant differences in yield can be attributed to phosphorus fertilizer. There were no yield differences between the different phosphorus treatments. The phosphorus treatments generally had high test weights and lower protein content. The lower protein content reflected the larger grain yields for these treatments.

Table 3 lists the soil test data for 1985 and 1986. The addition of phosphorus for treatments 3-10 in the fall 1985 is generally reflected in the increases of soil test P. Treatment 1 and 2 have maintained the same very low P level since the beginning of this study. The soil exchangeable K is larger for the treatments (2, 3, 4, 5, 7, 8, 9, and 10) that have received K fertilizer in 1986.

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Table 2. Grain yield, test weight, and protein for 1986.

Treatment	Grain Yield	Grain Test Weight	Grain Protein
	bu/A	#/bu	%
1	27.1	56.6	14.9
2	30.6	58.0	14.7
3	36.0	59.2	12.8
4	35.6	60.1	13.0
5	36.7	58.8	13.9
6	35.5	59.0	13.5
7	37.1	60.2	13.2
8	37.4	59.3	12.9
9	37.0	57.9	13.2
10	38.4	58.8	13.7
Statistical Analyses			
Treatment	**	*	**
C.V.	10.9	2.3	5.1
LSD .05	5.6	1.9	1.0

Table 3. Soil test 0-6" pH, $NaHCO_3$-P, and exchangeable K for 1985 and 1986.

Treatment	pH		$NaHCO_3$ P		Exchangeable K	
	1985	1986	1985	1986	1985	1986
			ppm			
1	8.3	8.4	3	3	135	142
2	8.3	8.3	4	3	180	194
3	8.3	8.3	12	13	168	181
4	8.2	8.4	20	27	176	185
5	8.3	8.3	8.5	18	181	191
6	8.3	8.5	22	25	130	137
7	8.4	8.3	21	28	145	154
8	8.1	8.3	21	28	153	169
9	8.3	8.3	6.5	13	136	146
10	8.3	8.4	4	10	129	155
Statistical Analyses						
TRT	+	*	**	**	**	**
C.V.	1.4	1.0	16.6	19.3	9.5	7.9
LSD .05	0.16	0.12	3.0	4.8	21	18.9

INTENSIVE FERTILIZER MANAGEMENT ON SPRING WHEAT

J.A. Lamb and R.K. Severson

In the past five years a large amount of information on the intensive management of inputs on small grains has been reported from Europe and the eastern United States. These practices emphasize the use of several different fertilization practices such as high yield goals, starter, and foliar application of N. These practices have proven to be effective in increasing yields and protein content in these areas. Little data exists for the effectiveness of these practices on spring wheat grown in the soil and atmospheric environments similar to those found in northwestern Minnesota and eastern North Dakota. With this in mind, in 1985 a study was started at the Northwest Experiment Station to evaluate: 1) if these intensive fertilization practices will increase spring wheat grain yield and quality, 2) if there was an increase in yield and quality, what practice or combination of practices were effective, and 3) what effect does the use of intensive fertilization practices have on the residual soil fertility.

This study has been conducted in 1985 and 1986 and will be concluded after the 1987 cropping season. The treatments involved are: 1) preplant fertility for two yield goals (60 and 110 bushels/A), 2) starter fertilizer (0 or 100 #/A 18-46-0 in 1985 and 180 #/A 10-34-0 in 1986), 3) foliar N applied at flag leaf (0, and 15 # N/A as Urea disolved in water), and 4) two applications of fungicide (0, or 2 #/A M-45).

In the two years we have conducted this study, we have had two different weather and growing conditions. In 1985 the potential for high yields was present. The growing season had adequate moisture and temperatures, low disease pressure, early planting date (May 2, 1985) and a long grain fill period. The growing season in 1986 did not have as great yield potential because of early wet weather, dry weather in July, and disease pressure caused by leaf rust, scab, and leaf disease. The 1986 planting date was May 5. Marshall wheat was used both years because of its short stature which reduces lodging, and the large number of acres it occupies in the spring wheat production areas of Minnesota and North Dakota. The soil tests for 1985 and 1986 are listed in Table 1. From the soil test information, the appropriate amounts of preplant fertilizer was applied to obtain the 60 and 110 bu/A yield goals (Table 2).

In both years grain yield and protein were increased with increased preplant fertility (Table 3). Grain yields in 1985 were increased by 8% while in 1986 the increase was not as large, 3%. The protein content was increased 1% and 0.6% in 1985 and 1986, respectively. Grain yields and protein are not directly related. The wheat will use N for increasing grain yield first before translocation into the grain to increase protein content. Because of the larger grain yields in 1985 when compared to 1986, the protein content was less on the average in 1985 when compared to 1986. The additional fertilization from 60 bu/A to 110 bu/A yield goal also cause a larger increase in protein content in 1985.

In 1985, the addition of 15 # N/A as a foliar spray at flag leaf stage increased the grain yield at the 60 bu/A yield goal (Table 4). This did not occur at the 110 bushel yield goal in 1985, nor at either yield goal in 1986. Normally, you would not expect grain yield increase from foliar spray at flag leaf because most of the N for plant growth has been taken up by the plant at that stage of growth. The longer grain fill period of 1985 may explain why this occurred. The protein levels were not effected by foliar N application in either year.

Table 5 lists the effects of fungicide and yield goal on grain yield and protein in 1985 and 1986. This data suggests that when the nutrient status is at optimum or above optimum, the application of fungicide to decrease the loss of grain yield from disease is advantageous. If the nutrient status is below optimum, there is no benefit from fungicide application. Other studies have shown that increased soil fertility status, particularly N, increased the plant growth and increased the incidence of disease. The 110 bu/A yield goal in both years have had larger grain yields when fungicide has been applied than where no fungicide has been applied. The 60 yield goal has not shown this response.

The use of starter fertilizer did not influence grain yield or protein content in either year.

How is the residual soil nutrient status influenced by the increased addition of fertilizer? Table 1 indicates an increase in soil test NO_3^--N and P from fertilizer applied to meet a 110 bu/A yield

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goal. Even with the resultant increased grain yield, the crop did not use all of the nutrients supplied. The NO_3^--N content in the 0-24" depth was 100 # NO_3^--N/A greater in the 110 bu/A yield goal plots when compared to the 60 bu/A yield goal in the spring, 1986 soil test. The NO_3^--N content was decreased in the 60 bu/A yield goal plot but increase in the 110 bu/A yield goal when compared to the 1985 soil test. The phosphorus content was increased for both yield goals when compared to the original soil test in spring, 1985. The 110 bu/A yield goal fertilization increased the soil test P more than the 60 bu/A yield goal. The potassium soil test was not effected significantly. These increased soil test levels indicate there are some consequences to a producer's soil fertility management from using high fertilizer inputs. If a producer is raising sugarbeets or malting barley in rotation with spring wheat, with additional N could hurt the quality of the crop. This makes the need for a soil test more important than ever.

In summary, the following conclusions can be drawn in the first two years of this study:

1. Increasing preplant N fertilization will increase grain yield and protein.
2. Setting a realistic yield goal is important.
3. Addition of starter fertilizer did not effect yield or quality.
4. If an N deficient situation exists, the addition of N by foliar spray at flag leaf stage can increase yield.
5. If you are at optimum or above soil fertility, the use of a fungicide may be necessary.
6. Excess fertilizer use will increase the soil test values and may influence the future management of soil fertility.

Table 1. Spring soil tests for intensive management study, Northwest Experiment Station, 1985 and 1986.

	Spring, 1985 Yield Goal	Spring, 1986 Yield Goal	
	All Plots	60	110
OM %	3.1	2.7	2.7
NO_3^--N (0-24")	96	40	143
P (0-6")	8	22	30
K (0-6")	320	270	325
pH (0-6")	8.2	8.2	8.2
Salts (0-6")	0.3	0.3	0.3

Table 2. The quantity of preplant fertilizer applied for intensive management study, Northwest Experiment Station, 1985 and 1986.

	1985 Yield Goal		1986 Yield Goal	
	60	110	60	110
	---lbs/A--		---lbs/A--	
N	25	150	80	102
P_2O_5	70	100	30	30
K_2O	0	50	30	50

Table 3. The effect of yield goal (preplant fertilization) on grain yield, protein, and test weight.

Yield Goal bu/A	Yield bu/A 1985	Yield bu/A 1986	Protein % 1985	Protein % 1986	Test Weight #/bu 1985	Test Weight #/bu 1986
60	77.2	66.5	12.8	15.2	58.9	59.8
110	83.4	68.8	13.7	15.8	56.8	59.4

Table 4. Effect of foliar N and yield goal on grain yields and protein in 1985 and 1986.

	Yield bu/A				Protein %			
	1985		1986		1985		1986	
	foliar #/A							
Yield Goal bu/A	0	15	0	15	0	15	0	15
60	74.8	79.9	66.3	66.7	12.8	12.7	15.2	15.2
110	84.4	82.6	69.4	68.3	13.6	13.8	15.7	15.8

Table 5. The effect of fungicide and yield goal on grain yield and protein in 1985 and 1986.

	Yield bu/A				Protein %			
	1985		1986		1985		1986	
	fungicide #/A							
Yield Goal bu/A	0	2	0	2	0	2	0	2
60	78.4	76.0	67.7	65.3	12.9	12.7	15.3	15.1
110	80.6	86.3	66.0	71.6	13.7	13.8	15.7	15.8

MICRONUTRIENTS ON SPRING WHEAT

J.A. Lamb, R.K. Severson and E. Bernhardson

OBJECTIVE: Update existing secondary and micronutrient response data for spring wheat.

MATERIALS AND METHODS: This study utilized a missing element design involving iron, copper, sulfur, zinc, and manganese. Chloride was also added as a separate treatment to evaluate the possibilities of a Cl response in the Red River Valley. These treatments were replicated four times in a randomized complete block design. Table 1 reports the soil test for the Clay County location. The treatments were applied and the study planted to Marshall wheat May 16, 1986. The grain was harvested August 21, 1986 with a plot combine.

RESULTS AND DISCUSSION: The grain yield data in Table 1 indicates no response occurred in this study. As the soil test in Table 1 indicates, the soil nutrient status was high in many of the nutrients used. Wheat traditionally does not respond in grain yield to the addition of micronutrients and did not in this study. The addition of fertilizer (N) decreased the test wieght and the exclusion of any micronutrient did not influence the test weight.

Table 1. Soil test for micronutrient study, Clay County, 1986.

Soil Test	Sample Depth	Value
OM	0-6"	6.0%
NO_3^--N	0-24"	55 #/A
$NaHCO_3$-P	0-6"	29 #/A
K	0-6"	490 #/A
Zn	0-6"	1.4 ppm
SO_4^--S	0-6"	50 ppm
pH	0-6"	8.0
Salts	0-6"	0.7 mmhos
Cl	0-24"	109 #/A

Table 2. Grain yield and test weight for the micronutrient study, Clay County, 1986.

Treatments	Grain Yield	Grain Test Weight
	bu/A	#/bu
Check	36.4	57.6
Minnesota Recommendation (MR)	38.6	55.2
MR + 48 Cl as KCl	41.6	55.8
MR + 48 Cl as $CaCl_2$	41.0	56.4
MR + All	38.3	54.7
MR + All - Iron	40.4	54.6
MR + All - Copper	40.0	54.8
MR + All - Sulfur	39.7	54.7
MR + All - Zinc	38.6	55.2
MR + All - Manganese	35.9	52.4
Statistical Analyses		
Treatment	NS	**
CV%	9.6	1.8
LSD (.05)	-	2.3

All = 20 #/A Mn as $MnSO_4$
10 #/A Zn as $ZnSO_4$
10 #/A Cu as $CuSO_4$
10 #/A Fe as $FeSO_4$
20 #/A S as S

MR = 65 # N/A as Urea
0 # P_2O_5
0 # K_2O

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YIELD AND ROOT ROT RESPONSES OF SPRING WHEAT TO CHLORIDE FERTILIZATION

J.A. Lamb, C.E. Windels and R.K. Severson

OBJECTIVE: The purpose of this study was to determine if spring wheat grown in the Red River Valley responded to chloride fertilization in grain yield and/or incidence of common root rot caused by *Cochliobolus sativus*.

METHODS AND MATERIALS: In 1986, a field study located in Polk County Minnesota was conducted using five rates of chloride (0, 12, 24, 36 and 48 # Cl/A) and two sources ($CaCl_2$ and KCl). The factorial combination of these treatments were arranged in a randomized complete block design with four replications. The plots were fertilized according to soil test for all nutrients but chloride. The chloride soil test was 71 #/A (0-2'). Other soil test information is included in Table 1. The treatments were broadcast-applied April 10, 1986 and incorporated. Marshall wheat was planted. Plant populations were determined before tillering occurred. Whole plant samples were taken at the soft dough stage for ICP analysis. The grain was harvested by plot combine on August 21, 1986. Because previous reports from North Dakota, South Dakota, and Oregon demonstrate that chloride reduces common root rot in small grains, root disease evaluations were made on August 12 (50 plants per plot). Subcrown internodes were rated on a scale from 0 to 3; 0=clean, 1=1-25% discoloration, 2=26-50% discoloration, and 3=51-100% discoloration. Disease intensity (DI) was calculated using the McKinney's "infection index".

$$DI = \frac{\Sigma(\text{Category value x no. plants in category})}{\text{Total no. plants x maximum category value}} \times 100$$

RESULTS AND DISCUSSION: Table 2 contains the currently available data for 1986. Grain yields were increased by the application of chloride. The maximum grain yield occurred with the 24 # Cl/A rate. This increase was not a K response because there were no differences in the grain yields between the fertilizer sources (KCl vs $CaCl_2$). Also, the K soil test was extremely high (730 #/A). The chloride soil test was 71 #/A (which is higher than the 60 # Cl/A soil test value that South Dakota research suggests as nonresponsive) which suggests that a reduction in root disease may have been responsible for the yield increase. The test weight was also increased with use of Cl. The disease index results are reported as a root rot index (0-100 scale); in which the larger the value the greater the severity of root rot. There was a trend where greater yields correspond with the lower root rot indexes, but this was not a strong relationship.

ACKNOWLEDGEMENT: The authors thank Allan Dragseth for providing land and John Lee, Minnesota Valley Testing Lab for soil chloride analysis.

Table 1. Soil test information for Chloride experiment, Dragseth location, 1986.

Soil Parameter	Depth inches	Unit	Value
OM	0-6	%	4.4
NO_3--N	0-24	#/A	138
$NaHCO_3P$	0-6	#/A	49
K	0-6	#/A	730
pH	0-6		8.0
Salts	0-6	mmhos	0.7
Cl	0-24	#/A	71

Please refer to title page of this publication for information regarding application and use of this article.

SURVEY OF SOIL CHLORIDE STATUS IN THE RED RIVER VALLEY

J. Lamb, C. Holen, B. Holder, C. Nygaard, J. Arneson, and E. Bernhardson

OBJECTIVE: Determine the soil chloride status in the Red River Valley.

METHODS AND MATERIALS: In August, 1986 soil samples were taken from three counties in the Red River Valley (Clay, West Polk, and Kittson). The locations were chosen from the following criteria: 1) Include three soil series in common with each county (Wheatville, Donaldson, and Fargo) and one other soil series which was predominate in that county, and 2) the locations had no history of manure application or fertilization with KCl. The soil samples were taken in wheat stubble to a depth of 24" with increments of 0-6", 6-12", and 12-24".

RESULTS AND DISCUSSION: Table 1 lists the location, soil series, and chloride values for 1986. There was a large range in numbers. There is no relationship between chloride content and soils series. The extremely high value in Kittson County is caused from the high salt content of the soil at that location. South Dakota State research indicates that a soil with a chloride content of greater than 60 #/A (0-24") will not produce a yield response. Seven of the twelve sites were greater than that value.

ACKNOWLEDGEMENT: The authors would like to thank John Lee, Minnesota Valley Testing Lab for doing the chloride analyses.

Table 1. Chloride values for 1986 survey.

		Chloride #/A			
County	Soil Series	0-6"	6-12"	12-24"	0-24"
Kittson	Fargo	99	146	464	709
	Northcote	27	14	11	52
	Donaldson	33	23	18	74
	Wheatville	27	11	33	71
West Polk	Fargo	50	38	26	114
	Bearden	22	9	13	44
	Donaldson	82	70	79	231
	Wheatville	17	13	20	50
Clay	Fargo	16	9	16	41
	Bearden	20	30	75	125
	Donaldson	12	8	16	36
	Wheatville	21	35	74	130

Please refer to title page of this publication for information regarding application and use of this article.

RESIDUAL SOIL N, FERTILIZER N, AND INOCULATION EFFECTS ON SOYBEAN PRODUCTION IN NORTHWESTERN MINNESOTA

J.A. Lamb and R.K. Severson

OBJECTIVE: The overall objective of this study is to measure the effect of residual NO_3^--N, fertilizer N, and seed inoculation on soybean production in the Red River Valley of Minnesota.

MATERIALS AND METHODS: Three sites were located in 1986. The NO_3^--N (0-2') contents were 97, 53, and 22 #/A for the St. Hilaire, Marshall County, and Norman County, respectively. The N fertilizer (Urea) treatments (0, 30, 60, 90, and 120 # N/A) and inoculation treatment (none and inoculated) were applied and the plots planted to McCall soybean May 23, 26 and 28 for St. Hilaire, Marshall County, and Norman County sites, respectively. The most recently matured trifoliate leaves were sampled at 50% bloom July 21 and 22 for nitrogen analysis. The plots were harvested by combine September 23 at the St. Hilaire and Marshall County locations and October 3 at Norman County.

RESULTS AND DISCUSSION: Table 1 and 2 list the statistical analyses, grain yield, and trifoliate N contents for 1986. At the St. Hilaire location the soil test NO_3^--N content was 97 #/A (0-2'). The grain yield was not affected by inoculation or N fertilization. The trifoliate N content was increased by addition of N fertilizer but not by inoculation. At Marshall County N fertilizer increased grain yield 3.5 bu/A with 120 # N/A. The use of inoculant increased grain yields 1.1 bu/A. The trifoliate N contents were increased by N fertilization but not by inoculant. The Norman County site soybean yields were not affected by the treatments. This was not expected since the NO_3^--N soil test was low at 22 #/A (0-2'). The trifoliate N contents at the Norman County site were increased with increasing N fertilization. Except at the 120 # N/A rate the inoculated treatments had greater trifoliate N contents than the uninoculated treatments.

Since none of the locations had a soybean cropping history the chance of forming nodules on soybean plant in the noninoculated treatments were low. The observation for 1986 was if inoculant was applied propertly, the soybean plant would form nodules. If the soybean was not inoculated, nodules did not form.

Table 1. Grain yields (bu/A) and statistical analyses for 1986.

N Rate	St. Hilaire			Marshall County			Norman County		
#/A	0	I	$\bar{X}$	0	I	$\bar{X}$	0	I	$\bar{X}$
0	43.1	42.7	42.9	35.4	37.0	36.2	32.9	32.4	32.6
30	44.5	42.6	43.6	37.0	37.6	37.3	31.6	31.8	31.7
60	44.1	43.1	43.6	36.5	37.5	37.0	31.6	31.8	31.7
90	44.3	44.8	44.5	37.3	37.7	37.5	31.6	30.6	31.1
120	44.1	43.2	43.6	38.8	40.6	39.7	32.5	32.6	32.6
$\bar{X}$	44.0	43.3	43.6	37.0	38.1	37.6	32.0	31.8	31.9
Statistical Analysis									
I		NS			+			NS	
N		NS			*			NS	
Linear		NS			**			NS	
Quadratic		NS			N			+	
I * N		NS			N			NS	
C.V.%		6.0			5.0			5.7	

**, *, and + are 0.01, 0.05, and 0.20 significance levels, respectively.

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Table 2. Trifoliate N contents (%N) and statistical analyses for 1986.

N Rate	St. Hilaire			Marshall County			Norman County		
#/A	0	I	X	0	I	X	0	I	X
0	5.94	5.87	5.90	5.87	5.54	5.68	4.64	4.38	4.53
30	5.99	5.91	5.95	5.85	5.76	5.80	4.56	4.65	4.60
60	6.00	6.03	6.01	6.04	5.94	5.99	5.29	4.97	5.11
90	6.15	5.97	6.06	6.00	6.04	6.02	5.52	5.56	5.54
120	6.02	6.03	6.02	6.09	5.99	6.04	5.72	5.65	5.67
X	6.02	5.96	5.99	5.97	5.85	5.91	5.07	5.08	5.07
Statistical Analysis									
I		NS			NS			++	
N		+			*			**	
Linear		*			**			**	
Quadratic		NS			NS			NS	
I * N		NS			NS			NS	
C.V.%		2.3			3.8			4.7	

**, *, and + are 0.01, 0.05, and 0.20 significance levels, respectively.

USE OF ACID BASED FERTILIZERS FOR MORE EFFECIENT SOYBEAN PRODUCTION IN NORTHWESTERN MINNESOTA

J.A. Lamb, R.K. Severson, and G.W. Rehm

OBJECTIVES: The primary objective of this study is to evaluate low pH fertilizers as carriers for micronutrients for soybean production in northwestern Minnesota. Particular objectives include 1) determine if low pH fertilizer increases the uptake of Zn and Fe in soybeans grown on calcareous soils, 2) determine the effect on soybean nodulation by the addition of micronutrients in different fertilizer carriers, and 3) determine effect of acid fertilizer on soybean yields.

MATERIALS AND METHODS: This study was located at two sites; Norman County - Johnson site, and Marshall County - Anderson site. The soil test information is reported in Table 1. McCall soybeans were planted on May 26, 1986, and June 2, 1986 at the Marshall County and Norman County sites, respectively. The fertilizer treatments listed in Table 2 were applied as a starter placement 2" x 2" from the row. The treatments were in a randomized complete design with four replications. Small whole plants and population counts were taken three weeks after emergence. The Marshall County and Norman County plots were harvested September 23, 1986 and October 3, 1986, respectively.

RESULTS AND DISCUSSION: Norman County Location: Table 3 lists the results for the Norman County site. A small yield increase was detected when comparing the untreated check with the fertilizer treatments. This was probably a P response. The only fertilized treatment effect was a reduction in yield with the acid + Fe and nonacid + Fe treatments.

An increase in P concentration and uptake occurred from fertilizer addition. The acid treatments did have a higher P uptake than the nonacid. This effect did not increase yields.

Overall the addition of fertilizer did not effect Zn and Fe concentrations or uptake when compared to the untreated check. There were some differences between fertilizer treatments. The acid fertilizers did have higher Zn and Fe concentrations and uptakes than the nonacid.

This location had a marginal Zn soil test and although it was the most likely candidate for a grain yield response to Zn, no response occurred.

Marshall County Location: Table 4 lists the results for the Marshall County site. The yield for the acid fertilizer treatments was slightly higher than the nonacid treatments but the treated plots were not significantly better than the check.

The application of fertilizer significantly increased the concentrations and uptakes of P and Zn. The acid + Zn and acid + Fe + Zn treatments had greater Zn concentrations and uptakes than the corresponding nonacid treatments.

The acid fertilizer treatment had a lower plant population than the nonacid. This may have been caused by the fertilizer placement (2 x 2 starter). The reduction in population did not have a strong correlation with yield (r=.38).

Although there was grain yield difference between fertilizer treatments there was no increase of yield over the untreated check thus indicating the use of fertilizer for P, Zn, and Fe would not be an economical input for soybean production.

ACKNOWLEDGEMENTS:

We would like to thank Lynn Johnson and Dwight Anderson for allowing us to conduct these studies on their land and also thank Ray Thompson and Ken Pazdernik for their help in locating these sites.

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Table 1. Soil test information for soybean fertilizer carrier study, 1986.

	Depth	Norman County	Marshall County
OM%	0-6"	4.0	4.7
NO_3^--N #/A	0-24"	22	53
$NaHCO_3$ P #/A	0-6"	12	38
K #/A	0-6"	510	280
pH	0-6"	8.0	7.7
Salts mmhos	0-6"	0.5	0.4
Zn ppm	0-6"	1.0	1.6
Fe ppm	0-6"	14.3	32.4

Table 2. Treatments for soybean fertilizer carrier study, 1986.

Carrier	Micronutrient
1. Acid fertilzier (4-21-0-4)	-
2.	1 # zn
3.	1 # Fe
4.	Zn + Fe
5. 10-34-0 + 12-0-0-26 (8-21-0-4)	-
6.	1 # Zn
7.	1 # Fe
8.	Zn + Fe
9. Check no fertilizer	

Table 3. Treatment means and statistical analyses for yield, small plant P, Zn, and Fe concentrations and uptakes and population for Norman County location.

	Yield bu/A	P ppm	P Uptake #/A	Zn ppm	Zn Uptake #/A	Fe ppm	Fe Uptake #/A	Population plants/A
Acid	31.2	3781	20.9	23.6	.13	618	3.50	101,277
Acid + Zn	33.1	4006	20.9	29.5	.15	562	2.96	103,455
Acid + Fe	29.6	3459	17.8	26.3	.13	823	4.00	102,366
Acid + Zn + Fe	30.6	3402	17.6	26.6	.14	539	2.75	100,188
Nonacid	33.4	3457	16.5	23.6	.11	592	2.90	100,188
Nonacid + Zn	31.6	3538	17.0	25.5	.12	601	2.87	101,277
Nonacid + Fe	29.4	3409	16.2	23.0	.11	482	2.29	95,832
Nonacid + Fe + Zn	32.3	3666	19.4	24.8	.13	527	2.88	107,811
Check	29.4	2938	14.8	25.2	.13	589	2.97	99,099
Check vs Rest	+	**	++	NS	NS	NS	NS	NS
Acid	NS	NS	++	++	*	+	*	NS
Iron	*	+	NS	NS	NS	NS	NS	NS
Zinc	NS	NS	NS	++	*	NS	NS	NS
A * I	NS	++	++	NS	NS	+	NS	NS
A * Zn	NS	NS	NS	NS	NS	++	*	NS
I * Zn	NS	NS	NS	NS	NS	NS	NS	NS
A * I * Zn	++	NS	NS	NS	NS	NS	+	NS
C.V.	6.9	10.5	18.0	13.9	15.3	26.7	24.6	9.4

**, *, ++, and + are 0.01, 0.05, 0.10, and 0.20 significance levels, respectively.

Table 4. Treatment means and statistical analyses for yield, small plant P, Zn, and Fe concentrations and uptakes, population for Marshall County location.

	Yield bu/A	P ppm	P Uptake #/A	Zn ppm	Zn Uptake #/A	Fe ppm	Fe Uptake #/A	Population plants/A
Acid	35.4	5053	64.7	18.2	.24	240	3.26	76,230
Acid + Zn	34.9	4265	69.6	39.7	.65	233	3.81	90,387
Acid + Fe	36.1	5434	83.2	24.1	.36	251	3.66	69,696
Acid + Zn + Fe	35.9	4325	72.1	37.1	.58	226	3.60	82,764
Nonacid	33.3	4701	62.1	15.2	.21	240	3.27	84,942
Nonacid + Zn	34.4	4549	68.0	23.8	.34	240	3.41	88,209
Nonacid + Fe	34.0	5098	80.1	19.6	.31	260	4.09	82,764
Nonacid + Fe + Zn	33.2	4885	73.2	27.2	.40	191	2.84	91,476
Check	34.8	3420	43.4	18.2	.22	210	2.57	84,942
Check vs Rest	NS	**	**	**	**	NS	++	NS
Acid	**	NS	NS	**	**	NS	NS	**
Iron	NS	+	++	+	+	NS	NS	NS
Zinc	NS	**	NS	**	**	+	NS	**
NS* I	NS	NS	NS	NS	NS	NS	NS	NS
A * Zn	NS	*	NS	*	*	NS	NS	NS
I * Zn	NS	NS	NS	+	+	+	+	NS
A * I * Zn	NS	NS	NS	NS	NS	NS	NS	NS
C.V.	4.8	10.8	22.2	20.0	28.9	18.7	28.4	10.4

**, *, ++, and + are 0.01, 0.05, 0.10, and 0.20 significance levels, respectively.

EVALUATION OF THE EFFICIENCY OF BAND PLACEMENT OF P FERTILIZER FOR CORN, SOYBEAN AND WHEAT

J.A. Lamb, G.W. Rehm, G.W. Randall, and W.W. Nelson

OBJECTIVES: The primary objective of this study was to evaluate the efficiency of deep band placement methods for P fertilizers over the diverse environmental conditions of Minnesota. Results obtained from these studies relate closely to the Northern Great Plains and for much of the Corn Belt. Under this broad objective are the following specific objectives:

1. Determine the efficiency of deep band application of P as compared to broadcast application on a wheat-soybean rotation in Northwestern Minnesota and a corn-soybean rotation in Southern and Western Minnesota.

2. Determine the effect of distance from the row of a deep band in row crops and the distance between of bands in solid seeded crops on both P uptake by crops and subsequent yield.

3. Determine the effect of soil test P level on the efficiency of deep bands.

4. Determine residual effects of deep band and broadcast placement of fertilizer P on P uptake and crop yield.

MATERIALS AND METHODS: This study was conducted at three locations; Waseca, Lamberton, and Crookston, MN in 1986. Corn and soybean were grown at Waseca and Lamberton and spring wheat and soybean grown at Crookston. Table 1 presents the soil test information for each location. The following variables were measured on corn at Waseca and Lamberton; grain yield, forage yield, forage P concentration and uptake, ear leaf P concentration at silking, and grain moisture content. Soybean variables measured at all locations were; grain yield, forage yield, forage P concentration and uptake, leaf P concentration at mid-flower, and grain moisture. At Crookston the parameters measured on the wheat were grain yield, grain protein content, bushel weight, grain moisture content, forage yield, and whole plant P concentration and uptake at anthesis. Only part of the P analyses, Lamberton corn ear leaf and soybean leaf, are available from the laboratory at the time of this report. The grain moisture has been incorporated into the grain yield data. The corn, soybean, and wheat grain yields have been corrected to 15.5, 13.5, and 13.5% moistures, respectively.

Table 1. Soil test values for P-efficiency study, 1986.

	Crookston*		Waseca**		Lamberton**	
	Wheat	Soybean	Corn	Soybean	Corn	Soybean
pH	7.8	7.9	5.9	5.9	6.2	6.1
OM%	3.0	2.4	3.5	3.5	3.8	3.9
Salts mmho	0.2	0.4	-	-	-	-
NO_3^--N 0-24"	8	10	-	-	-	-
P #/A	10	9	10	10	3	7
K #/A	230	240	331	382	259	290

* $NaHCO_3$-P
** Bray-P

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Table 2 lists the treatments that were established on all six sites. Four replications of a complete factorial arrangement of three methods of phosphorus placement and five phosphorus rates were established. The broadcast method was incorporated at all locations. The knife method at Waseca (corn and soybean) and Lamberton (corn and soybean), placed a preplant band of fertilizer at a 6-inch depth between the 30 inch width rows. At the Crookston (spring wheat) site the knife method placed preplant fertilizer 6 inches deep with a shank spacing of 15 inches. The knife method for Crookston soybean was two 15" width preplant bands between the 30" rows applied at a 6" depth. The row method at Waseca (corn and soybean), Lamberton (corn and soybean), and Crookston (soybean) involved a band of fertilizer applied at planting 5 to 7 inches from the row and 2.5 to 3 inches deep. The Crookston (spring wheat) site row treatment involved placement of fertilizer directly with the seed. The phosphorus rates were 0, 10, 20, 30 and 40 pounds P per acre. Ammonium polyphosphate, 10-34-0, was the P source at all locations.

RESULTS AND DISCUSSION: Tables 3, 4, and 5 list the means for each treatment and each level of each factorial effect at all locations. Also included is a summary of significance probabilities for each measured observation.

Corn - Grain and forage yield at Waseca and Lamberton were increased by P fertilization. This would be expected because for the low soil test value for phosphorus. Grain yields were maximized at 30 lb P/A according to the regression. Method of application did not effect grain yields. At Waseca the forage yield was maximized at a P rate greater than 40 lb P/A. No method effect occurred for forage yield. At Lamberton there was a significant method by P rate interaction for forage yield. With all methods, forage yields increased with P fertilization. The broadcast method produced larger yields at the same P rate when compared to row and knife except at the 40 lb P/A P rate. The knife treatment had greater forage yields than the row treatments at the lower rates. At 40 lb P/A row, knife, and broadcast application methods performed similarly. With row and knife treatments the maximum forage yield occurred at 40 lb P/A. The maximum forage yield for the broadcast treatment occurred at the 30 lb P/A rate. The broadcast treatment at Lamberton was more efficient than the banded treatment for forage yield.

Ear leaf P was increased by P application at Lamberton. The broadcast method had larger concentration of P in the ear leaf than the banded methods. There were no differences in P concentration between knife and row application methods.

Soybean - Soybean grain and forage yields were increased at Waseca and Lamberton from P fertilizer. Also, soybean leaf P concentrations were increased at Lamberton. No response in grain yield occurred at Crookston, but a forage yield increase did occur from P fertilization. No method response occurred at Waseca for grain and forage yields or at Crookston for forage yield.

Lamberton had a significant method effect on grain yield, forage yield, and leaf P concentration. In all cases the broadcast treatments were larger than the banded treatments. There were no significant differences between row and knife method of application.

Wheat - The spring wheat grain yields at Crookston were significantly increased by P application. The maximum yield occurred at the 20 lb P/A rate. No method effects occurred.

Grain yields at all sites except the Crookston soybean site, responded to P application. Only the Lamberton corn and soybean sites had a method response. The broadcast application had significantly higher soybean grain yields, corn and soybean forage yields, corn ear leaf P concentrations, and soybean leaf P concentrations, than the banded applications (row and knife).

Table 2. Treatment description for P-efficiency study.

Treatment Number	Placement	P Rate # P/A
1	Broadcast	0
2	Broadcast	10
3	Broadcast	20
4	Broadcast	30
5	Broadcast	40
6	Knife *	0
7	Knife *	10
8	Knife *	20
9	Knife *	30
10	Knife *	40
11	Row +	0
12	Row +	10
13	Row +	20
14	Row +	30
15	Row +	40

* 15-inch width at wheat-soybean location
\+ 5-7 inches from row in soybean and corn - applied with seed in spring wheat.

Broadcast and knife applied:	Crookston	October 25, 1985
	Lamberton	October 20, 1985
	Waseca	October 22, 1985
Row applied:	Crookston	May 16, 1986 - Soybean
	Crookston	May 19, 1986 - Spring Wheat
	Lamberton	May 7, 1986 - Corn and Soybean
	Waseca	May 21, 1986 - Corn and Soybean

Table 3. Phosphorus rate and method means for corn grain yield, corn forage yields, soybean grain yield, and soybean forage yield at Waseca, 1986.

Method	P Rate # P/A	Corn Grain Yield Bu/A	Corn Forage Yield #/A	Soybean Yield Bu/A	Soybean Forage Yield #/A
Broadcast	0	94.3	9425	33.1	4850
	10	102.3	9895	35.8	5175
	20	110.4	10995	36.4	4915
	30	125.1	10910	37.3	5630
	40	117.3	11270	37.9	5715
Knife	0	103.5	9890	33.5	5120
	10	107.4	11015	35.9	5430
	20	120.4	10670	36.1	5115
	30	125.5	11635	36.0	5090
	40	122.4	11380	36.9	5640
Row	0	97.6	9850	32.3	4640
	10	114.2	10760	34.4	5150
	20	110.8	10660	35.6	5040
	30	112.4	11090	37.5	5925
	40	115.0	11250	37.9	5720
Broadcast		113.8	10768	36.8	5359
Knife		118.9	11175	36.2	5319
Row		113.1	10940	36.3	5459
	0	98.5	9722	32.9	4870
	10	107.9	10557	35.4	5252
	20	113.9	10775	36.0	5023
	30	121.0	11212	36.9	5548
	40	118.2	11300	37.5	5692
Statistical Analysis					
Method		0.37	0.56	0.70	0.73
Broadcast vs Knife and Row		0.56	0.38	0.41	0.85
Knife vs Row		0.20	0.54	0.89	0.45
P Rate		0.0006	0.003	0.0004	0.001
Linear		0.0001	0.0002	0.0001	0.0002
Quadratic		0.095	0.25	0.21	0.62
Method x P Rate		0.57	0.86	0.88	0.46
C.V.		11.3	9.5	6.7	9.7

Table 4. Phosphorus rate and method means for corn grain yield, corn forage yield, corn ear leaf P concentration, soybean grain yield, soybean forage yield, and soybean leaf P concentration at Lamberton, 1986.

		Corn			Soybean		
Method	P Rate # P/A	Grain Yield Bu/A	Forage Yield #/A	Ear Leaf P %	Grain Yield Bu/A	Forage Yield #/A	Leaf P %
Broadcast	0	133.0	11105	0.219	32.0	5465	0.289
	10	133.3	12615	0.236	33.6	5485	0.307
	20	143.5	13230	0.254	34.9	5835	0.360
	30	145.5	13385	0.275	35.9	6105	0.343
	40	144.5	12975	0.277	34.9	5935	0.360
Knife	0	125.3	11895	0.212	31.4	5350	0.309
	10	134.8	12280	0.218	31.5	5230	0.276
	20	145.8	11830	0.232	31.5	5390	0.311
	30	133.8	12695	0.247	32.2	5295	0.309
	40	139.5	12750	0.243	33.6	5625	0.324
Row	0	130.0	11465	0.211	31.3	5315	0.282
	10	139.3	10740	0.220	33.4	5415	0.308
	20	143.5	11970	0.231	32.6	5610	0.314
	30	129.5	11645	0.233	32.6	5540	0.316
	40	144.0	13240	0.242	34.6	5560	0.337
Broadcast		141.7	13051	0.260	34.8	5840	0.343
Knife		138.4	12389	0.235	32.6	5385	0.305
Row		139.1	11899	0.231	33.3	5531	0.319
	0	129.4	11488	0.214	31.5	5377	0.294
	10	135.8	11878	0.225	32.8	5377	0.297
	20	144.3	12343	0.239	33.5	5612	0.328
	30	136.3	12575	0.252	33.6	5647	0.323
	40	142.7	12988	0.254	34.4	5707	0.340
Statistical Analysis							
Method		0.55	0.001	0.0001	0.0006	0.04	0.005
Broadcast vs Knife and Row		0.28	0.001	0.0001	0.0002	0.01	0.002
Knife vs Row		0.84	0.10	0.55	0.19	0.40	0.21
P Rate		0.001	0.001	0.0001	0.0006	0.32	0.0007
Linear		0.002	0.0001	0.0001	0.0001	0.04	0.0001
Quadratic		0.09	0.84	0.34	0.38	0.88	0.78
Method * P Rate		0.28	0.07	0.75	0.27	0.90	0.85
C.V.		6.4	7.0	7.4	4.5	8.8	9.2

Table 5. Phosphorus rate and method means for wheat grain yield, wheat bushel weight, wheat grain protein, wheat forage yield, soybean grain yield, and soybean forage yield at Crookston, 1986.

		Wheat				Soybean	
Method	P Rate # P/A	Grain Yield Bu/A	Bushel Weight #/Bu	Grain Protein %	Forage Yield #/A	Yield Bu/A	Forage Yield #/A
Broadcast	0	43.2	59.8	14.8	7065	37.3	4755
	10	44.8	59.2	14.7	6474	35.7	4441
	20	45.7	59.2	14.8	6314	39.3	5027
	30	46.1	59.7	15.0	6400	38.6	4486
	40	44.8	59.8	14.8	6340	35.5	4367
Knife	0	42.4	60.0	15.0	6146	34.6	3845
	10	45.4	59.6	15.0	6431	37.7	4810
	20	45.6	59.4	15.1	6591	34.3	4588
	30	46.0	59.7	15.0	6980	37.3	4985
	40	42.9	58.9	14.8	6199	35.0	4747
Row	0	44.3	59.1	15.1	6291	34.1	4054
	10	43.4	58.9	14.9	6817	33.1	4337
	20	47.0	59.6	15.0	6413	36.5	4175
	30	45.4	59.7	14.9	6284	35.4	4850
	40	45.4	58.2	14.8	6931	34.5	4795
Broadcast		45.4	59.5	14.8	6382	37.3	4580
Knife		45.0	59.4	15.0	6550	36.1	4783
Row		45.3	59.1	14.9	6611	34.9	4539
	0	43.3	59.7	14.9	6501	35.3	4218
	10	44.6	59.2	14.9	6574	35.5	4529
	20	46.1	59.4	14.9	6440	36.7	4597
	30	45.8	59.7	15.0	6555	37.1	4774
	40	44.4	58.9	14.8	6490	35.0	4637
Statistical Analysis							
Method		0.92	0.69	0.29	0.49	0.28	0.59
Broadcast vs Knife and Row		0.82	0.56	0.18	0.25	0.16	0.71
Knife vs Row		0.75	0.52	0.43	0.43	0.76	0.43
P Rate		0.06	0.51	0.45	0.98	0.65	0.32
Linear		0.15	0.37	0.49	0.94	0.79	0.08
Quadratic		0.01	0.72	0.39	0.97	0.23	0.27
Method x P Rate		0.72	0.72	0.64	0.29	0.67	0.59
C.V.		5.8	2.0	1.7	9.4	11.1	14.3

THE EROSION-PRODUCTIVITY STUDY AT THE SOUTHWEST EXPERIMENT STATION, LAMBERTON, MN[1]

J.A. Staricka, M. Lindstrom, W.W. Nelson, and J.B. Swan

This experiment is part of RRF project NC-174, Soil Productivity and Erosion. The objectives of this study are "To asses the effect of erosion-modified soil physical properties on potential productivity of selected soils under rainfed conditions, with emphasis on evaluation of physically-based simulation models."

Methods and Materials: Plot for this study were located in areas of a field which have been slightly (SLT), moderately (MOD), and severely (SEV) eroded. Two tillage systems were used on the field: CONVentional (fall moldboard plow) and RIDGE-till.

The field has been planted in corn since the experiment started in 1984. Fertilizer was applied based on the soil test of each erosion treatment. The amounts of fertilizer applied are listed in Table 1. Additional management information is given in Table 2.

Stand counts and leaf number were recorded in June of both years and are listed in Tables 3 and 4. The weights of early plant samples taken in 1985 are listed in Table 5.

Grain yields are given in Table 6.

Summary of results: Both 1985 and 1986 had higher than normal growing season precipitation (17.13 and 16.61 inches versus the 26-yr avg. of 13.59 inches). We expect larger differences in yield between erosion levels during years having closer to normal growing season precipitation.

The yield difference between tillage systems was quite high and is due, at least in part, to using a continuous corn cropping sequence. In a related study at the station using a corn-soybean rotation (data not shown here) there was no difference in yield between the CONV and RIDGE treatments.

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[1] Please refer to the title page of this publication for information regarding application and use of this article.

Table 1. Applied Fertilizer.

Time	Plots[1]	N	P_2O_5	K_2O	Zn	Comments
		------- # / Ac -------				
Fall 1984	All	200	100	100	--	
Fall 1984	SEV	---	---	60	10	
Spring 1985	All	9	25	8	---	(starter)
Fall 1985	All	---	---	50	--	
Fall 1985	SEV	---	100	---	--	
Spring 1986	All	200	---	---	--	
Spring 1986	All	6	19	6	--	(starter)

Table 2. Management Information.

Item	type	rate	date
---------- 1985 ----------			
Secondary Tillage	digger	--	5/6/85
Insecticide	Counter	1.0 #/Ac	" "
Seed	Pioneer 3732	26,000 p/Ac	" "
Herbicides	Lasso	2.5 #/Ac	5/7/85
	Bladex	1.5 #/Ac	" "
---------- 1986 ----------			
Secondary Tillage	disk	--	5/13/86
Insecticide	Furadan	1.0 #/Ac	5/15/86
Seed	Pioneer 3732	26,500 p/Ac	" "
Herbicides	Lasso	3.0 #/Ac	" "
	Bladex	1.5 #/Ac	" "

[1] Key : Erosion Levels: SLT = Slight, MOD = Moderate, SEV = Severe
Tillage systems: CONV = Conventional (fall moldboard plow), RIDGE = Ridge-till

Table 3. Stand Counts.[2]

Treatment[1]	1985 CONV	1985 RIDGE	1985 Avg	1986 CONV	1986 RIDGE	1986 Avg
	plants (thousands) / Ac					
SLT	24.6	24.4	24.5	21.2	22.2	21.7
MOD	24.6	23.9	24.3	21.1	22.0	21.6
SEV	23.8	24.5	24.2	20.5	23.0	21.8
Avg	24.3	24.3	24.3	20.9	22.4	21.7

Table 4. Leaf Numbers.[2]

Treatment[1]	1985 CONV	1985 RIDGE	1985 Avg	1986 CONV	1986 RIDGE	1986 Avg
	Leaf Number					
SLT	4.13	4.18	4.16	7.52	7.38	7.45
MOD	4.08	4.08	4.08	7.39	6.86	7.13
SEV	3.67	3.83	3.75	7.47	7.54	7.50
Avg	3.96	4.03	4.00	7.46	7.26	7.36

Table 5. Early Plant Growth -- 1985[2]

Treatment[1]	CONV	RIDGE	Avg
	g / 10 plants		
SLT	486.5	400.0	443.3
MOD	462.0	371.5	416.8
SEV	348.5	293.0	320.8
Avg	432.3	354.8	393.6

[1] Key : Erosion Levels: SLT = Slight, MOD = Moderate, SEV = Severe
Tillage systems: CONV = Conventional (fall moldboard plow), RIDGE = Ridge-till

[2] Samples and measurements taken 4 June 1985 and 25 June 1986.

Table 6. Grain Yield.

Treatment[1]		Rep 1	Rep 2	Rep 3	Rep 4	Avg
		------- Bu / Ac @ 15.5% moisture -------				
---------- 1985 ----------						
SLT	CONV	165.2	157.3	177.8	164.6	166.2
SLT	RIDGE	166.9	159.4	170.9	155.8	163.3
MOD	CONV	163.3	157.5	172.4	176.9	167.5
MOD	RIDGE	156.2	139.8	160.7	165.6	155.6
SEV	CONV	167.6	159.0	152.9	150.7	157.5
SEV	RIDGE	168.5	151.1	145.0	126.8	147.8
---------- 1986 ----------						
SLT	CONV	171.8	172.4	160.9	166.5	167.9
SLT	RIDGE	160.4	141.5	146.6	164.1	153.2
MOD	CONV	159.9	166.4	161.1	156.1	160.9
MOD	RIDGE	140.7	136.0	145.7	143.4	141.5
SEV	CONV	162.6	153.8	173.1	166.2	163.9
SEV	RIDGE	165.3	154.8	156.7	138.6	153.9

1 Key : Erosion Levels: SLT = Slight, MOD = Moderate, SEV = Severe
Tillage systems: CONV = Conventional (fall moldboard plow), RIDGE = Ridge-till

Table 2. Influence of nitrogen form, nitrogen rates, and time of application on grain yield on a Webster loam, Southwest Experiment Station, Lamberton, MN 1986.

-- Nitrogen Trt. --			---------- Yield ----------				
Rate	Form	Time[1]	Rep. 1	Rep. 2	Rep. 3	Rep. 4	Av.
#N/Ac			------- Bu/Ac @ 15.5% moisture ------				
	Check		70.7	49.4	37.2	57.5	65.0
40	NH_4NO_3	FPD	64.5	82.7	57.2	91.5	83.0
40	Urea	FPD	68.2	105.1	63.9	76.9	87.0
40	NH_4NO_3	FS	89.9	70.5	79.4	88.5	80.0
40	Urea	FS	62.2	57.5	84.9	98.9	86.0
80	NH_4NO_3	FPD	77.8	122.9	84.8	105.2	104.0
80	Urea	FPD	86.1	199.6	113.4	128.0	103.0
160	NH_4NO_3	FPD	120.6	128.7	144.2	148.8	111.0
160	Urea	FPD	98.8	137.2	113.6	156.8	113.0
40	NH_4NO_3	STD	79.6	107.0	79.1	104.3	95.0
40	Urea	STD	84.1	75.2	94.1	92.0	92.8
80	NH_4NO_3	STD	103.3	107.3	130.7	117.1	106.4
80	Urea	STD	117.0	112.3	139.4	118.7	108.3
40	NH_4NO_3	SD	91.3	105.6	100.9	114.0	96.9
40	Urea	SD	103.7	104.7	122.3	136.4	97.2
80	NH_4NO_3	SD	134.5	117.9	149.6	145.8	103.0
80	Urea	SD	144.0	136.7	148.5	144.0	111.5
160	NH_4NO_3	SD	165.2	153.3	171.2	165.2	115.5
Sign.							>99
LSD 0.05							18.6

[1] FPD = Fall Plowed Down; FPS = Fall Plow Surface; STD = Spring Top Dress; SD = Side Dress.

Table 3: Distribution and statistics of relative yields of 80# urea FPD and SD for years 1970 to 1986

Class	FPD[1]	SD[1]
0.85-0.90	1	2
0.90-0.95	5	0
0.95-1.00	5	3
1.00-1.05	4	2
1.05-1.10	0	4
1.10-1.15	0	0
1.15-1.20	0	3
1.20-1.25	0	1
Median	0.97	1.05
Av	0.97	1.04
SD	0.058	0.108

Table 4: Correlation of relative yields of 80# urea FPD and SD for years 1970 to 1986 with soil water-related indices.

Index	FPD[1]	SD[1]
FSM[1]	0.130	0.435
May Prec.	0.171	0.226
June Prec.	-0.606*	0.382

*

Sign. @ 5%

[1]Key: FPD = Fall plowed down SD = Side Dress FSM = Fall Soil Moisture

WEST CENTRAL EXPERIMENT STATION
WEATHER SUMMARY - 1986

Month	Period	Precipitation 1986	Precipitation 100-yr. av.	Precipitation from av.	Temperature 1986	Temperature 100-yr. av.	Temperature Dev. from av.	Soil Temperature (10 cm depth) 1986	Soil Temperature (10 cm depth) 10 yr. av.
January	1-31	0.45	0.68	-0.23	13.8	8.0	+5.8	- -[1]	20.7
February	1-28	1.25	0.67	+0.58	10.0	12.8	-2.8	- -[1]	23.9
March	1-31	0.88	1.13	-0.25	28.7	26.7	+2.0	- -[1]	29.2
April	1-10	1.36	0.57	+0.79	45.0	38.0	+7.0	39.8	
	11-20	3.21	0.64	+2.57	41.9	44.4	-2.5	39.6	
	21-30	1.61	1.05	+0.56	46.8	48.3	-1.5	43.2	
Total or av.		6.18	2.26	+3.92	44.6	43.6	+1.0	40.9	41.4
May	1-10	2.33	0.77	+1.56	51.5	52.0	-0.5	47.0	
	11-20	0.64	0.95	-0.31	56.1	55.8	+0.3	54.3	
	21-31	0.88	1.25	-0.37	61.8	60.0	+1.8	58.1	
Total or av.		3.85	2.97	+0.88	56.7	56.1	+0.6	53.3	57.1
June	1-10	0.75	1.29	-0.54	66.4	63.0	+3.4	63.2	
	11-20	1.99	1.30	+0.69	66.7	66.3	+0.4	66.0	
	21-30	1.46	1.37	+0.09	70.3	68.1	+2.2	69.2	
Total or av.		4.20	3.96	+0.24	67.8	65.8	+2.0	65.4	69.3
July	1-10	0.43	1.44	-1.01	70.6	70.1	+0.5	69.2	
	11-20	3.36	1.06	+2.30	72.0	71.4	+0.6	73.5	
	21-31	2.67	1.01	+1.66	70.8	71.4	-0.6	73.4	
Total or av.		6.46	3.51	+2.95	71.1	70.9	+0.2	71.4	76.7
August	1-10	2.55	1.04	+1.51	66.8	70.4	-3.6	68.6	
	11-20	1.42	0.93	+0.49	66.2	69.0	-2.8	67.6	
	21-31	1.54	1.04	+0.50	58.9	66.9	-8.0	62.5	
Total or av.		5.51	3.01	+2.50	63.8	68.7	-4.9	66.1	73.9
September	1-30	3.22	2.20	+1.02	56.0	59.0	-3.0	57.6	61.5
October	1-31	0.28	1.74	-1.46	45.5	47.2	-1.7	47.1	47.8
November	1-30	1.35	0.97	+0.38	23.9	29.7	-5.8	32.6	33.6
December	1-31	0.01	0.68	-0.67	22.6	15.2	+7.4	27.0	23.4
April-August Growing Season		26.20	15.71	+10.52	60.8	61.0	-0.2	59.5	63.8
January-December Annual		33.64	23.78	+9.86	42.2	42.0	+0.2	- -[1]	46.7

[1] Missing data

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

S. D. Evans, P. R. Goodrich and R. C. Munter
Morris, 1986

The experiment initiated in 1970 was continued. Manure was applied in 1970 and 1971 only. Fertilizer has been applied to the fertilized checks each year.

I. Planting Information

The plots were planted with Pioneer 3901 on May 21, 1986, @ 24,300 seeds/acre. Counter was applied @ 12 lb/acre (1.8 lb/acre active ingredient) in the row to the entire area at planting. The fertilized plots received 120 + 50 + 50 ($N + P_2O_5 + K_2O$) lb/acre on October 28, 1985. The plots were moldboard plowed following fertilizer application. Lasso @ 3 lb/acre and Bladex @ 2.2 lb/acre were broadcast on May 22. Silage samples were taken by hand on September 29 and the grain harvest was taken with a plot combine on October 14.

II. Soil Sampling and Analysis

NO_3-N was measured in the fall of 1985 (Table 1). The total amount of NO_3-N in the 0-4 foot profile is less for all treatments as compared to the fertilized check. The impact of these low amounts of NO_3-N is seen on the yield results (Table 3) where the fertilized check is significantly higher than all the other treatments.

III. Plant Tissue Analysis

The nutrient concentrations in the ear leaves at silking in 1986 are given in Table 2. There are significant effects on most elements. The fertilized check has significantly greater amounts of N and Zn as compared to all other treatments.

IV. Yield Measurements (Table 3)

A. Grain - For the first time since the study was started all treatments yielded significantly less than the fertilized check.

B. Silage - The LH treatment had significantly less silage D.M. yield/acre as compared to the fertilized treatment.

V. Summary

For the first time since manure treatments were applied in 1970 and 1971 the grain yields were significantly less for all treatments as compared to the fertilized check. The amount of N in the ear leaf at silking is also significantly less for all the manure treatments.

Table 1. Levels of NO_3-N in a Tara soil fifteen years (Fall 1985) after the application of high rates of manure.

	Treatment				
Depth	CK	FE	SD	LB	LH
- ft -	- - - - - - - -		NO_3-N, ppm	- - - - - - - -	
0-1	5.2	11.4	9.0	10.5	7.5
1-2	2.4	13.1	4.1	4.6	3.0
2-3	1.5	21.0	7.3	9.4	2.5
3-4	1.4	25.8	18.8	25.4	7.5

Please refer to title page of this publication for information regarding application and use of this article.

Table 2. Summary of analysis of corn leaves at silking - 1986.

Treatment	Elements									
	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	- - - - - - % - - - - - -					- - - - - ppm - - - - -				
CK	1.47	0.15	1.77	0.47	0.25	76.2	10.0	3.8	65.4	4.7
FE	2.51	0.23	2.04	0.41	0.22	84.0	24.6	3.5	59.9	3.5
SB	1.57	0.25	2.11	0.39	0.16	66.4	11.6	2.7	54.1	3.3
LB	1.68	0.35	2.14	0.38	0.18	75.4	15.8	2.5	49.5	3.6
LH	1.50	0.26	2.11	0.38	0.18	65.1	14.0	3.2	55.9	3.7
Signif. level (%)	>99	>99	98	98	96	91	>99	97	69	87
BLSD (.05)	0.37	0.07	0.22	0.05	0.06	NS	3.6	0.9	NS	NS
CV (%)	11.4	14.6	5.4	6.7	15.8	10.7	13.1	13.6	15.3	16.3

Table 3. Summary of plant measurements - 1986.

Treatment	Early plant height	Early plant (10) dry weight	Grain		Silage		
			Moisture at harvest	Yield at 15.5% moisture	Dry matter at harvest	Silage yield (D.M.)	Ear wt. as a % of silage
	inches	- grams -	- - % - -	bu/acre	- - % - -	lb/acre	- - % - -
CK	11.5	6.0	40.8	29.3	37.2	5080	52.4
FE	15.1	12.4	36.2	103.9	43.6	11687	57.5
SB	16.6	19.7	36.9	64.5	46.2	8651	52.5
LB	15.9	18.2	37.2	67.9	40.5	8917	55.1
LH	15.2	14.8	37.6	56.3	45.7	7646	53.6
Signif. level (%)	>99	97	92	>99	99	99	96
BLSD (.05)	1.9	8.5	NS	25.0	4.7	3098	3.7
CV (%)	6.8	29.9	4.6	20.9	5.7	19.0	3.4

MANURE RATE STUDY

S. D. Evans, P. R. Goodrich and R. C. Munter
Morris, 1986

Solid and liquid beef manures were applied at three rates and the effects were compared against check plots. The last manure applications were made in the fall of 1978, but fertilizer has been applied to the fertilized check each year.

I. Planting Information

The plots were planted with Pioneer 3901 on May 21, 1986, @ 24,300 seeds/acre. Counter was applied @ 12 lb/acre (1.8 lb/acre active ingredient) in the row to the entire area at planting. The fertilized plots received 120 + 50 + 50 (N + P_2O_5 + K_2O) lb/acre on October 28, 1985. The plots were moldboard plowed following fertilizer applications. Lasso @ 3 lb/acre and Bladex @ 2.2 lb/acre were broadcast on May 22. Silage samples were taken by hand on September 29 and the grain harvest was taken with a plot combine on October 14.

II. Soil Sampling and Analysis

NO_3-N was measured in the fall of 1985 (Table 1). Only the SB3 treatment had a greater amount of total NO_3-N as compared to the fertilized check.

III. Plant Tissue Analysis

The nutrient concentrations in the ear leaves at silking in 1986 are given in Table 2. There are significant effects on most elements. The fertilized check is significantly higher in N than the SB1, LB1, and LB3 treatments. The fertilized treatment also has greater amounts of Zn than all the other treatments.

IV. Yield Measurements (Table 3)

A. Grain - In 1985 no treatments were significantly less in yield than the fertilized check. In 1986 the fertilized treatment outyielded all liquid beef treatments.

B. Silage - As it did last year, the LB1 treatment yielded significantly less than the fertilized check.

V. Summary

The 1986 season was the eighth since manure has been applied. All liquid beef treatments yielded significantly less grain than the fertilized check.

Table 1. Effect of two types of beef cattle manure and commercial fertilizer on the NO_3-N level of a Tara soil profile - Fall 1985.

	Treatment							
Depth	CK	FE	SB1	SB2	SB3	LB1	LB2	LB3
- ft -	- - - - - - - - - - - - - - - - NO_3-N, ppm - - - - - - - - - - - - - - - - - -							
0-1	5.7	29.8	11.2	14.1	18.6	8.7	12.5	6.9
1-2	2.9	44.8	9.6	15.2	50.2	4.7	8.0	24.9
2-3	2.6	43.7	26.4	31.0	69.4	8.2	20.4	22.1
3-4	2.2	40.8	26.5	66.8	98.2	12.9	29.8	30.1

Please refer to title page of this publication for information regarding application and use of this article.

Table 2. Summary of analysis of corn leaves at silking - 1986.

Treatment	Elements									
	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	- - - - - - - -		%	- - - - - - - -		- - - - - - - -		ppm	- - - - - - - -	
CK	1.50	0.17	1.77	0.39	0.26	75.7	11.9	3.6	58.0	4.2
FE	2.85	0.26	2.05	0.45	0.23	88.1	28.0	4.1	82.7	3.7
SB1	1.89	0.23	2.15	0.41	0.18	73.7	12.3	3.3	62.5	3.5
SB2	2.55	0.34	2.43	0.37	0.17	89.9	16.2	4.0	57.1	3.3
SB3	2.53	0.35	2.41	0.35	0.13	97.8	19.1	3.1	55.9	3.2
LB1	1.92	0.21	1.91	0.43	0.23	74.2	11.0	4.0	71.3	3.7
LB2	2.51	0.26	1.88	0.47	0.27	81.6	13.0	4.7	81.6	3.7
LB3	2.21	0.27	2.12	0.41	0.22	82.5	13.0	4.1	73.7	3.5
Signif. level (%)	>99	>99	>99	99	>99	97	>99	87	84	81
BLSD (.05)	0.49	0.05	0.18	0.07	0.05	16.7	2.5	NS	NS	NS
CV (%)	12.5	11.8	5.3	8.4	12.9	10.1	10.2	16.5	20.7	11.4

Table 3. Summary of plant measurements - 1986.

Treatment	Early plant height	Early plant (10) dry weight	Grain		Silage		
			Moisture at harvest	Yield at 15.5% moisture	Dry matter at harvest	Silage yield (D.M.)	Ear wt. as a % of silage
	inches	- grams -	- % -	- bu/acre -	- - % - -	lb/acre	- - % - -
CK	12.2	7.6	38.0	47.4	39.7	5173	50.3
FE	14.0	10.9	36.9	139.3	39.9	11464	58.6
SB1	16.8	15.0	35.3	92.6	45.6	8958	54.8
SB2	19.5	28.6	34.5	134.2	43.4	12705	60.6
SB3	18.3	23.7	36.4	136.5	39.8	13514	59.1
LB1	13.8	9.2	37.8	55.4	41.9	5911	55.0
LB2	15.3	12.3	36.9	87.8	44.0	8522	56.0
LB3	16.5	19.5	34.7	67.4	42.0	10216	57.5
Signif. level (%)	>99	>99	63	>99	82	>99	>99
BLSD (.05)	2.9	8.3	NS	49.5	NS	3858	4.3
CV (%)	10.3	30.2	5.9	28.9	9.5	22.5	4.2

CONTINUOUS CORN SILAGE

S. D. Evans
Morris, 1986

I. Experimental Description

In 1965 an experiment was initiated on a 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 lb/acre of zinc as zinc sulfate in the fall of 1965.

II. 1986 Operations

In 1986 the variety was Dekalb 461 and was planted @ 24,300 seeds/acre. Counter was applied @ 12 lb/acre at planting on May 29. Lasso @ 3 lb/acre and Bladex @ 2.2 lb/acre were applied broadcast on May 29. Silage yields were taken on October 13 and grain yields on October 22.

III. Silage Yields - Dry matter, tons/acre

Treatment	1986 Yield	1966-86 Yield
Silage, low fertility	1.95	5.43
Silage, high fertility	3.53	5.98
Grain, low fertility	2.20	5.49
Grain, high fertility	4.10	5.89

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

	1986 Yield	1966-86 Yield
Grain, low fertility	20.9	86.7
Grain, high fertility	70.0	93.0

V. Check Yields

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

	1986 Yield	1966-86 Yield
Grain (0 + 0 + 0)	11.0	44.1
Silage (0 + 0 + 0)	1.44	3.49

VI. Discussion

A. The grain high fertility and the silage high fertility silage yields were significantly higher than the grain low fertility or silage low fertility treatments.

B. The 21-year average yields show very little difference between silage and grain plots, but there is a slight advantage for the higher fertility level.

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Figure 1. The effect of Tillage and Nitrogen on Corn Grain Yield of Pioneer 3906.

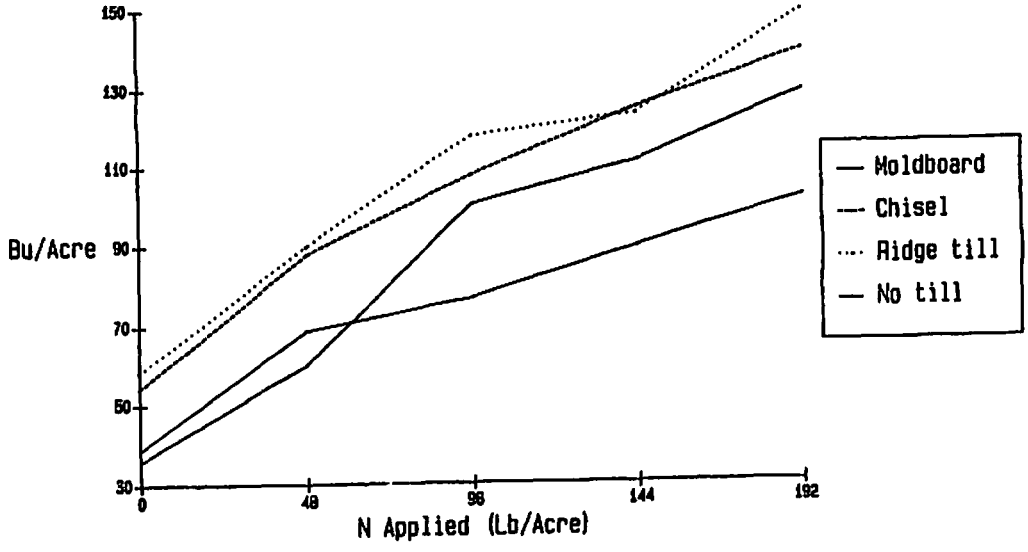
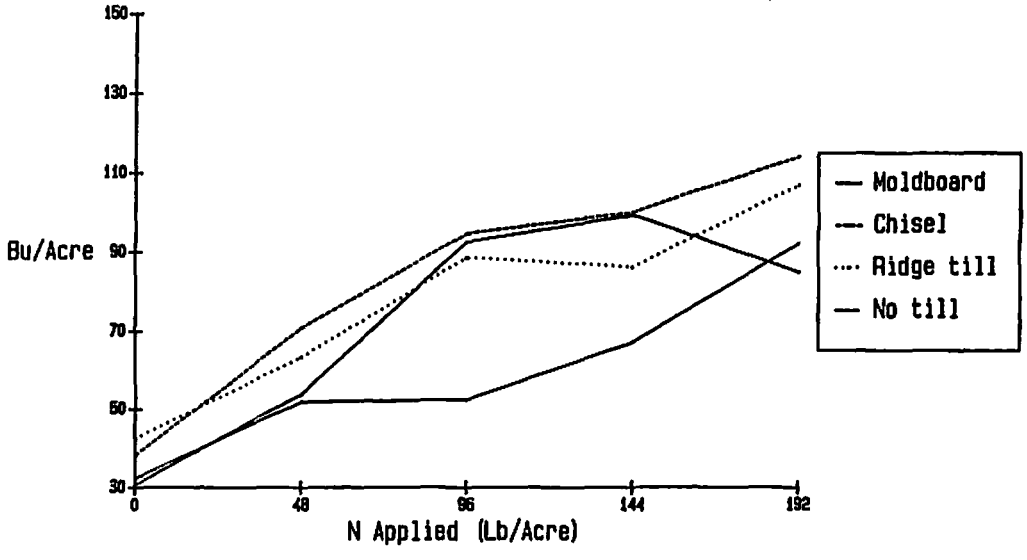


Figure 2. The effect of Tillage and Nitrogen on Corn Grain Yield of Dekalb XL8.



INVESTIGATIONS OF TILLAGE, N RATE, AND CORN HYBRID ON A PACHIC UDIC HAPLOBOROLL (TARA SILT LOAM)

S. D. Evans, J. F. Moncrief, and A. E. Olness
Morris, 1986

The purpose of this study was to investigate (1) the interaction of corn hybrid and N response, (2) the effect of tillage on the rate of N transformation of applied N and its availability, and (3) the effect of tillage on corn hybrid performance.

Experimental Procedures

The experimental site is located in west central Minnesota on a Pachic Udic Haploboroll (Tara silt loam). The experimental design is a split-plot with tillage as main plots, N rates as subplots, and hybrids as sub-subplots. There are four replications. Plot size is 10 feet by 40 feet. The experimental area has been in continuous corn from 1982-86. Nitrogen treatments have been located on the same areas starting in 1984. The hybrids (Pioneer 3906 and Dekalb XL8) are rotated each year within a nitrogen block. In 1982 the area was in a study with a number of hybrids while in 1983 the entire area was planted to Pioneer 3906. The experiment as it now stands was established in the fall of 1983.

The moldboard plow and chisel plow treatments were tilled on November 4, 1985. The stalks were not chopped on these two tillage treatments. The nitrogen had been applied as anhydrous ammonia on November 1, 1985. The moldboard plow plots were field cultivated twice and the chisel plow plots were disked once on May 22. The plots were planted on May 23 with a Hiniker planter. The row clearing disks were raised on the moldboard, chisel, and no-till treatments while they were lowered to clearing position for the ridge till treatments. The plots were planted at 30,000 seeds/acre to allow for sampling during the season.

Weed control was obtained with Lasso at 3 lb/acre a.i. and Bladex at 2.2 lb/acre a.i. preemerge broadcast on May 24. Row fertilizer was applied at planting (9.4 gal/acre of 7.4-25-0).

Residue measurements were made by the line intercept method on the 48 N and 144 N plots on May 30 with the row and interrow areas measured separately.

Stand counts were made on a 30-foot section of the center two rows. Tasseling and silking dates were estimated visually as the date 50% of the plants tasseled or silked.

The moldboard, chisel, and no-till plots were not cultivated. The ridge till plots were cultivated on July 3 and then ridged the same day.

Silage yields were taken by hand on September 30 from one 20-foot border row of each plot. The ears and stover were weighed separately and samples were taken for moisture and chemical analysis.

Grain yields were taken on October 15 with a modified JD 3300 combine. The two center rows of each plot 30 feet long were harvested and weighed on the combine. A grain sample was saved for moisture and chemical analysis.

Results and Discussion

Residual levels in the row (Table 2) varied from 2% with the moldboard plow to 28% with no till. The residue levels between the rows were about the same as in the row area with moldboard, chisel, and no till. There was a two-fold difference between row and interrow residue with ridge till.

The final emerged stands were affected by tillage (P>99%) and hybrid (P>99%) as shown in Table 1.

Tassel and silk dates were significantly affected by many factors (Table 2). The moldboard, chisel, and no-till treatments tasseled and silked slower with the 0 N treatment than with all other N treatments. The ridge till system tasseled and silked about the same day, regardless of N rate. The tillage x hybrid interaction appeared to be due to more delay with Dekalb XL8 than with Pioneer 3906 at the 0 N rate. At all other N rates there was no difference in date.

Grain and silage yields and harvest index were significantly affected by hybrid (Tables 2 and 4). Pioneer 3906 always had a higher value than Dekalb XL8 for all three variables. The tillage x nitrogen interaction for grain yield is shown in Figures 1 and 2 for each hybrid even though the 3-way interaction was not significant. Both hybrids responded well to nitrogen. With Pioneer 3906, moldboard and no till were lower yielding at the low N rates than chisel and ridge till. At the higher N rates, chisel, ridge till, and no till were higher yielding than moldboard. With Dekalb XL8,

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chisel, ridge till, and no till were similar and higher in yield than moldboard. At the 192 N rate, the no-till treatment did drop in yield.

Table 1. Treatment summary at Morris, 1986.

Treatment:	Fall moldboard plow Fall chisel plow Ridge till No till
N Rate:	0, 48, 96, 144, and 192 lb/acre applied November 1, 1985, as anhydrous ammonia. Previous rates on these same treatments were 0, 40, 80, 120, and 160 lb/acre, respectively.
Hybrid:	Pioneer 3906 Dekalb XL8

Table 2. Significance levels of treatment effects on measured variables.

Variable	Residue Cover after Planting Row	Residue Cover after Planting Interrow	Emerged Population	Tassel Date	Silk Date	Grain Yield	Silage Yield	Harvest[1] Index
	Significance level[2] (%)							
Tillage (T)	>99	>99	>99	>99	>99	>99	>99	93
Nitrogen (N)	>99	>99	43	>99	>99	>99	>99	>99
T x N	>99	>99	42	>99	>99	>99	98	94
Hybrid (H)	45	96	>99	34	34	>99	>99	>99
T x H	34	14	72	77	77	93	15	42
N x H	74	86	17	>99	>99	93	85	>99
T x N x H	40	06	41	85	85	40	81	12

[1] Harvest index is defined as ear dry matter as a percent of the total dry matter.

[2] Probability that differences are not due to chance.

Table 3. Main effects of tillage, N rate, and hybrids on residue cover, tassel date, and silk date.

Tillage	N Rate	Hybrid	Residue Level[1] after Planting Row	Residue Level[1] after Planting Interrow	Emerged Population	Tassel Date	Silk Date
	lb/acre		%		plants/acre	Day in July	
Moldboard			2.0	3.3	25193	26.7	28.7
Chisel			12.7	12.0	25534	25.1	27.1
Ridge till			8.8	19.4	26050	25.9	27.9
No till			28.0	27.4	27189	27.8	29.8
BLSD (.05)			3.8	2.6	1048	1.1	1.1
	0		- -	- -	26282	27.9	29.9
	48		31.1	37.3	25828	26.5	28.5
	96		- -	- -	25656	25.9	27.9
	144		33.2	40.4	26237	25.8	27.8
	192		- -	- -	25955	25.7	27.7
	BLSD (.05)		2.6	2.6	NS	0.4	0.4
		Pioneer 3906	12.4	14.3	24943	26.3	28.3
		Dekalb XL8	13.2	16.8	27041	26.4	28.4
CV (%)			65.1	46.3	6.5	2.7	2.5

[1] Residue measurements were made only on the 48 N and 144 N plots.

Table 4. Main effects of tillage, N rate, and hybrid on grain yield, silage yield, and harvest index.

Tillage	N Rate	Hybrid	Grain Yield	Silage Yield	Harvest Index
	lb/acre		bu/acre	lb DM/acre	- % -
Moldboard			67.3	7347	52.4
Chisel			93.2	10183	54.2
Ridge till			92.6	8971	56.2
No till			79.8	10093	52.0
BLSD (.05)			9.8	1084	NS
	0		41.3	5523	46.7
	48		68.4	8297	53.6
	96		91.4	9669	54.6
	144		100.2	10859	56.4
	192		114.7	11396	57.2
	BLSD (.05)		5.4	647	1.9
		Pioneer 3906	93.3	9866	56.0
		Dekalb XL8	73.1	8432	51.4
CV (%)			16.7	20.2	8.8

SOIL TEST LAB COMPARISON

S. D. Evans and G. A. Regimbal

Morris, 1986

In west central Minnesota there are several laboratories where soil samples are analyzed and fertilizer recommendations given. Recommendations of commercial laboratories sometimes differ greatly from the University of Minnesota Soil Testing Laboratory. In order to develop educational material for extension soils specialists, trials were started at the West Central Experiment Station in 1980 on a corn-wheat rotation. Results from 1980-85 trials were summarized previously (Soil Series 109 and Misc. Publ. 2-1982 to 1986).

In the fall of 1985 soil samples from the plow layer and 0-2 foot zone (corn only) were taken from all plots except the check. The soil from the four replications was combined to make two samples (plow layer and 0-2 foot) from each treatment. The samples were dried thoroughly, mixed, subdivided and sent to the appropriate laboratory. Recommendations were requested from five laboratories for corn at a yield goal of 130 bu/acre and spring wheat at a yield goal of 65 bu/acre. Analyses requested were (1) a complete analysis on the plow layer samples and (2) a nitrate-N analysis and recommendation on the 0-2 foot samples for treatments to be planted to wheat. After receiving the soil tests and recommendations (Tables 1 and 2), the fertilizer treatments were calculated with an adjustment for soil buildup with Harris Labs. Harris Labs gave no indication that the 0-2 foot sample was used for the nitrogen recommendation on wheat. The treatment labeled

Table 1. Soil test results and the suggested fertilizer program for wheat in 1986.

	Soil Test Results				
Test	Agvise	A & L	Harris	Eco-Agri	U of MN
pH	8.0	8.0	8.0	8.0	7.7
P (Bray 1), ppm	-	13L	-	12	11
(NaHCO3), ppm	10M	-	15	21	10
K, ppm	132H	148M	185	148	108
O.M., %	3.4	3.4H	3.7	3.6	3.4M
Ca, ppm	4950	2830H	4396	3520	-
Mg, ppm	475	460VH	436	530	-
Na, ppm	5	33VL	19	70	-
S, ppm	4L	8M	6	9	10
Fe, ppm	17.9VH	17H	15	13	-
Mn, ppm	9.4VH	10M	7.6	8.4	-
Zn, ppm	1.13H	2.6M	1.6	1.9	1.2
Cu, ppm	.7H	1.5H	0.7	0.68	-
B, ppm	-	1.3M	1	3.7	-
ENR (lb/acre)	-	70	-	-	-
Nitrate-N (lb/acre)	124	-	42	117	75
C.E.C. (meq/100 g)	29	18.5	26.2	23	-
Soluble salts (mmhos/cm)	.27	0.8L	0.2	-	0.3

	Suggested Fertilizer Program[1]				
Nutrient	Agvise	A & L	Harris	Eco-Agri[2]	U of MN
	- - - - - - - -	- - - - - -	lb/acre	- - - - - -	- - -
Nitrogen	28	115	75	0	45
Phosphorus (P_2O_5)	53	60[3]	65	25	50
Potassium (K_2O)	46	85[3]	110	65	30
Sulfur	0	9	5	0	0
Manganese	0	1	0	0	0

[1] All values indicate pounds of nutrient suggested per acre for a yield goal of 65 bushels per acre for wheat.
[2] Suggested applications are the minimum to obtain the desired yield goal.
[3] Values include maintenance plus 1/2 of suggested buildup.

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as Eco-Agri was originally tested by Willmar Testing Lab, Willmar, MN from 1980-83. Tests in the fall of 1984 and again in the fall of 1985 were tested by Eco-Agri Laboratories, Willmar, MN.

Table 2. Soil test results and the suggested fertilizer program for corn in 1986.

	Soil Test Results				
Test	Agvise	A & L	Harris	Eco-Agri	U of MN
pH	7.6	7.7	7.7	7.9	7.7
P (Bray 1), ppm	-	20H	-	16	16
(NaHCO3), ppm	12M	-	17	17	11
K, ppm	155VH	198H	215	145	136
O.M., %	4.4	3.6H	4.1	3.6	3.9M
Ca, ppm	3800	2490H	3934	3200	-
Mg, ppm	550	597VH	524	462	-
Na, ppm	5	42VL	17	47	-
S, ppm	5L	6L	5	9	-
Fe, ppm	20.3VH	26VH	20.3	14	-
Mn, ppm	10.1VH	14H	9.4	9	-
Zn, ppm	1.52H	2.6M	1.8	2.1	1.9
Cu, ppm	.73H	1.3H	0.7	.66	-
B, ppm	-	1.4H	0.8	3.5	-
ENR (lb/acre)	-	84	-	-	-
Nitrate-N (lb/acre)	-	-	-	-	-
C.E.C (meq/100 g)	24	18.1	24.7	20	-
Soluble salts (mmhos/cm)	.38	0.8L	0.16	-	0.3

	Suggested Fertilizer Program[1]				
Nutrient	Agvise	A & L	Harris	Eco-Agri[2]	U of MN
	- - - - - - - -	- - - - - - -	lb/acre	- - - - - - - -	- - - -
Nitrogen	132	140	175	150	150
Phosphorus (P_2O_5)	86	50	75[3]	80	35
Potassium (K_2O)	30	90	90[3]	100	30
Sulfur	0	13	10	0	0

[1] All values indicate pounds of nutrient suggested per acre for a yield goal of 130 bushels per acre for corn.
[2] Suggested applications are the minimum to obtain the desired yield goal.
[3] Values include maintenance plus 1/2 of suggested buildup.

General

The experimental design is a randomized complete block with four replications on each crop. Two blocks, each with 24 plots, are adjacent and alternate between wheat and corn. The plot size is 15 feet by 40 feet. Row spacing on the corn is 30 inches.

Wheat

The fertilizer was applied by hand on October 29, 1985. All plots were then moldboard plowed. In the spring the plots were field cultivated and dragged. On May 7, 1986, the plots were seeded to Marshall wheat @ 1 3/4 bu/acre. Bronate was applied @ .25 + .25 lb/acre on June 4 and Hoelon @ 1.25 lb/acre on June 9. The plots were harvested with a plot combine on August 19.

Corn

The fertilizer was applied by hand on October 29, 1985. All plots were then moldboard plowed. In the spring the plots were field cultivated and dragged. On May 21, 1986, the plots were planted to Dekalb-Pfizer T950 @ 24,300 seeds/acre. Lasso @ 3 lb/acre and Bladex @ 2.2 lb/acre were applied broadcast on May 21. The plots were harvested on October 14 with a plot combine.

Results and Discussion of the Wheat Trial

The soil tests and fertilizer recommendations for wheat are shown in Table 1. For the major nutrients, there was very little difference in test results between labs. For Na, Cu, and B there were wide differences between labs. As in the past the recommendations for N, P, and K varied

widely between labs. The N recommendation varied from 0 with Eco-Agri to 115 lb/acre with A & L. The P and K recommendations varied over 2-fold with the highest values by Harris. The lowest P recommendation was by Eco-Agri and the low K by U of MN. The two labs (A & L and Harris) recommended sulfur and A & L recommended manganese.

Wheat yield (Table 3) was closely related to N application with the A & L recommendation giving the highest yield and Eco-Agri giving the lowest yield. The return over the check for wheat in 1986 (Table 4) was greatest for A & L at $40.33 and smallest for Harris at $23.70.

Table 3. Effect of fertilizer recommendations on various plant measurements - 1986.

	Wheat				Corn	
Lab	Plant Lodging	Plant Height at Harvest	Grain Yield	Grain Moisture	Grain Yield	Grain Moisture
	-Score[1]-	-inches-	Bu/A	%	Bu/A	%
Agvise	1	23.3	40.5	15.7	154.3	37.3
A & L	1	25.5	50.9	14.8	166.4	37.3
Harris	1	24.0	41.8	15.7	171.5	36.9
Eco-Agri[2]	1	21.0	32.5	16.2	149.8	38.3
U of MN	1	21.8	37.7	15.2	153.4	38.2
Check	1	19.3	17.2	15.9	78.9	38.7
Signif. level (%)	0	>99	>99	94	>99	78
BLSD (.05)	NS	2.3	7.0	1.1	17.7	NS
CV (%)	0	6.8	13.4	3.9	8.7	2.9

[1] Lodging score: 1 = No lodging, 9 = Flat.
[2] Tested by Willmar, 1980-83.

Table 4. Economic return over fertilizer costs - 1986.

	Wheat				Corn			
Lab	Value of Crop @ $2.50/Bu	Fertilizer Cost[1]	Return over Fertilizer	Return over Check	Value of Crop @ $2.00/Bu	Fertilizer Cost	Return over Fertilizer	Return over Check
	- - - - -	- - - - -	- - - - -	- - - $/A	- - - - -	- - - - -	- - - - -	- - - - -
Agvise	101.25	19.78	81.47	38.47	308.60	43.60	265.00	107.20
A & L	127.25	43.92	83.33	40.33	332.80	46.94	285.86	128.06
Harris	104.50	37.80	66.70	23.70	343.00	57.40	285.60	127.80
Eco-Agri[2]	81.25	10.85	70.40	27.40	299.60	52.00	247.60	89.80
U of MN	94.25	20.80	73.45	30.45	306.80	36.70	270.10	112.30
Check	43.00	0	43.00	-	157.80	0	157.80	-

[1] Values used ($/lb) were: N = $0.18, P_2O_5 = $0.20, K_2O = $0.09, S = $0.28, Zn = $0.40, Mn = $1.05.
[2] Tested by Willmar 1980-83.

Results and Discussion of the Corn Trial

The soil tests and fertilizer recommendations for corn are shown in Table 2. For the major nutrients the tests do not vary much between labs. Wide ranges in soil tests show up for Na, Cu, and B. The nitrogen recommendations range from 132 lb/acre with Agvise to 175 lb/acre with Harris. The phosphorus recommendations range from 35 lb/acre with U of MN to 86 lb/acre with Agvise. For K the range is from 30 lb/acre with Agvise and U of MN to 100 lb/acre with Eco-Agri. Both A & L and Harris have a recommendation for sulfur.

Corn yield (Table 3) ranged from 149.8 bu/acre with Eco-Agri to 171.5 bu/acre with Harris. The highest yield occurred with the highest N recommendation, but the lower yields were not directly related to N application. The return over check for corn in 1986 (Table 4) was greatest for A & L and Harris and lowest for Eco-Agri.

Seven-Year Summary

The combined average return per year for 1980-86 shows a range of $49.81 (Harris) to $89.77 (U of MN) over the check (Table 5). For wheat, Harris shows the smallest return over check while U of MN shows the greatest. For corn, A & L, Harris, and Eco-Agri are low and show similar results while Agvise and U of MN are high and show similar results.

Table 5. Seven-year summary of yields and economic returns 1980-1986.

	Wheat[1]				Corn[2]				
Lab	Aver. 7-year Yield	Total 7-year Fertilizer Cost	Economic Return over Fertilizer	Return over Check	Aver. 7-year Yield	Total 7-year Fertilizer Cost	Economic Return over Fertilizer	Return over Check	Combined Average Return per Year
Agvise	59	184.30	1384.40	343.70	120	352.29	1712.40	205.74	78.49
A & L	62	298.92	1333.58	292.88	119	419.02	1618.94	112.28	57.88
Harris	61	325.43	1277.87	237.17	122	483.11	1618.19	111.53	49.81
Eco-Agri[3]	58	217.68	1311.62	270.92	118	431.04	1608.94	102.28	53.31
U of MN	61	153.23	1455.12	414.42	119	292.12	1720.60	213.94	89.77
Check	39	0	1040.70	-	86	0	1506.66	-	-

[1] Wheat valued at $4/bu, 1980-84, $3.50/bu for 1985, and $2.50/bu for 1986.
[2] Corn valued at $3.00, $2.40, $2.00, $3.00, $2.80, $2.07, and $2.00/bu in 1980, 1981, 1982, 1983, 1984, 1985, and 1986, respectively.
[3] Tested by Willmar, 1980-83.

Final Soil Tests

Soil samples from the 0 to 8-inch zone were taken from each plot at the conclusion of the study in the fall of 1986. The samples were combined by treatment. Samples from the two blocks (one in corn each year and the other in wheat) were kept separate. All samples were sent to the U of MN lab for analysis. The results are reported in Table 6 along with the total N, P_2O_5, K_2O, and Zn applications for each treatment within each block

The total nitrogen application rate varied 3- to 4-fold between labs while the yields (Table 5) show no significant difference in average yield. The range in P application rates was 92 lb/acre on Block 1 and 159 lb/acre on Block 2. The higher rates generally resulted in a buildup of the soil P levels. The K application rate also varied widely with about a 4-fold difference between labs. Again the higher rates are reflected in higher K soil test levels. The Zn application with A & L, Harris, and Eco-Agri are also reflected in higher Zn soil tests. However, the Minnesota research results show that 1.0 ppm is adequate and only when levels are below 0.5 ppm is Zn required for sensitive crops.

Overall, the seven-year study shows the labs which gave fertilizer recommendations similar to the U of MN have yields which were not significantly different from labs which gave considerably higher total plant food recommendations. The higher application rates of P, K, and Zn are reflected in soil tests, so future applications of these fertilizers could be reduced.

Table 6. Total N, P, K, and Zn applications and final soil test results.

Block 1

Lab	Total 7-year Fert. Appl. N	P_2O_5	K_2O	Zn	Soil Test Results pH	Bray P	Olsen P	Ex. K	Zinc	Org. Matter
	- - - - lb/acre - - - -					- - - lb/acre - - - -			ppm	%
Agvise	659	457	325	0	8.0	38	27	204	1.3	4.3
A & L	737	405	670	6.0	7.9	37	27	249	1.8	4.5
Harris	858	452	938	7.5	7.9	39	29	249	1.8	4.5
Eco-Agri[1]	774	401	584	8.0	8.0	37	26	276	2.3	4.2
U of MN	580	365	200	0	8.0	30	21	198	1.2	4.0
Check	- -	- -	- -	- -	8.0	20	16	226	1.5	4.3

Block 2

Lab	Total 7-year Fert. Appl. N	P_2O_5	K_2O	Zn	Soil Test Results pH	Bray P	Olsen P	Ex. K	Zinc	Org. Matter
	- - - - lb/acre - - - -					- - - lb/acre - - - -			ppm	%
Agvise	607	506	375	0	8.1	5	24	216	1.0	3.3
A & L	860	485	665	8.5	8.1	26	21	219	1.6	3.9
Harris	815	566	1238	6.0	8.2	14	23	283	1.3	3.4
Eco-Agri[1]	489	407	645	14.0	8.1	23	18	232	2.1	3.9
U of MN	545	425	318	0	8.1	23	19	190	1.1	3.9
Check	- -	- -	- -	- -	8.2	2	10	186	1.0	3.5

[1] Willmar recommendations followed from 1980-83.

EFFECT OF LIQUID STARTER RATE, PLACEMENT, AND ANALYSIS ON CORN GROWTH AND YIELD

S. D. Evans and G. A. Regimbal

Morris, 1986

With the increase in reduced tillage systems, many new types of fertilizer placement devices have been developed to overcome the adverse effects of plant residues on operation of fertilizer placement disks or knives outside the seed opener area. One of these devices is a knife mounted inside the double disk opener on minimum tillage row crop planters. This device supposedly places the liquid fertilizer 1/2 to 3/4 inch to the side and 1/2 to 1 inch below the seed. The close proximity to the seed may cause seedling damage at high starter rates. This study was set up to examine the effect of three liquid fertilizers (7-21-7, 9-18-9, and 10-34-0) with three seed placements (with the seed, near the seed, and 2" x 2" placement).

Experimental Procedures

The study was located on a Hamerly clay loam (Aeric Calciaquoll). Nitrogen as urea was applied to provide 120 lb/acre of N. The area was field cultivated once before the urea application and once after in preparation for planting. The soil tests were: pH=7.1, O.M.=High, Bray P=60 lb/acre, and exchangeable K=501 lb/acre.

The design was a split-split plot with four replications. Main plot treatments consisted of three liquid starters (7-21-7, 9-18-9, and 10-34-0), subplot treatments of three rates of each fertilizer (5, 10, and 15 gal/acre for 7-21-7 and 10-34-0 and 4, 8, and 12 gal/acre for 9-18-9), and sub-subplot treatments of three placement methods (with the seed, near the seed and 2 inches to the side and 2 inches below the seed). There was a zero starter check in each subplot.

Corn (Pioneer 3906) was planted in 30-inch rows with a Hiniker minimum tillage planter with Kinze planter units at 24,300 plants/acre on May 6-7. Chemical weed control consisted of 3 lb/acre of Lasso and 2.2 lb/acre of Bladex applied broadcast on May 14.

Plant counts to obtain emergence rate, final emerged stand and harvest stand were taken from one row for a length of 40 feet. Grain yield was determined by harvesting 2 rows 40 feet long with a modified JD 3300 combine.

Results and Discussion

In the two days following planting over 2 inches of rain fell (Table 1). This possibly diluted the fertilizer bands and lessened potential salt damage. There was also 0.78 inch of rain the fifth day after planting. Temperatures at the 2-inch depth ranged from 47° to 62°F and averaged 55°F.

Salt values (Table 2) ranged from 5.8 lb/acre at the 5-gal/acre rate of 10-34-0 to 23.5 lb/acre at the 15 gal/acre rate of 7-21-7 and the 12 gal/acre rate of 9-18-9. The Minnesota salt limit for placement with the seed is 5-7 lb/acre on fine-textured soils.

Emergence rate was significantly affected by placement (Figure 1) with the check (CK) and with the seed (WS) treatments emerging before the near the seed (NS) and 2" x 2" treatments. Material and rate of material did not affect emergence rate. The emerged population shows a significant rate x placement interaction (Figure 2). All treatments except the NS treatment showed a decrease in emerged population as rate was increased.

The WS and NS treatments were significantly taller than the 2" x 2" and CK treatments as measured on June 13 (Figure 3). All treatments were the tallest at the medium fertilizer rate and decreased in height at the high rate. Material and the rate x material interaction effects on height were not significant.

There was a significant three-way interaction (P=96%) between rate x material x placement (Figure 4). For 10-34-0 yield increased from 5 to 10 gal/acre and then either leveled off or decreased at 15 gal/acre. The 7-21-7 material showed very little yield variation due to rate for the WS and NS treatments. The 2" x 2" treatment was highest yielding at the 5 gal/acre and then decreased sharply

Please refer to title page of this publication for information regarding application and use of this article.

at 10 and 15 gal/acre. The NS treatment for 9-18-9 behaved similarly. Yield decreased from 4 to 8 gal/acre and then leveled off from 8 to 12 gal/acre. The NS treatment averaged approximately 10 bu/acre greater than the CK. The WS treatment increased 10 bu/acre from 4 to 8 gal/acre and then decreased 10 bu/acre from 8 to 12 gal/acre. The 2" x 2" treatment varied only a few bushels for all rates.

Summary

The application of liquid starter did not enhance the emergence of corn in 1986 because of check treatment with no fertilizer emerged as fast or faster than all other treatments. There was some indication of a detrimental effect of the high rate of fertilizer with the seed on emerged population and early plant height, but some of the other placement methods also showed this effect. There was no significant difference between materials for emerged population or early plant height.

The effects on grain yield were quite varied. The near seed placement yielded more than the check in all cases except for the low rate of 10-34-0. The with seed placement showed a decrease in yield at the high rate with 10-34-0 and 9-18-9. The with seed placement on 7-21-7 showed no effect on yield regardless of rate.

The 1986 results indicate some precaution should be taken in applying liquid fertilizer with or near the seed. The differences and trends observed in 1986 were small due to rainfall soon after planting, average soil temperatures, and the high phosphorus soil test.

Table 1. Daily precipitation and average soil temperature (2" depth) in the 2-week period following planting.

Days after planting	Avg. Soil temperature (2")	Precipitation
	- °F -	- inches -
1	47	1.85
2	48	0.18
3	55	Trace
4	62	0
5	62	0.78
6	57	0
7	59	0
8	59	0
9	56	0
10	48	0
11	51	0
12	54	0
13	56	0
14	56	0

Table 2. Salt rate as influenced by starter fertilizer material and rate of application.

Application rate	Liquid fertilizer 10-34-0	7-22-5	9-18-9
		- lb N + K_2O -	
Low	5.8	7.8	7.8
Medium	11.7	15.6	15.7
High	17.6	23.5	23.5

Figure 1. Influence of Liquid Starter Fertilizer Placement on Emergence Rate.

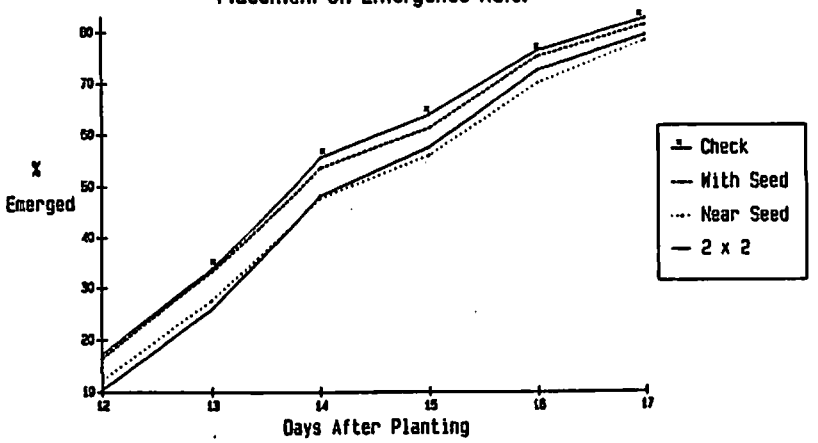


Figure 2. Influence of Liquid Starter Fertilizer Application Rate and Placement on Emerged Population.

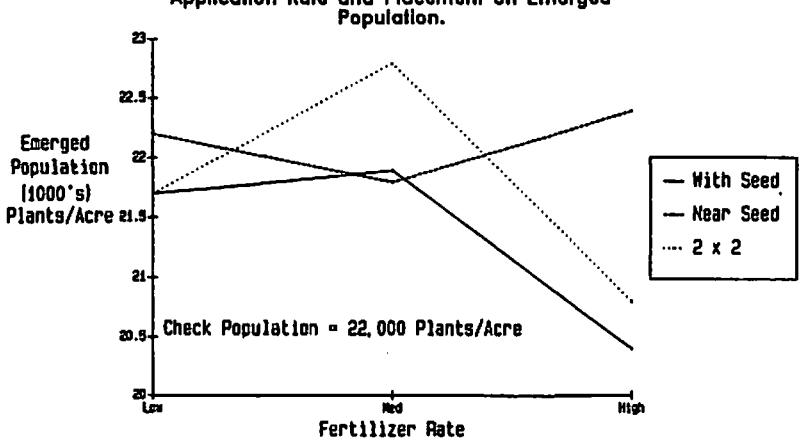


Figure 3. Plant Height on 6-13-86 as affected by Liquid Starter Fertilizer Application Rate and Placement.

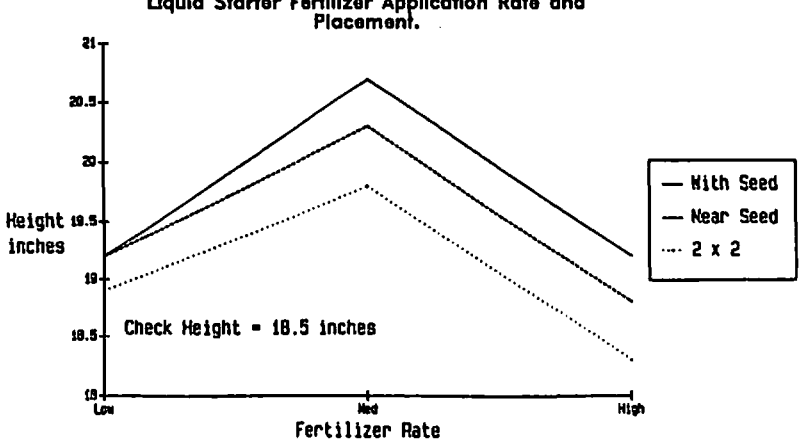
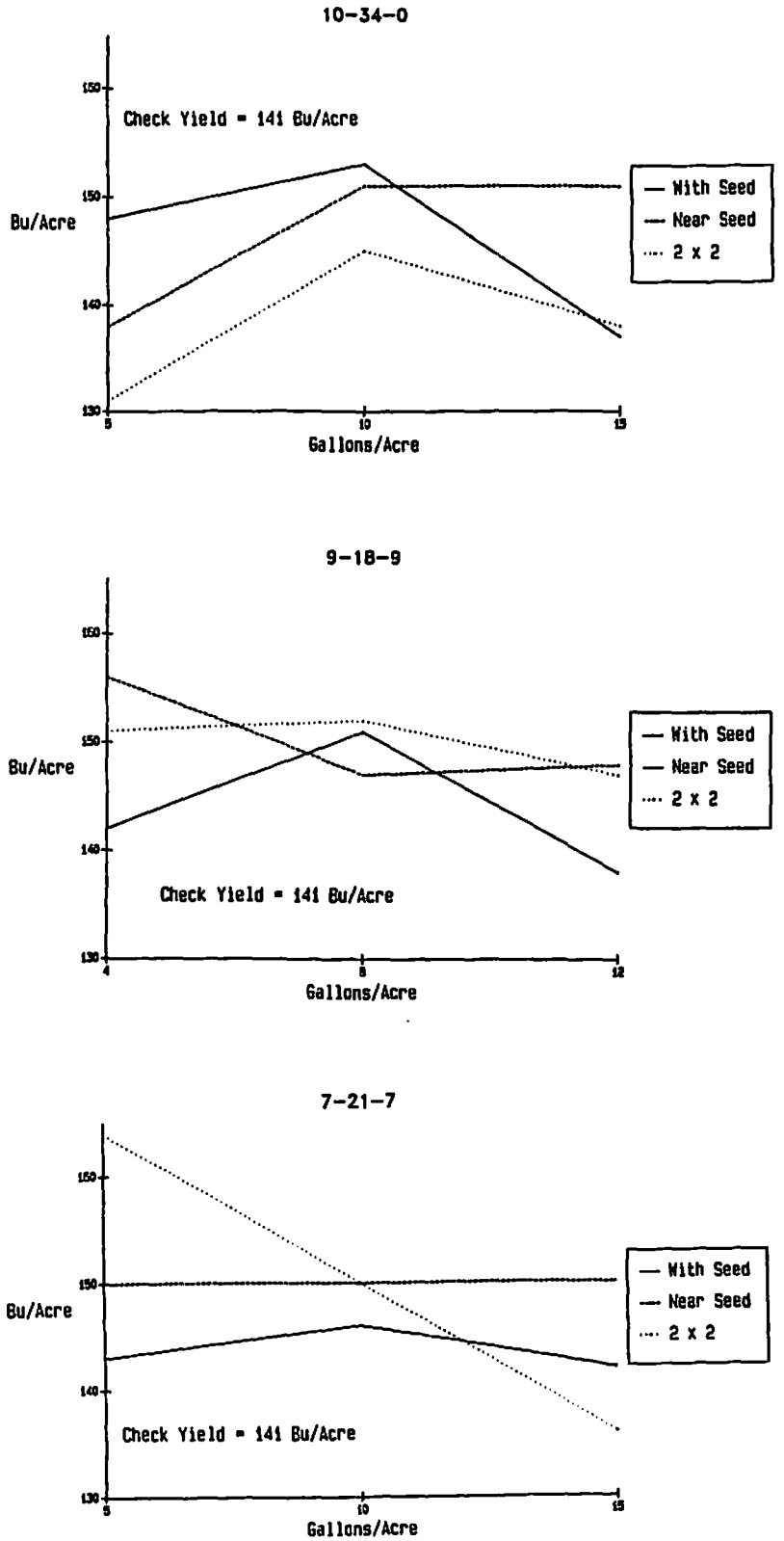


Figure 4. Influence of Liquid Starter Fertilizer Material, Application Rate, and Placement on Corn Grain Yield.



SOYBEAN TILLAGE STUDY

S. D. Evans, J. F. Moncrief, and G. A. Regimbal
Morris, 1986

The purpose of this study was to investigate various methods of no-till seeding of soybeans into the previous year's wheat stubble where the straw was chopped. In a previous study at the West Central Experiment Station stands were reduced in some years for soybeans no-till seeded in 10-inch rows into standing wheat stubble. This was particularly evident in areas of concentrated chaff from the combine.

Experimental Procedures

The experimental site is located at the West Central Experiment Station on a Aastad clay loam (Pachic Udic Haploboroll). The experimental design is a randomized complete block with four replications. The treatment descriptions are given in Table 1 and the cultural practices in Table 2. Stand counts were made on one 10-foot row in each plot. Residue levels were measured on June 2 by the line intercept method. With the Hiniker and Haybuster treatments, row and interrow areas were measured separately. All of the implements worked well except in treatment 7 were the soil was so loose it tended to pile up in front of the drill and was pushed to the end of the plot. The plots were handweeded once on June 19 to remove the yellow goatsbeard which were present in a number of the no-till plots.

Results and Discussion

The residue levels soon after planting are shown in Table 4. The levels in the row varied from 16% to 86%. Most of the no-till treatments had the highest levels of residue while the Hiniker, moldboard, spring disk, and chisel treatments had much lower levels of residue. Comparison of the row vs. between row residue levels shows a greater difference with the Hiniker than with the Haybuster.

The rate of soybean emergence as measured by percentage of final stand on various dates during the emergence period (Table 3) were not significantly affected by tillage. All treatments were at least 90% emerged by day 17 except the Haybuster treatment which emerged slower.

Comparing all treatments planted with the GT drill, the spring disk, spring chisel plow, and drag treatments were the lowest in population (Table 4) while treatments 3 and 8 (no-till) were highest in population. The Hiniker and Haybuster treatments had the highest populations and it is not possible to determine if this is a treatment effect or due to an increased seeding rate with these implements.

Weed population differences were estimated just prior to harvest (Table 4). The highest level of broadleaf control was with the Hiniker treatment which was cultivated twice and with treatment 8 which had Basagran in addition to Lasso. The lowest levels were with spring disk, drag, and fall moldboard. The no-till treatments and spring chisel were intermediate. There were no significant differences in foxtail control.

Volunteer wheat was present in many plots and the population was also estimated on October 8 (Table 4). Populations were highest with the Haybuster and the drag treatments.

Plant height and lodging (Table 5) were significantly affected by tillage. The treatments with the lowest populations tended to be taller while the higher population treatments were shorter. Lodging appeared to be inversely related to height.

Grain yield (Table 5) was not significantly affected by tillage. However, the slight differences that did occur seem logical. Treatment 1 with the Hiniker on 30-inch rows was the 2nd lowest yielding while treatment 8 with the extra herbicide was the highest yielding. The drag treatment was lowest yielding. This may be due to a combination of factors such as high residue level in the row, low population, low broadleaf and foxtail control and a high level of volunteer wheat.

Overall, the no-till treatments with the GT drill yielded quite well. The Haybuster treatment did not work well in the moist soils of the spring of 1986. Weed control was a problem, particularly the pigweed and lambsquarters, but the populations were reduced by an application of Basagran.

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Table 1. Treatments included in soybean tillage study, Morris, 1986.

Treatment No.	Treatment Description+
1	No-till, Hiniker 30-inch row crop planter
2	No-till, Haybuster 10-inch hoe drill
3	No-till, GT 10-inch no-till disk drill
4	Spring Disk 2X, GT 10-inch no-till disk drill
5	No-till, Drag stubble 1X, GT 10-inch no-till disk drill
6	Fall moldboard plow, Spring disk 2X, Drag 1X, GT 10-inch no-till disk drill
7	Spring chisel plow, Spring disk 1X, GT no-till disk drill
8	No-till, GT 10-inch no-till disk drill

+ Weed Control:
(1) Treatments 2-7, Lasso (3 lb/acre a.i.) + Paraquat (½ lb/acre a.i.), preemerge to the soybeans, broadcast on May 31.
(2) Treatment 1, Lasso (3 lb/acre a.i.) + Paraquat (½ lb/acre a.i.), preemerge to the soybeans, 15-inch band over row on May 31, 2 cultivations (6/20 & 7/3).
(3) Treatment 8, Lasso (3 lb/acre a.i.) + Paraquat (½ lb/acre a.i.), preemerge to the soybeans, broadcast on May 31 + Basagran (1 lb/acre a.i.) + oil (1 qt/acre), broadcast on July 2.

Table 2. Cultural practices, 1986.

Preceding Crop
Hard red spring wheat
Stubble height - approximately 12 inches

Plot Size - 20 feet wide x 50 feet long

Tillage
No-till
Chisel plow - spring, May 30
Moldboard plow - October 25, 1985

Soil Tests (Fall 1985) by Rep
pH - 6.7 to 7.4
Bray P - 63 to 92 lb/acre, Ave. = 78 lb/acre
Exch. K - 354 to 506 lb/acre, Ave. = 445 lb/acre

Fertilizer - None applied

Variety - Evans, planted May 30

Seeding Rate
Hiniker planter - 65 lb/acre
Haybuster drill - 70 lb/acre
GT drill - 70 lb/acre

Harvest - October 10 with plot combine

Harvest Area
30-inch rows: 2 rows x 40 feet
10-inch rows: 5 rows x 40 feet

Table 3. The effect of tillage on rate of soybean emergence.

Trt. No.	Treatment Description: Tillage	Planter	Row Width	Days after Planting: 7	10	12	14	17	19	26
				% of final stand						
1	No till	Hiniker	30	19	75	82	91	100	100	100
2	No till	Haybuster	10	4	49	56	66	83	88	100
3	No till	GT	10	10	68	73	81	97	97	100
4	Spring Disk	GT	10	3	65	76	94	96	96	100
5	No till, Drag	GT	10	0	47	55	76	92	96	100
6	Moldboard	GT	10	12	55	61	75	95	100	100
7	Chisel	GT	10	13	71	79	92	98	98	100
8	No till[1]	GT	10	19	71	75	84	96	96	100
Significance Level:				82	57	76	84	52	35	0

[1] Extra herbicide = Basagran + oil

Table 4. The effect of tillage on various parameters.

Trt. No.	Treatment Description: Tillage	Planter	Row Width	Residue Level[1] on June 2: 0	R	B	Final Emerged Stand	Weed Control[2] on October 8: Broadleaf	Foxtail	Volunteer[3] Wheat on October 8
			- in -	- -	%	- -	pl/acre x 10^{-3}	- - - -	%	- - - -
1	No till	Hiniker	30	-	49	82	143	85	81	2.0
2	No till	Haybuster	10	-	82	87	121	69	92	3.2
3	No till	GT	10	76	-	-	97	64	91	2.5
4	Spring Disk	GT	10	52	-	-	58	51	94	1.5
5	No till, drag	GT	10	84	-	-	62	55	78	3.5
6	Moldboard	GT	10	16	-	-	74	48	88	1.0
7	Chisel	GT	10	50	-	-	64	68	89	1.5
8	No till[4]	GT	10	50	-	-	88	94	96	1.5
Significance Level:				-	>99[5]	>99[5]	>99	96	94	>99
LSD (.05) :				-	7	8	30	9	-	1.5

[1] Residue Level: 0 = Overall, R = 10 cm area centered on row, B = area between the rows

[2] Weed Ratings: (1) Broadleaf - mainly pigweed and lambsquarters worst area, 5-6 plants/m^2
(2) Foxtail - worst area, 2 plants/m^2

[3] Wheat: 1 = no wheat, 5 = highest population, worst area = 1 plant/m^2

[4] Extra herbicide = Basagran + oil

[5] Row area significance level and LSD calculated from row residue for the first two treatments and overall residue from other treatments. Between row significance level and LSD calculated from between row residue from the first two treatments and overall residue from the other treatments.

Table 5. The effect of tillage on harvest measurements.

Trt. No.	Treatment Description			Plant Height	Lodging[1]	Grain Moisture	Soybean Yield
	Tillage	Planter	Row Width				
			- in -	- in -		- % -	bu/acre
1	No till	Hiniker	30	39	2.2	12.8	45.7
2	No till	Haybuster	10	36	3.0	13.2	49.9
3	No till	GT	10	41	3.0	12.8	47.8
4	Spring Disk	Gt	10	42	4.0	13.7	49.6
5	No till, Drag	GT	10	36	3.0	12.9	41.8
6	Moldboard	GT	10	40	3.2	13.3	50.8
7	Chisel	GT	10	42	3.5	13.2	49.4
8	No till[2]	GT	10	37	2.2	12.7	52.7
Significance Level:				95	>99	50	73
LSD (.05) :				4	0.7	- -	- -

[1] Lodging Score: 1 = Erect, 5 = Flat

[2] Extra herbicide = Basagran + oil

ALFALFA FERTILITY-MANAGEMENT STUDY

S. D. Evans, C. C. Sheaffer and G. A. Regimbal
Morris, 1986

With the newer alfalfa management procedures, higher yields have resulted. In many cases this might put the plant under greater stress, so it is important to investigate the effect of P and K fertilization on alfalfa yield and stand longevity. Therefore, a study was set up at Morris in 1983 to investigate the effect of (1) P and K fertilization, (2) alfalfa cutting schedule and (3) variety on alfalfa.

Experimental Procedures

The experiment was set up in 1983 on a Tara silt loam (Pachic Udic Haploboroll) site that tested medium in Bray P (19 lb/acre) and high in exchangeable K (234 lb/acre). The experiment was direct seeded on May 23-24, 1983. The design was a split-split plot with four replications. The main plots were cutting schedule. The first split was P and K fertilizer and the second split was variety. In 1983 the area was harvested but no yields were taken and no fertilizer applied. In 1984-1986 the cuttings were taken as scheduled. Fertilizer was applied by hand after the first cutting except for the 300- and 400-lb K rates where 200 lb/acre was applied after the first cutting and the remainder after the second cutting. The 4-cut schedule was harvested on May 29, June 27, July 30, and September 4. The 3-cut schedule was harvested on June 6, July 7, and August 13. Yields were taken with a small flail chopper, weighed and a moisture sample collected from each plot. Samples of the Answer variety were saved for chemical analysis. Soil samples were taken of the 0 to 2-inch and 2- to 8-inch zones in early September.

Results and Discussion

After three crop years no significant difference in total seasonal yield has occurred between the two varieties used (Tables 1 and 2). There was also very little difference between varieties at the individual cuttings (Table 4). In 1986 the 3-cut schedule outyielded (P = 93%) the 4-cut schedule (Table 3), similar to the results in 1985. The addition of P fertilizer has increased yields significantly in all years (Tables 1 and 2). The addition of K fertilizer affected yields very little in 1984 and 1985. In 1986 there was a trend for higher yields with increasing K rates, particularly on the 4-cut system (Tables 1 and 2). Dry matter percentage (Table 5) was significantly affected by PK treatment in all of the cuttings. In all cases the No-P treatment was drier than the 50-P and 100-P treatments.

Statistical analysis of the soil tests shows many significant fertilizer effects in the 0 to 2-inch and the 2- to 8-inch soil zones (Table 6). Increasing either P or K fertilizer generally increased both the P and K soil tests in the 0 to 2-inch and 2- to 8-inch zones (Tables 7 and 8). Cutting schedule also significantly affected P levels, especially at the high rate, with the lower yielding 4-cut schedule having higher P soil tests (Table 7). In 1985 the same effect was evident, but P = 87% for cutting schedule.

The summary of the plant analysis shows many elements significantly different depending on the cut and also the PK treatment (Table 9). Many elements other than P and K are significantly different even though only P and K were applied.

Only selected fertilizer treatments of the 3-cut system of Answer have been analyzed so far. They include the 0, 50, and 100 lb P_2O_5/acre treatments at a constant level of 200 lb K_2O/acre and the lowest and highest rates of K_2O (0 and 400 lb/acre) with a constant level of 50 lb P_2O_5/acre.

The summary of the plant analysis data shows many elements significantly affected by fertilizer treatment and cut (Table 9). All elements were significantly affected by cut. Elements affected by PK treatment were P, K, Ca, Mg, Na, Zn, and B. The interaction between cut and PK treatment was not significant.

The actual levels of P and K are shown in Table 10. Both P and K were highest in the 2nd cutting, intermediate in the 3rd cutting and lowest in the first cutting. Within a cutting the P levels increased with increasing P fertilizer and K levels increased with increasing K fertilizer.

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Table 1. Effect of cutting schedules, P and K fertilization and varieties on alfalfa yields at Morris in 1986.

Fertilizer Rate		1/2 Bud (4 cuttings) Variety			1/10 Bloom (3 cuttings) Variety			Average over Fertilizer
P_2O_5	K_2O	Vernal	Answer	Average	Vernal	Answer	Average	
- lb/acre -		Dry Matter (T/acre)						
0	200	2.78	2.71	2.75	3.08	3.08	3.08	2.91
50	200	4.18	4.25	4.21	4.81	4.75	4.78	4.50
100	200	4.47	4.52	4.49	5.14	4.86	5.00	4.75
50	0	3.92	3.98	3.95	4.19	4.47	4.33	4.14
50	100	3.93	4.07	4.00	4.78	4.52	4.65	4.33
50	200	4.27	4.04	4.16	4.69	4.69	4.69	4.42
50	300	4.26	4.15	4.20	4.75	4.77	4.76	4.48
50	400	4.40	4.49	4.44	4.70	4.85	4.78	4.61
Average		4.03	4.03	4.03	4.52	4.50	4.51	4.27

CV = 6.5%

Table 2. Effect of P and K fertilization and variety on alfalfa yields at Morris in 1986.

Fertilizer Rate		Varieties	
P_2O_5	K_2O	Vernal	Answer
- - lb/acre - -		Dry Matter (T/acre)	
0	200	2.93	2.89
50	200	4.49	4.50
100	200	4.80	4.69
50	0	4.05	4.22
50	100	4.36	4.30
50	200	4.48	4.37
50	300	4.50	4.46
50	400	4.55	4.67
Average		4.27	4.26

CV = 6.5%

Table 3. Effect of cutting schedule, P and K fertilization and variety on alfalfa yields.

Variable	Signif. level[1]
	- % -
Cutting Schedule (CS)	93
PK Treatment (PK)	>99
CS x PK	7
Variety (V)	17
CS x V	15
PK x V	22
CS x PK x V	36

[1] Probability that differences are not due to change.

Table 4. Effect of P and K fertilization and variety on alfalfa yields by individual cuttings.

Variable	3-cut Schedule 1st	2nd	3rd	4-cut Schedule 1st	2nd	3rd	4th
	Signif. level (%)[1]						
PK Treatment (PK)	>99	>99	>99	98	>99	>99	>99
Variety (V)	4	32	88	89	95	37	31
PK x V	60	47	84	11	76	62	63

[1] Probability that differences are not due to chance.

Table 5. Effect of P and K fertilization and variety on alfalfa dry matter percentage by individual cuttings in 1986.

Variable	3-cut Schedule 1st	2nd	3rd	4-cut Schedule 1st	2nd	3rd	4th
	Signif. level (%)[1]						
PK Treatment (PK)	>99	>99	>99	99	>99	>99	>99
Variety (V)	98	59	64	23	32	85	58
PK x V	71	51	77	97	76	75	38

[1] Probability that differences are not due to chance.

Table 6. Effect of cutting schedule and P and K fertilization on Answer only on soil test levels in September 1986.

Variable	Soil Tests (lb/acre) Bray P 0-2"	Bray P 2-8"	Olsen P 0-2"	Olsen P 2-8"	Exch. K 0-2"	Exch. K 2-8"
	Signif. level (%)[1]					
Cutting Schedule (CS)	98	98	98	87	73	0
PK Treatment (PK)	>99	99	>99	97	>99	96
CS x PK	>99	>99	>99	97	98	63

[1] Probability that differences are not due to chance.

Table 7. Effect of P rate on Answer only on soil test P of the 0-2 and 2-8 inch soil zones in September 1986.

Fertilizer Rate P_2O_5	K_2O	0-2 inch Bray P 3-Cut	Bray P 4-Cut	Olsen P 3-Cut	Olsen P 4-Cut	2-8 inch Bray P 3-Cut	Bray P 4-Cut	Olsen P 3-Cut	Olsen P 4-Cut
lb/acre		lb/acre				lb/acre			
0	200	7	7	5	4	7	6	4	4
50	200	12	16	9	11	7	9	4	5
100	200	29	59	22	48	6	11	4	7

Table 8. Effect of K rate on Answer only on soil test K of the 0-2 inch soil zone in September 1986.

Fertilizer Rate P_2O_5	K_2O	Exch. K 0-2 inch 3-Cut	0-2 inch 4-Cut	2-8 inch 3-Cut	2-8 inch 4-Cut
lb/acre		lb/acre			
50	0	190	189	177	178
50	100	232	204	183	178
50	200	250	250	172	182
50	300	364	452	185	199
50	400	516	646	204	199

Table 9. Summary of analysis of Answer alfalfa from the 3-cut schedule in 1985.

Variable	Element										
	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	Signif. level (%)[1]										
Cut	>99	>99	99	>99	>99	>99	98	>99	99	98	76
PK	>99	>99	>99	>99	83	83	99	87	96	46	>99
PK x Cut	84	13	5	13	44	38	62	1	38	41	52

[1] Probability that differences are not due to chance.

Table 10. Effect of cut and fertilizer rate on P and K plant levels of alfalfa in 1985.

Fertilizer Rate		P			K		
P_2O_5	K_2O	1st Cut	2nd Cut	3rd Cut	1st Cut	2nd Cut	3rd Cut
lb/acre		%					
0	200	.120	.157	.127	1.94	2.72	2.19
50	200	.154	.238	.194	1.87	2.90	2.32
100	200	.168	.253	.215	1.99	2.85	2.18
50	0	.140	.255	.204	1.65	2.22	1.71
50	400	.147	.233	.196	2.09	2.91	2.43

METHOD OF FOLIAR NITROGEN APPLICATION ON THREE SPRING WHEAT VARIETIES

S. D. Evans, E. A. Oelke, and G. W. Rehm
Morris, 1986

The past two or three years there has been an increased interest in wheat protein levels because of premiums for high protein. This study was established to investigate the effect of application of small amounts of foliar nitrogen at the early anthesis on yield and protein level of spring wheat.

Experimental Procedures

The experiment was established on a Hamerly clay loam (Aeric Calciaquoll). Soil test levels in the spring of 1986 were as follows: pH = 7.4, Olsen P = 16 lb/acre, exchangeable K = 338 lb/acre, NO_3-N (0-2 ft) = 48 lb/acre, and O.M. = high.

A randomized complete block design with four replications was used. Plot size was 8 ft x 45 ft. Factorial treatments consisted of three hard red spring wheat varieties: Wheaton, Len and Stoa, and four nitrogen fertilizer rate/timing treatments as follows:

Symbol	Extra 50 lb/acre N Preplant	Cerone @ .25 lb/acre	10 lb/acre N-Foliar
Rec	No	No	No
+10 BC	No	No	Below Canopy
+10 TC	No	No	Above Canopy
+50	Yes	Yes	No

All treatments received 82 lb/acre of N as urea preplant incorporated, 100 lb/acre of 18-46-0 with the drill at seeding, and Dithane M-45 at 2 lb/acre + Tritron CS-7 at 1/2 pt/acre for disease control on June 24, July 7, and July 4. The plots were seeded on May 5. The seeding rates were adjusted for seed size and germination to provide the same number of viable seeds/acre. Hoelon was applied at 1.25 lb/acre a.i. on June 9 and Bronate at .25 + .25 lb/acre a.i. on June 13. The Cerone was applied on June 20 when the plants were in Feekes stage 8-9 (flag leaf emerged to collar visible). The foliar N was applied on June 24 in the late morning when the plants were in Feekes stage 10.1-10.2 (first spikelet to one-fourth of the head visible). The N source was 28-0-0 dissolved in water and applied at 20 gal/acre (635 cc 28-0-0/gal of spray). The below canopy treatments were applied with drop nozzles. The plots were harvested with a plot combine on August 12. Lodging evaluation and plant heights were taken on August 12 just prior to harvest. Samples of the grain were taken for moisture and protein determination.

Results and Discussion

There was a slight amount of leaf burn with the +10 TC treatment, but the plants recovered in 7-10 days following treatment. There was no apparent tissue damage with the +10 BC treatment.

There was both a variety and nitrogen effect on lodging as indicated in Table 1. Wheaton had the highest lodging, probably due to the fact that it matured slightly ahead of the other two varieties. Lodging was reduced on the +50 treatment where Cerone was applied. There was no significant variety x N treatment interaction.

Plant height (Table 2) was also significantly affected by variety and N treatment. Stoa was about 5 inches taller than the other two varieties. The +50 treatment was 2.0-2.7 inches shorter than the other treatments. The two-way interaction was not significant.

The yield by treatment is shown in Table 3. The variety x N treatment interaction was significant at the 98% level. Len did not increase in yield with the three extra N treatments and, in fact, there was an indication of a yield decrease with the +50 treatment. Both Stoa and Wheaton showed yield increases when Rec is compared to +50. The foliar treatments on Stoa showed a possible yield increase over Rec, while on Wheaton the foliar N treatments did not increase yield.

The protein levels (Table 4) were significantly affected only by variety. Wheaton was the lowest protein at 12.5%. The other two varieties were significantly higher and not different from one another. The N treatments had no significant effect on protein.

Overall, the canopy treatments had no effect on lodging, height, and protein as compared to the recommended N treatment. With the variety Stoa, there was an indication of a small yield increase over Rec with no difference between +10 BC and +10 TC. The +50 treatment increased yield significantly indicating that the 100 lb/acre of N applied preplant + drill application was insufficient with the rainfall amount and climate in 1986.

Please refer to title page of this publication for information regarding application and use of this article.

Table 1. Effect of variety and N treatment on lodging of wheat.

Variety	N Treatment				
	REC	+10BC	+10TC	+50	Mean
	lodging score, 1=erect, 5=flat				
Len	1.5	1.2	1.2	1.0	1.2
Stoa	1.5	1.8	1.5	1.5	1.6
Wheaton	2.0	2.5	2.2	1.2	2.0
Mean	1.7	1.8	1.7	1.2	

Signif. levels: Variety = >99%, N = >99%, V x N = 92%
LSD (.05) : Variety = 0.3 in., N = 0.3 in.

Table 2. Effect of variety and N treatment on height of wheat.

Variety	N Treatment				
	REC	+10BC	+10TC	+50	Mean
	in.				
Len	29.8	30.0	29.5	27.0	27.0
Stoa	33.5	33.0	32.8	31.5	32.7
Wheaton	28.2	28.2	27.2	25.0	27.2
Mean	30.5	30.4	29.8	27.8	

Signif. levels: Variety = >99%, N = >99%, V x N = 35%
LSD (.05) : Variety = 0.7 in., N = 0.8 in.

Table 3. Effect of variety and N treatment on yield of wheat.

Variety	N Treatment				
	REC	+10BC	+10TC	+50	Mean
	bu/a @ 13% M.				
Len	54.0	55.2	52.5	51.2	53.2
Stoa	60.8	63.2	63.3	68.1	63.8
Wheaton	66.1	68.6	67.6	70.0	68.1
Mean	60.3	62.3	61.1	63.1	

Signif. levels: Variety = >99%, N = 94%, V x N = 98%
LSD (.05) : Variety = 1.9 bu/a, V x N = 3.8 bu/a

Table 4. Effect of variety and N treatment on protein of wheat @ 13% moisture.

Variety	N Treatment				
	REC	+10BC	+10TC	+50	Mean
	%				
Len	14.2	14.4	14.4	13.8	14.2
Stoa	14.2	14.1	13.8	14.0	14.0
Wheaton	12.5	12.6	12.7	12.5	12.6
Mean	13.6	13.7	13.6	13.4	

Signif. levels: Variety = >99%, N = 35%, V x N = 21%
LSD (.05) : Variety = 0.4%

TOPDRESSING UREA ON SPRING WHEAT

S. D. Evans
Morris, 1986

Foliar application of nitrogen has the potential to burn the leaf tissue and possibly affect yield adversely. This study was established to investigate the effects of application of dry urea to spring wheat at early anthesis on yield and protein level.

Experimental Procedure

The experiment was established on a Hamerly clay loam (Aeric Calciquoll). Soil test levels in the spring of 1986 were as follows: pH = 7.4, Olsen P = 16 lb/acre, exchangeable K = 338 lb/acre, NO_3-N (0-2 ft) = 48 lb/acre, and O.M. = high.

A randomized complete block design with four replications was used. Plot size was 8 feet x 45 feet. The urea treatments included: (1) check, (2) 10 lb N/acre, (3) 25 lb N/acre, and (4) 50 lb N/acre. The urea was hand spread in a dry form when the plants were in Feekes stage 10-10.1 (awns showing on half the plants) on June 24 when the leaf tissue was dry. Nitrogen was applied to the entire area prior to seeding in the urea form to provide 82 lb/acre of N. The urea was incorporated in the land preparation. Marshall wheat was seeded on May 6. Dithane M-45 at 2 lb/acre and Tritron at ½ pt/acre were applied on June 24, July 7, and July 16 for disease control. Lodging evaluation and plant heights were taken on August 12 just prior to harvest with a plot combine. Samples of the grain were taken for moisture and protein determination.

Results and Discussion

There was no significant effect of the urea treatments on height, lodging, or protein. The N effect on yield was almost significant (94% level) but only the higher rates of 25 and 50 lb/acre of urea increased yield over the check.

With the growing season conditons in 1986, the application of small amounts of dry urea at the early heading stage had no measureable effect on grain yield or protein. Perhaps the urea should have been applied earlier; i.e., before Feekes stage 3 or before tillering was complete.

Table 1. Effect of topdressing urea on Marshall wheat.

N	Lodging+ Score	Height	Yield	Protein
lb/a		in.	lb/a @ 13% M	% @ 13% M
0	2.5	29.2	64.8	13.1
10	2.2	27.8	62.6	13.0
25	2.0	31.5	66.5	12.9
50	2.0	29.2	67.5	13.3
Signif. level (%)	48	80	94	24

+ 1 = Erect, 5 = Flat

Please refer to title page of this publication for information regarding application and use of this article.

MANAGEMENT OF BORON FOR CROP PRODUCTION ON IRRIGATED SANDY SOILS IN MINNESOTA

G.W. Rehm, B. Anderson, G. Cremers

Background and Justification:

Some past research trials in Minnesota have indicated that there is a potential for use of fertilizer boron (B) for the production of both corn and alfalfa. The potential for need is highest where these crops are grown on those sandy soils that have a low organic matter content.

The results of the previous research, however, have not been consistent. In one study, annual application of B did increase the yield of an alfalfa-grass mixture in northeastern Minnesota. In another study in north-central Minnesota, broadcast applications of B increased corn yield but had little effect on the production of alfalfa. Application of fertilizer B had no effect on corn yield at the irrigated Sand Plains Experimental Field.

Boron, like nitrogen (N) and sulfur (S), is considered to be a mobile nutrient in soils. The early trials in northeastern and north-central Minnesota showed that there was substantial downward movement of applied B through the soil profile. Management programs have been developed which, if followed, minimize the movement of nitrate-nitrogen (NO_3-N) to the ground water. In Minnesota, no research efforts have been directed to the development of management systems which will minimize the loss due to leaching of fertilizer B.

Previously, the B applied in research studies has been broadcast and incorporated before planting. It is possible that some of the B applied in this way was lost and this might help to explain some of the erratic responses noted to date. The study described in this report is designed to evaluate the effect of rate of applied B as well as frequency of application on production of both alfalfa and corn grown on an irrigated sandy soil.

Experimental Procedures:

This study was initiated in 1985 and continued in 1986. Treatments were reapplied to the original plots in April of 1986. The study is conducted at the Irrigation Research Center, Staples, Minnesota where the soil is classified as a Hubbard sandy loam. Relevant soil properties as determined from analysis of samples collected at the initiation of the study are listed in Table 1.

Table 1. Relevant soil properties (0-6 in.) of the experimental site prior to initiation of the study.

Property	Value
pH	7.0
P (Bray and Kurtz #1)	89 lb/acre
K (1 N $NH_4C_2H_3O_2$)	206 lb/acre
Mg	340 lb/acre
S	4 ppm
B	.24 ppm
Organic Matter	2.4%

Trials were conducted with both corn and alfalfa. Prior to treatment application, soil samples were taken from each corn plot at depths of 0-6, 6-12, 12-24 and 24-36 inches. Soil samples were collected from all corn plots in November, 1985 at the same increments to monitor changes in the B concentration in the soil.

In April, 1986, samples from the same increments were collected from selected treatments. These results are summarized in Table 2. All corn plots were again sampled in November, 1986. The results from this sampling date are summarized in Table 3. In all cases, the hot water soluble procedure was used to extract B from the soil.

Four rates of B (0,1,2,4 lb/acre) in either single or split applications were broadcast to established alfalfa each year. When split applications were used, 1/2 was applied in April and 1/2 after the second cutting. Adequate S (as gypsum) and K (as 0-0-60) were applied to all plots in April. Three cuttings were taken starting in early June and whole plant samples were collected from each plot at each cutting. Rainfall plus irrigation totaled 21.6 inches for the growing season.

Three rates of B (0,1,2 lb/acre) in either single or split application were broadcast for corn. Single applications were applied when the corn was at the 8-leaf stage. Where split applications were used, 1/2 was applied at the 8-leaf stage and 1/2 was applied at early silk. A treatment consisting of 2 lb. B/acre preplant, 1 lb. B/acre at the 8-leaf stage and 1 lb. B/acre at early silk was added in 1986. This treatment, however, could not be incorporated into the randomized complete block design of the study.

All corn plots received broadcast S (gypsum) and K (0-0-60) prior to planting. The N rate for all treatments was 200 lb/acre with 1/2 applied before planting and 1/2 applied at the 8-leaf stage. Seasonal rainfall plus irrigation was 21.4 inches. Other management practices needed to achieve high yields in the area were used.

Powdered borax was used to supply B throughout the study. This material was dissolved in water and the solution applied with a sprayer mounted on a small tractor. Application rate was constant at 40 gal./acre but concentration was varied to supply the desired rate of B.

Ear leaf samples were collected at early silk, dried, and analyzed for B. Both grain and total dry matter yields were recorded. Stover samples used to calculate dry matter production were analyzed for B in order to determine B removal by the corn crop.

Results and Discussions:

Boron Movement in Soil

One objective of this study was to monitor movement of B through the root zone of this sandy soil. Soil samples collected in the fall of 1985 indicated no major movement of B below 12 inches. The B concentration in the 0-6 in. and 6-12 in. depths, however, was increased by the use of B fertilizer.

Spring snow melt and early spring rainfall did not move B below 24 inches when 2 lb. B/acre was applied in either a single or split application (Table 2). The values recorded for these selected treatments in the early spring of 1986 were similar to those recorded from the late fall sampling of 1985 (1985 data not shown).

Table 2. Concentration of B in sandy soil from selected treatments applied in April, 1985. Samples collected in spring of 1986.

Treatment	Depth (in.)			
	0-6	6-12	12-24	24-36
	ppm B			
Control	.25	.28	.13	.10
2 lb. B/acre (single)	.38	.45	.25	.10
2 lb. B/acre (split)	.43	.50	.18	.10

With the exception of the 24-36 in. depth for soil samples collected in the spring of 1986, the B concentration in the soil increased with rate of applied B when averaged over both methods of application (Table 3). This increase was also linear. There was, however, a highly significant rate by method of application interaction for the B concentration at depths down to 24 in. The B concentration was lower when 1 lb. B/acre was split rather than added in a single application. When the B rate was 2 lb/acre, however, the B concentration was higher when a split application was used. The B concentration did not increase substantially when 4 lb. B/acre was applied in a split application (Table 3). This treatment was added for 1986, was not incorporated into the randomized complete block design, and thus could not be part of the statistical analysis.

Table 3. Concentration of boron at various depths at the end of the 1986 growing season.

Treatment	Depth (in.)			
	0-6	6-12	12-24	24-36
	ppm B			
Control	.24	.18	.10	.06
1 lb. B/acre (single)	.48	.41	.19	.09
2 lb. B/acre (single)	.49	.43	.22	.10
1 lb. B/acre (split)	.42	.32	.18	.10
2 lb. B/acre (split)	.56	.51	.28	.14
4 lb. B/acre (split)	.59	.47	.17	.08

The fact that the B concentration did not increase at the 12-24 in. and 24-36 in. depths suggests that there was no leaching of applied B through the root zone. This was also true for the 4 lb. B/acre rate. There is an accumulation of fine textured material at 12-24 in. depth and this probably prevented downward movement of soil and fertilizer B.

Alfalfa Yield

Neither rate nor method of B application had a significant effect on alfalfa yield in 1986 (Table 4). These data are consistent with the results recorded for alfalfa in 1985. This irrigated sandy soil is apparently capable of supplying the B needed for the alfalfa yield produced. We speculate that the majority of the B needed comes from the mineralization of the organic matter under these irrigated conditions. The concentration of B in the irrigation water is low (.04 ppm).

Table 4. Effect of rate and frequency of boron application on the yield of irrigated alfalfa.

	Cutting (1986)				
Treatment	1	2	3	Total (1986)	Total (1985)
	--------- ton dry matter/acre ---------				
Control	1.56	1.44	1.33	4.33	4.6
1 lb. B/acre (single)	1.54	1.49	1.32	4.35	4.2
2 lb. B/acre (single)	1.45	1.49	1.37	4.31	4.4
4 lb. B/acre (single)	1.47	1.51	1.35	4.33	4.2
1 lb. B/acre (split)	1.57	1.51	1.39	4.47	4.5
2 lb. B/acre (split)	1.52	1.38	1.31	4.21	4.3
4 lb. B/acre (split)	1.58	1.53	1.40	4.51	-

Corn Production

The 1986 data collected from the corn production portion of the study are summarized in Table 5. Again, the 4 lb. B/acre split treatment was not part of the original design and could not be included in the statistical analysis.

Table 5. Effect of rate and frequency of boron application on corn grain and total dry matter yield, B concentration in the ear leaf tissue at silking, B concentration in tissue at physiological maturity and B removed by corn.

Treatment	Grain Yield	Dry Matter Yield	B Conc. Ear Leaf	B Conc. Mature	B Removed
	bu/acre	ton/acre	ppm B		lb/acre
Control	161.2	5.9	12.6	4.7	.055
1 lb. B/acre (single)	153.2	6.4	15.5	5.7	.073
2 lb. B/acre (single)	160.8	5.7	21.7	6.2	.070
1 lb. B/acre (split)	154.7	5.7	15.5	4.9	.055
2 lb. B/acre (split)	160.3	5.4	14.6	6.3	.068
4 lb. B/acre (split)	162.6	6.3	-	-	-
CV: %	4.0	8.8	19.0	20.3	16.9

Application of fertilizer B had a significant effect on grain production. Yield was significantly reduced compared to all other treatments when 1 lb. B per acre was applied in either a single or split application. The use of 2 and 4 lb. B per acre, however, had no effect on yield when compared to the control treatment. Therefore, the yield reduction from the 1 lb. per acre rate is impossible to explain at this time. Since this effect was not observed in 1985, a large amount of significance cannot be attached to this reduction. A CV of 4% would certainly indicate that error and variability was kept to a minimum during the conduct of this study. Frequency of B application had no significant effect on yield and there was no significant rate by frequency interaction.

Total dry matter yield measured at physiological maturity was not significantly affected by either rate or frequency of B application. This is further evidence that the yield reduction observed with grain yield should not be heavily weighted.

The B concentration in the ear leaf tissue was influenced by both rate and frequency of application. There was also a significant rate by frequency interaction (Table 5). The B concentration increased linearly with rate of applied B and this would be expected. Highest B concentration was recorded when 2 lb. B per acre was used in a single application at the 8-leaf stage. Since the second application of B in the split application treatments was applied 2 days before ear leaf collection, it would be expected that B concentration would not be high in these treatments. The B concentrations in 1986 were higher than those recorded in 1985. This observation suggests that environmental conditions in any given year can have an effect on B uptake by corn.

Compared to the control, application of B increased the B concentration in the tissue sampled at physiological maturity. Frequency of application had no effect on this concentration and there was no significant rate x frequency interaction. Average concentration was 5.3 ppm when the B rate was 1 lb/acre. This increased to 6.3 ppm when applied B was 2 lb/acre.

The amount of B removed by the corn crop was small and was not significantly affected by either rate or frequency of application.

Conclusions:

After 2 years, the data gathered from this study lead to the following general conclusions.

1. Fertilizer B does not appear to move below 2 feet in the root zone when applied to this sandy soil. Highest B concentrations occur in the 0-6 and 6-12 in. increments for all treatments used.

2 Neither rate nor frequency of B application has increased the yield of irrigated alfalfa. Release of B from the organic matter under the irrigated conditions may supply the B needed by the alfalfa crop.

3. Effect of rate of fertilizer B on corn yield has been inconsistent. Little consideration should be given to the yield reduction recorded in 1986 when 1 lb. B per acre was applied. Frequency of application has had no significant effect on yield.

4. The concentration of B in the ear leaf tissue was affected by both rate and frequency of application. These data confirm that applied B is absorbed by the corn crop. Yet, native soil B plus the B released from organic matter is apparently adequate for irrigated corn production on this soil.

CORN - SOYBEAN ROTATION

H. Meredith and M. Weins

(Special appreciation to Dr. George Rehm, Greg Cremers and Brian Anderson)

The irrigaton corn-soybean rotation experiment inititated in 1981 at the Staples Station to evaluate continuous corn yields vs. corn yield following soybean continues.

Objective: Determine optimum corn and soybean yields under intensive management.

Discussion: This study applies management practices available to commercial farmers. Early planting, high plant population, hybrid selection, pest control, soil moisture, etc., receive special attention.

Note that 1986 was an excellent growing year for corn in the area. Kernel moisture at harvest was about the same for both hybrids in the study. Of particular interest is the 35 bushel yield differential from the 95-day R.M. over the 90-day R.M. As moisture content was the same at harvest the greater yield must be emphasized. This was the widest yield variance to date when two relative maturity hybrids were compared.

Temperatures were above normal in April through July as follows: April + 3.1°F, May + 2.3°F, June + 1.3°F, and July 1.1°F, August was 3.4°F below normal.

1986 Sequence of Events

	Corn	Soybeans
Disk	4/8	4/8
Plow, Disk & Smooth	4/22	4/22
Planting	4/25	5/20
Population (planting)	37,800	122,000 (est.)
Herbicide Dual	1 qt/A	1 qt/A
Insecticide, 1 lb/A a.i.	Counter	Counter
Varieties, Pioneer	3790 & 3881	Ossie
Rainfall, in. 5/1 - 8/31	22.2	22.2
Irrigation in. 5/1 - 8/31	7.5	7.5

Weed problems: wild buckwheat, ragweed, lambsquarters, hairy night shade.

Disease problems: eyespot

Insect problems: minimal

Fertilization (corn) 200-50-60
N applied 20 lbs. on 4/25; 60 lbs. each on 6/12, 6/25 and 7/23.

Harvest	10/2	10/2
Emergence	5/3	
Tasseling or flowering	7/3	7/17
Ear or pod set	7/17	7/31
Early dent	8/21	
Yellow and leaf drop		9/11
Forage samples	9/22	

Table 1. Corn yield, bu/A, Staples Station, Staples, MN 1986.

No.	Treatment	Yield 1981	1982	1983	1984	1985	1986	Avg.
		bu/A						
1	Continuous corn[1]	151	168	135	130	125	149	143
2	Continuous corn[2]	151	166	150	128	124	180	150
3	Soybean - Corn[1]	-	170	148	140	123	142	145
5	Soybean - SB - Corn[1]	-	-	-	-	-	144	144
	Averages	151	168	144	133	124	154	146

[1] 85-90 day relative maturity
[2] 95-day relative maturity

Table 2. Supportive Information Pertaining to Corn Yields at Staples Station, Staples, MN 1986.

Treatment Number	Harvest Population (x 1000)	Kernel Moisture (% H_2O)	Grain Yield T/A (DM)	Silage Yields T/A (DM)	Stover Yield T/A (DM)	Grain Silage Ratio
1	31.7	28.8[1]	3.52	6.27	2.75	.56
2	30.7	29.2[2]	4.26	7.58	3.32	.56
3	31.8	27.0[1]	3.36	6.98	3.62	.48
5	29.9	28.4[1]	3.41	6.68	3.27	.51

[1] Pioneer 3881, 90-day R.H.
2 Pioneer 3790, 95-day R.H.

Table 3. Nutrient Removal in Corn Grain - lb/A.

Treatment No.	N	S	P_2O_5	K_2O	Ca	Mg	Mn	Zn
1	140.6	8.9	58.1	41.4	.26	12.5	.05	.22
2	143.6	10.6	71.5	48.0	.36	13.5	.05	.24
3	125.8	8.0	59.8	40.6	.28	12.3	.04	.20
5	132.2	8.6	60.0	41.1	.25	12.6	.05	.20
Average	135.6	9.0	62.4	42.8	.45	12.7	.05	.22

Table 4. Nutrient Removal in Corn Stover - lb/A. (Average of 4 treatments).

N	P_2O_5	K_2O	Ca	Mg	Mn	Zn
27	6.8	157.2	28	7	.41	.07

Table 5. Nutrient Removal in Corn Silage (Grain + Stover).

Treatment No.	N	P_2O_5	K_2O	Ca	Mg	Mn	Zn	B
1	154	64.9	186	25	18	.43	.30	.09
2	169	78.3	211	31	20	.50	.30	.08
3	170	68.5	200	27	21	.43	.28	.07
5	160	66.8	205	28	20	.49	.28	.09
Average	163	69.6	200	28	20	.46	.29	.08

Table 6. Leaf Tissue Analyses at Silking.

Treatment No.	N	S	P	K
1	2.9	.20	.30	2.5
2	2.9	.21	.30	2.3
3	2.8	.20	.32	2.5
5	2.8	.20	.33	2.6

Table 7. Analyses of Corn Grain.

Treatment	N	S	P	K	Ca	Mg	Mn	Zn
	%						ppm	
1	1.6	.10	.28	.38	.003	.14	5.2	24.6
2	1.3	.10	.29	.37	.003	.12	5.0	22.4
3	1.5	.09	.30	.40	.003	.14	5.0	23.0
5	1.5	.10	.30	.39	.003	.14	5.4	23.0

Table 8. Analyses of Corn Stover.

Treatment	N	P	K	Ca	Mg	Mn	Zn	B
	%					ppm		
1	1.2	.17	1.2	.20	.14	34	25	6.2
2	1.1	.16	1.2	.21	.13	33	20	5.4
3	1.2	.19	1.2	.19	.15	31	20	5.2
5	1.2	.18	1.3	.21	.15	36	21	6.6

Table 9. Soybean Leaf Analyses at Initiation of Blossom.

Treatment	S	P	K	Ca	Mg	Mn	Zn	B
	%						ppm	
4	.36	.46	2.7	1.1	.42	.01	68	54
6	.35	.46	2.8	1.0	.42	.01	56	52

Table 10. Soybean Stem Nutrient Analyses, 1986

Treatment	S	P	K	Ca	Mg	Mn	Zn	B
	%					ppm		
4	.16	.38	5.5	1.3	.47	53	34	42
6	.13	.39	5.5	1.2	.48	50	28	42

Table 11. Soybean Seed Nutrient Analyses, 1986

Treatment	S	P	K	Ca	Mg	Mn	Zn	Cu	B
	%					ppm			
4	.42	.69	2.2	.14	.27	27	34	8.5	42
6	.41	.69	2.2	.14	.27	30	54	8.2	34

Table 12. Soybean Seed Nutrient Removal, lb/A, 1986

Treatment	S	P	K	Ca	Mg	Mn	Zn	Cu	B
	lb/A								
4	12.4	20	64	4.0	7.8	.08	.17	.02	.10
6	13.1	22	69	4.3	8.5	.10	.17	.03	.11

Table 13. Yield of Soybeans, bu/A Summary.

1982	1983	1984	1985	1986	1986
47.0	47.0	37.6	36.4	49.2[1]	53.0[2]

[1] 1st year soybean following corn
[2] 2nd year soybean following corn

LUPIN BEAN STUDY

H.L. Meredith and M. Wiens[1]

Lupinus alba (white lupin) studies were initiated at the Staples Station in 1984 and these studies continue. Lupins grow best on well drained, slightly acidic soils. The plant is cold tolerant thereby allowing seeding with the earliest spring planted crops. Lupins have the potential for high yields; they are highly palatable and are high in protein.

Yields from studies conducted to date appear in Table 1.

Table 1. Ultra Lupin Yields at the Staples Station, Staples, Minnesota, 1984-86. Yields are based on 13.5 Moisture Basis and Bushel Weight of 60 lbs.

	Yield, bu/A			
Treatment	1984[2]	1985[3]	1986[3]	
			Exp. #1	Exp. #2
1. No fertilizer	39.1	71.4	40.6	32.0
2. 100# 8-32-16 [4]	39.4	64.1	41.8	37.4 [5]
3. 25# sulfur	43.2	71.2	44.0	31.7
4. 300# K_2O	40.5	63.8	40.6	43.3
5. PKS + 60# P_2O_5	39.4	68.8	39.2	40.2
6. PKS + 60# N [6]	41.5	64.9	33.8	32.8
Avg.	40.5	67.4	40.0	36.0

No significant difference in yield as a result of any fertility treatments was observed. Yield differences were attributed to population variables and weed competition, especially in 1986.

Experiment #1 is continuous lupins while Experiment #2 is rotated with a cereal crop. Long term studies are designed to determine if diseases are intensified in the continuous plot.

A Review of the 1986 Growing Season:

Lupin yields were quite disappointing in 1986 for more than one reason. We feel that we understand most of the reasons.

The fall of 1985 was considered a poor environment for development and growth of seed quality. The cool

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1 A special thanks for the assistance and interest shown by Dr. George Rehm, Brian Anderson, and Greg Cremers.

2 30-inch row spacing

3 6-inch grain drill

4 Changed to 160 # N split application in 1985, no fertilizer in 1986

5 Boron + SKPZn

6 N deleted in 1986, 10 lb. zinc (Zn) added.

(cold) wet weather prevented maturation. Normally harvest is accomplished in late August-early September. In 1985 harvest could not be initiated prior to a hard freeze in mid to late October. Even then lupins contained excessive moisture in many cases. We believe "poor" seed quality resulted even though germination testing at room temperature (90%) indicated good, viable seed. However, given the soil environment in mid April when lupins should be planted, a germination temperature more in line with soil temperatures would be more meaningful, such as 50-60°F.

Soil preparation: Sandy soils become quite "fluffy" when spring plowed. Grain drills have tension on disks to push downward only and seed depth is not uniform. The result is excessively deep seed placement. Especially where seed viability was suspect, deep placed seed likely resulted in poor populations. We believe this accounted for the poor stands experienced in 1986.

Weed competition: Lupins are poor competitors with weeds. Especially where lupin populations were low, late germinating weeds were rampant. Ragweeds and wild buckwheat were perhaps the most troublesome weeds. The year was also one of high rainfall and the excessive moisture likely played a heavy role in the premature dissipation of herbicides in the profile permitting a heavy infestation of weeds.

Flowering temperatures: Seed set occurred for the most part from the primary flowers and only partially from the secondary flowers. High temperatures during this stage prevented pod set thereby limiting yield.

Plans for 1987 to offset potential problems: Soils where lupins are to be planted will not be plowed in the spring. Soils will receive a double disking and smoothed prior to planting.

A cold temperature (50-60°F) germination test will be administered prior to planting to test seed viability. The seed quality in 1986 should be excellent owing to the near ideal weather at maturation.

Experimental plots will be seeded at a heavy rate (200 lb/A or more) to ensure uniform population. Long season herbicides are essential. To date Lasso, Dual, Prowl, and Lorox have been used on lupins with success.

Fertility response: Poor stands, severe weed competition, and high temperatures during flowering put a lid on yields. Yields of this magnitude harvested in 1986 represent less than half the potential yield for this crop. The lupin plant is a vigorous forager of plant nutrients. To date, no yield increases have been attributed to any fertilizer nutrient. Only when high yields are harvested from uniform populations free of weed competition will a nutrient response be more likely to occur.

Although yields varied from one fertilizer treatment to another, this should not be attributed to a fertility response. Population variability and weed competition likely accounted for all of the variables in yield observed.

Sulfur: Note that the sulfur concentration in the lupin bean increased rather dramatically with the addition of 25 pounds of sulfur (S) per acre. The three sulfur containing amino acids, methionine, cysteine and cystine, require adequate sulfur be available in the soil medium. From a nutritional aspect, methionine becomes the first limiting amino acid in rations containing a high proportion of lupins or soybean meal. Therefore, it is essential that sufficient sulfur be present throughout the growth of the plant, but especially during the formation of the bean. It is of interest to note that one-sixth of the methionine requirement may be replaced with cystine in studies with rats. It is likely all three amino acids are enhanced in the presence of sufficient sulfur. Casein is a standard for methionine. Soybean meal requires the addition of 0.1% supplementation with methionine, whereas lupins would require 0.3% addition of methionine to make it equivalent to casein.

Sequence of Events in 1986

4/8 - Area plowed
4/16 - Area disked and fertilizer applied
4/16 - Lupins planted @ 190 lb/A, variety ultra
4/22 - Lasso applied @ 3 pt/A
5/3 - Lupin emerging
5/28 - Leaf and petiole sampling
6/4 - Flowering begins, plants 6-10 inches tall
6/23 - Pod set begins
7/3 - Second leaf and petiole sampling
7/21 - Third leaf and petiole sampling
7/31 - First leaf drop
8/16 - Plants 21-25 inches, flowering
8/19 - 90% of pods are brown, readily shatter on contact
9/5 - Harvest (could have harvested earlier as beans were at or below 14% and shattered easily)

4/15 - 8/15 Rainfall = 17.8; supplemental irrigation = 2.8"

Weeds: Wild buckwheat, ragweed and lambsquarters.

Moisture Requirements: The lupin plant is very practical in regards to soil moisture. At flowering the plant reads the soil moisture status. If it is dry or inadequate moisture is available the plant will deliver a low pod set. Likewise, moisture stress along with temperature and/or wind stress or any combinations which trigger a perceived moisture stress will result in low pod set. Where irrigation is available it is imperative that the moisture status be monitored at least on a daily basis. Slightly excessive moisture at this stage would be in preference to any moisture stress.

In 1986 the primary pod set was excellent but the secondary pod set was essentially absent. Note that yields were decreased about 40% over the previous year. Other factors along with moisture and temperature were responsible for the low yields. But, it should be duly noted that there was little to no pod set beyond the primary stage. Ideally, a heavy primary and secondary pod set is desired. Solid stands are the best bet for ensuring that pod set occurs predominately from the primary and secondary flowering.

Excessively high temperatures are known to cause abortion/poor pod set. Generally temperatures beyond 85°F would be detrimental at flowering.

Discussion: It is noted that 2.8" of irrigation water was supplied. Table 8 lists 32 days when the maximum temperature reached 80°F or above, 17 days were 85°F or above and four days were 90°F or above.

The period May 27-31 was critical as flowering was initiated on June 4. During this five-day period no precipitation was recorded, pan evaporation was 1.85 inches of water and the relative humidity ranged from 32-37 percent, temperature maximum averaged 86.4°F. Truly a stressful period. Supplemental irrigation at this stage would be absolutely essential. When temperatures reach 85°F it would be advantages to sprinkle irrigate to cool the canopy and provide moisture for evaporation to aid in the cooling process (539 calories of heat required to vaporize one gram of water).

Table 2. Nutrient Content of Lupin Beans, Staples Station, Staples, MN 1986. Experiment #1, Continuous lupins.

Treatment	N	S	P	K	Ca	Mg	Mn	Zn	Cu	B
	%							ppm		
1	5.6	.23	.45	1.2	.26	.20	.12	38	4.0	15
2	5.5	.22	.45	1.2	.24	.19	.12	36	4.0	15
3	5.6	.28	.42	1.2	.26	.19	.12	38	4.5	14
4	5.5	.29	.41	1.3	.26	.19	.10	39	4.0	14
5	5.6	.30	.49	1.4	.26	.21	.11	36	4.2	11
6	5.6	.31	.49	1.4	.26	.21	.12	45	5.0	14

Table 3. Nutrient Content of Lupin Beans, Staples, Staples, MN 1986. Experiment #2 (1st year lupins).

Treatment	N	S	P	K	Ca	Mg	Mn	Zn	Cu	B
	%							ppm		
1	5.4	.24	.49	1.2	.26	.20	.16	45	5.7	23
2	5.5	.28	.48	1.2	.26	.20	.14	48	5.1	21
3	5.3	.28	.47	1.3	.26	.20	.13	44	4.9	18
4	5.1	.28	.51	1.3	.27	.20	.15	46	5.5	18
5	5.4	.28	.48	1.4	.24	.20	.13	49	5.3	19
6	5.4	.29	.49	1.3	.25	.20	.13	49	5.2	28

Table 4. Lupin Bean (Grain) Nutrient Removal, Staples Station, Staples, MN 1986. Experiment #1, Continuous lupin.

Treatment	N	S	P	K	Ca	Mg	Mn	Zn	Cu	B
	lb/A							ppm		
1	120	4.9	9.8	25	5.6	4.3	2.6	.08	.01	.03
2	122	4.8	10.0	26	5.4	4.3	2.7	.08	.01	.03
3	130	6.7	9.8	28	6.2	4.5	2.7	.09	.01	.03
4	120	6.2	8.9	28	5.6	4.2	2.2	.09	.01	.03
5	118	6.2	10.0	29	5.3	4.4	2.3	.07	.01	.02
6	101	5.6	8.8	25	4.6	3.7	2.1	.08	.01	.03
Avg.	118	5.7	9.6	27	5.4	4.2	2.4	.08	.01	.03
lb/bu	3.0	.14	0.24	.67	.14	.10	.06	.002	-	-
Ratio: N = X		21	12.0	4.5	21	30	50	1500		

Table 5. Lupin Bean (Grain) Nutrient Removal, Staples Station, Staples, MN 1986. Experiment #2 (1st year lupins).

Treatment	N	S	P	K	Ca	Mg	Mn	Zn	Cu	B
	lb/A							ppm		
1	91	4.0	8.2	20	4.4	3.3	2.6	.08	.01	.04
2	93	4.8	8.0	20	4.4	3.4	2.4	.08	.01	.04
3	123	6.5	11	30	6.0	4.6	3.1	.10	.01	.04
4	108	6.1	11	28	5.8	4.3	3.1	.10	.01	.04
5	94	5.0	8.3	23	4.3	3.5	2.3	.08	.01	.03
6	105	5.6	10	26	5.0	3.9	2.6	.10	.01	.05
Avg.	102	5.3	9.4	29	5.0	3.8	2.7	.09	.01	.04
lb/bu	2.8	.15	0.26	.8	.15	.10	.07	.002	-	-
Ratio: N - X		19	11	3.5	19	28	40	1400		

Table 6. Soil Test Data, Staples Station, Staples, MN 1986. Experiment #1, Continuous Lupins.

	First Sampling					Second Sampling		
Treatment	Soil Texture	Organic Matter	Soil pH	Bray P lb/A	K lb/A	Soil pH	Bray P lb/A	K lb/A
1	SL	M	7.0	79	123	6.9	70	129
2	SL	M	7.1	87	128	7.1	70	111
3	SL	M	6.9	82	110	7.0	83	128
4	SL	M	7.1	73	288	7.2	68	192
5	SL	M	7.1	111	330	7.1	96	289
6	SL	M	6.8	109	249	6.7	97	218

Table 7. Soil Test Data, Staples Station, Staples, MN 1986. Experiment #2, Continuous Lupins.

	First Sampling					Second Sampling		
Treatment	Soil Texture	Organic Matter	Soil pH	Bray P lb/A	K lb/A	Soil pH	Bray P lb/A	K lb/A
1	SL	M	6.4	72	132	6.8	69	98
2	SL	M	7.0	71	89	69	65	87
3	SL	M	6.9	90	149	6.8	90	139
4	SL	M	6.3	98	154	6.3	95	162
5	SL	M	6.7	70	171	6.8	81	160
6	SL	M	6.5	80	177	6.5	76	125

Table 8. Maximum Air Temperature (above 80°F), Pan Evaporation, Precipitation, Relative Humidity, Wind Speed and Leaf Wetness, Staples Station, Staples, MN 1986.

	May				
	27	28	29	30	31
Max. Air Temp. °F	82	82	89	89	90
Pan Evaporation Water, inches/day	.29	.27	.17	.57	55
Precipitation, inches/day	0	0	0	0	0
Relative Humidity, Minimum %	37	37	33	32	34
Wind Speed, mean, miles/hr	2.6	3.2	1.3	5.8	10.4
Leaf Wetness 0 - dry 100 - wet % of day wet	30	35	28	2	0

	June								
	3	18	19	20	21	25	26	27	28
Max. Air Temp. °F	91	85	91	83	88	89	86	80	81
Pan Evaporation Water, inches/day	.25	.21	.26	.30	.38	.28	.18	.34	.26
Precipitation, inches/day	.23	.02	0	0	1.06	0	0	0	0
Relative Humidity, Minimum %	37	66	59	75	66	56	65	32	43
Wind Speed, Mean, miles/hr	9.5	7.4	3.9	8.1	3.9	8.6	8.4	5.6	4.2
Leaf Wetness 0 - dry 100 - wet % of day wet	20	40	13	4	64	0	4	27	9

	July																	
	3	4	5	7	9	15	16	17	18	19	22	23	24	25	27	28	29	30
Max. Air Temp. °F	83	91	85	85	83	80	84	88	87	81	86	86	85	81	84	81	84	81
Pan Evaporation Water, inches/day	.38	.27	.27	.31	.25	.14	.26	.13	.37	.37	.24	.51	.02	.20	.24	.20	.24	.31
Precipitation, inches/day	.63	.11	0	0	0	.64	0	0	.99	0	0	.15	.01	0	0	.47	.06	0
Relative Humidity, Minimum %	46	55	62	38	46	70	79	68	62	52	52	66	51	40	59	72	62	45
Wind Speed, mean, miles/hr	8.9	5.8	10.8	3.5	2.3	4.5	6.5	5.8	4.4	7.8	4.3	11.4	5.2	3.5	3.8	3.4	5.4	7.0
Leaf Wetness 0 - dry 100 - wet % of day wet	29	36	5	15	44	59	42	44	50	32	28	2	27	40	50	54	36	21

Table 9. Leaf and Petiole Samples of Lupins sampled on 5/28. Staples (sampled from Exp. #1).

Treatment	P	K	Ca	Mg	Mn	Zn	Cu	B
	--------- % -------					-- ppm --		
1	.32	2.8	.89	.21	.11	13	2.4	9.5
6	.29	1.7	1.18	.26	.11	15	2.8	12

Table 10. Leaf and Petiole Samples of Lupins sampled 5/28/86, Staples (sampled from Exp. #2).

Treatment	P	K	Ca	Mg	Mn	Zn	Cu	B
	---------- % --------					---- ppm ----		
1	.29	2.8	.99	.21	.11	12	2.2	11
2	.33	1.7	1.1	.31	.12	14	2.7	13
3	.31	2.0	1.1	.27	.12	14	2.4	12
4	.34	1.9	1.2	.26	.11	18	2.9	14
5	.36	3.1	.99	.22	.11	16	2.4	11
6	.30	2.9	.97	.27	.13	14	2.6	10

Table 11. Leaf Samples of Lupins sampled 5/28/86, Staples (sampled from Exp. #2) Plants Eight Inches Tall.

Treatment	P	K	Ca	Mg	Mn	Zn	Cu	B
	--------- % -------					-- ppm --		
1	.33	1.6	1.15	.31	.12	20	3.1	27
2	.34	1.4	1.36	.37	.12	21	2.9	16
3	.38	2.0	1.02	.20	.09	19	2.9	18
4	.40	1.7	1.12	.22	.10	22	2.9	21
5	.34	2.0	.96	.24	.11	21	3.0	25
6	.37	2.0	1.09	.19	.10	20	3.1	16

Table 12. Lupin Plant Samples, Top Four Inches When Plant Eight Inches Tall. 5/28, Staples

Treatment	P	K	Ca	Mg	Mn	Zn	Cu	B
	---------- % --------					---- ppm ----		
1	.37	2.4	.85	.27	.11	26	2.7	24
2	.35	1.8	1.08	.33	.11	32	2.9	18
3	.38	2.5	.96	.19	.09	30	3.1	20
4	.44	2.4	.93	.22	.10	30	2.9	18
5	.39	3.1	.82	.23	.11	26	3.3	20
6	.44	2.1	.93	.19	.11	26	3.3	20

TRITICALE - RYE STUDY

H. Meredith and M. Weins

Triticale is a synthetic grain derived from durum wheat x rye. Although the crop has been around for sometime, only recently has the crop received new emphasis.

New varieties have been released and this study is intended to evaluate these varieties. Three new winter varieties were planted in the fall of 1986 and one new spring variety will be planted in 1987. Additionally a new rye variety was planted in the fall of 1986 and this variety will be evaluated against the triticale varieties.

The data below lists limited data on the varieties harvested in 1986 at the Staples Station, Staples, MN.

Table 1. Composition of Whole Plant Harvested on 5/28/86 Just Prior to Heading.

Variety	N	S	P	K	Ca	Mg	Mn	Zn	Cu	B
	%						ppm			
Rymin Rye	2.2	.17	.30	2.7	.33	.16	47	28	2.2	3.8
Triticale I-18	2.4	.18	.35	3.3	.38	.13	73	30	2.1	3.0
Triticale 239	2.3	.20	.37	3.5	.36	.14	80	34	2.4	3.4
T-Double Crop	2.2	.19	.35	3.4	.40	.14	80	35	2.4	3.1

Table 2. Flag Leaf Harvested on 5/28/86 Just Prior to Heading.

Variety	P	K	Ca	Mg	Mn	Zn	Cu	B
	%				ppm			
Rymin Rye	.27	1.6	-	.23	55	19	2.4	-
Triticale I-18	.33	2.3	-	.15	61	29	2.2	4.8
Triticale 239	.34	2.3	.29	.14	52	34	2.5	6.5
T-Double Crop	.40	2.4	.23	.14	46	43	3.0	5.2

Table 3. Composition of Whole Plant at Forage Harvest.

Variety	N	S	P	K	Ca	Mg	Mn	Zn	Cu	B
	%						ppm			
Rymin Rye	1.2	.10	.22	2.0	.24	.13	25	14	5	4
Triticale I-18	1.5	.10	.22	2.2	.25	.12	40	24	5	4
Triticale 239	1.4	.10	.23	2.3	.21	.12	37	26	6	4
T-Double Crop	1.5	.10	.25	2.5	.26	.12	42	36	6	5

Table 4. Yield of Rye and Triticale, Grain and Forage.

Variety	Bu/A	Tons/A (DM)
Rymin Rye	53.8[1]	3.22
Triticale I-18	59.3[2]	2.72
Triticale 239	39.2[2]	2.91
Triticale Double Crop	30.1[1]	2.87
Spring Triticale	34.2[2]	-

[1] Average of 2 replications

[2] Average of 3 replications

Table 5. Composition of Triticale and Rye Grain

Variety	N	S	P	K	Ca	Mg	Mn	Zn	Cu	B
	%						ppm			
Rymin Rye	2.1	.16	.46	.58	.53	.17	52	51	1.3	1.2
Triticale I-18	2.0	.16	.46	.60	.60	.18	63	52	1.7	1.2
Triticale 239	2.3	.17	.48	.62	.62	.19	63	59	1.8	1.1
T-Double Crop	2.4	.17	.47	.62	.64	.18	69	63	1.9	1.2
Spring Triticale	2.5	.18	.55	.68	.62	.21	70	63	1.5	1.6

Table 6. Composition of Triticale and Rye Straw After Harvest.

Variety	N	S	P	K	Ca	Mg	Mn	Zn	Cu	B
	%						ppm			
Rymin Rye	.33	.08	.07	1.2	.21	.04	42	14	1.1	1.6
Triticale I-18	.67	.09	.10	1.0	.23	.06	30	16	1.6	1.7
Triticale 239	.43	.08	.10	1.2	.20	.06	44	16	1.2	1.9
T-Double Crop	.61	.09	.15	1.4	.24	.07	45	23	1.3	1.8
T-Spring	.35	.08	.10	1.4	.18	.04	39	10	1.3	1.4

SOUTHERN EXPERIMENT STATION
WASECA, MINNESOTA

WEATHER DATA - 1986

Month	Period	Precipitation 1986	Precipitation Normal 1/	Avg. Air Temp. 1986	Avg. Air Temp. Normal 1/	Growing Degree Days 1986	Growing Degree Days Normal 1/
		---- inches ----		------ °F -----			
January	1-31	0.89	0.84	14.5	10.0		
February	1-28	0.52	0.99	13.4	16.4		
March	1-31	2.18	1.99	31.4	27.6		
April	1-30	4.13	2.64	48.4	44.7		
May	1-10	0.95		56.4		97.5	
	11-20	2.04		56.4		84.5	
	21-31	0.77		62.2		145.5	
	Total	3.76	3.76	58.4	57.7	327.5	334
June	1-10	0.91		66.5		165.0	
	11-20	1.77		68.8		186.5	
	20-30	5.21		70.9		204.0	
	Total	7.89	4.48	68.7	67.1	555.5	518
July	1-10	1.51		69.8		196.0	
	11-20	1.87		72.9		222.5	
	21-31	0.52		72.9		251.5	
	Total	3.90	4.02	71.9	71.2	670.0	641
August	1-10	0.11		67.2		173.5	
	11-20	0.40		66.6		170.0	
	21-31	1.90		61.2		136.5	
	Total	2.41	3.99	64.9	68.8	480.0	579
September	1-30	5.57	3.36	59.8	59.8	340.5	311
October	1-31	2.83	2.08	48.3	48.9	37.0	38
November	1-30	1.42	1.43	25.6	32.5		
December	1-31	0.35	1.02	21.6	18.0		
Year	Jan-Dec	35.85	30.60	44.1	43.6	2410.5 2/	2421
Growing Season	May-Sep	23.53	19.61	64.7	64.9	2373.5	2383

1/ 30-year normal from 1951 - 1980.
2/ 50 to 86°F base, May 1 until first fall frost.

Notes:
1) Highest temperature on June 20 and July 19 -- 92°.
2) Highest 24-hour precipitation on June 21 -- 2.46".
3) Highest 48-hour precipitation on June 21-22 -- 4.64".
4) Last spring frost -- April 22.
5) First fall frost -- October 6.

ROTATION NITROGEN STUDY

Waseca, 1986

G. W. Randall, P. L. Kelly, and M. P. Russelle

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

EXPERIMENTAL PROCEDURES

Four crop sequences (continuous corn, corn-soybean, corn-wheat, and corn-wheat + alfalfa) were begun in 1974 on a Webster clay loam. Each N plot within each crop sequence is 15' wide (6 rows) by 50' long. Rates of N (0, 40, 80, 120, 160, and 200 lb N/A) have been applied annually to corn.

The corn-wheat + alfalfa sequence was dropped in 1981 in favor of a continuous corn system where all of the corn was removed as silage the preceding year. This gives us a comparison of the N needs between grain removal only compared to total above-ground biomass removal. In 1982, a C-C-Sb rotation was introduced to examine the N needs of second-year corn following soybeans. All plots are replicated five times in a split-split plot design with crop sequences as the main plot, which is split into six N rates with each N plot split into two corn hybrids.

In 1986, anhydrous ammonia was applied on April 23 to all corn plots. All plots were moldboard plowed in the fall of 1985 and field cultivated on April 25, 1986.

Each corn plot was split lengthwise and two corn hybrids (Pioneer 3732 and Pioneer 3906) were planted in 30" rows at 30800 ppA on May 3. Counter was applied to all corn plots at 1 lb/A to control rootworms. Weeds were chemically controlled along with one cultivation of the corn. A combination of 3½ qt Lasso plus 3½ lb Bladex/A was applied preemergence to corn. No starter fertilizer or broadcast P and K was used because of high soil test P and K levels.

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

After the 1985 harvest and again in the spring of 1986 prior to N application, soil samples were taken to a depth of 5' from the 0 and 160-lb N treatments which were applied to the continuous corn (grain) and continuous corn (silage) rotations. Soil samples were also taken from the 0-lb N treatments in the plots where soybeans and wheat were the 1985 crops. Two cores were taken/plot, divided into 1-foot increments, composited/rep, dried, crushed, and analyzed for NO_3-N by the University of Minnesota Soil Testing Laboratory.

RESULTS

Nitrate-N levels remaining in the soil profile after the 1985 crop, which was available to the 1986 corn, are presented in Table 1. When no fertilizer N was applied in 1985 (except the blanket 50-lb rate to wheat) very little difference in residual NO_3-N remaining in October appeared among the five crop sequences.

Samples taken from these 0-N plots the following spring showed marked decreases (33 to 58%) in NO_3-N compared to the fall sampling except following soybeans where NO_3 levels were reduced by only 22%. From 40 to 75% of the residual NO_3-N was found in the top foot of the 5-foot profile with all four crops. When the 160-lb rate of N was applied to continuous corn (grain and silage), a significant amount of residual N was found throughout the 5-foot profile in the fall. Samples taken the following April from these same plots showed approximately a 20% decline in NO_3-N throughout the profile. Reasons for these decreases are thought to be due to either denitrification or leaching.

Please refer to title page of this publication for information regarding application and use of this article.

Table 1. Effect of N rate applied to corn and crop sequence on residual NO_3-N remaining in the 0-5' profile in the fall of 1985 and at the beginning of the 1986 growing season.

	October, 1985				April 1, 1986			
	1985 Crop							
Profile depth	Corn (grain)	Corn (silage)	Soybeans	Wheat	Corn (grain)	Corn (silage)	Soybeans	Wheat
feet	lb NO_3-N/foot							
	0 lb N/A							
0-1	19	21	24	17	20	17	21	20
1-2	2	10	14	12	6	1	12	6
2-3	8	7	13	10	1	1	8	5
3-4	7	5	8	8	1	2	7	3
4-5	7	9	9	8	2	1	5	3
Total(lb NO_3-N/5')	53	52	68	55	30	22	53	37
	160 lb N/A							
0-1	27	23			24	23		
1-2	27	18			17	15		
2-3	24	19			19	19		
3-4	20	18			13	17		
4-5	21	19			15	12		
Total(lb NO_3-N/5')	119	97			88	86		

Corn grain yield, leaf N, grain N, grain N removed, and grain moisture at harvest are shown in Table 2 for each of the treatments. All data are an average of five replications. Averages and statistical interpretations for each of the main factors and the two-way interactions are shown in Table 3.

Grain yield

Corn yields were excellent in 1986 considering the moisture stress encountered from mid-July until mid-August. As in previous years crop sequence had a substantial effect on corn yield. Yields following soybeans or wheat were significantly higher (18 to 35 bu/A) than when following continuous corn (either for grain or silage) when averaged over N rates and hybrids. Second year corn yields following soybeans were not different from continuous corn. When averaged over N rates and hybrids, corn yields following soybeans were significantly higher than when following wheat. Yields were economically maximized with the 200-lb N rate when averaged over crop sequence and hybrids; however, the sequence x N rate interaction was highly significant. Yields from the two hybrids were identical when averaged over sequence and N rates.

Closer examination of the interactions reveals additional information. The sequence x N rate interaction was highly significant (P = 99% level) when averaged across hybrids. For the CC(g), CC(s), C-Sb, C-W, and Sb-C-C systems, highest yields were obtained statistically at the 160, 160, 120, 120, and 160-lb N rates, respectively, and were economically maximized at the 200, 200, 200, 160, and 200-lb rates, respectively. Yield responses of 84.7, 92.5, 72.0, 90.1, and 96.6 bu/A were obtained with the maximum economic rate of N for each of the respective crop sequences. Yields with the 0-lb N rate were lowest with the CC(g), CC(s) and Sb-C-C systems, intermediate with the C-W system, and highest with the C-Sb system. These data indicate that the higher amounts of plant residue incorporated from the 1985 CC(g) and Sb-C-C systems probably immobilized greater amounts of N than from the lower residue crop systems. Also, corn yield responses in all crop sequences to N rates of either 160 or 200 lb/A is not consistent with past years and indicates that the very wet June may have caused losses of fertilizer N.

Similar to 1985, the sequence x hybrid interaction was not significant indicating that the two hybrids behaved identically across all sequences. On the other hand, a significant N rate x hybrid interaction was found. At the 0- and 40-lb N rates, P3732 yields were 4.9 and 3.9 bu/A higher, respectively, than P3906. Yields were identical between the two hybrids at the 80-, 120- and 160-lb rates. At the 200-lb rate P3906 yielded 4.0 bu/A better than P3732 when averaged over sequences. No three-factor interaction was found.

Corn yield responses to N with each of the sequences did not appear to show any consistent relationship to the residual soil NO_3-N levels shown in Table 1. This is consistent with past years.

Table 2. Corn grain yield, leaf N, grain N, grain N removed, and grain moisture as influenced by previous crop, N rate and hybrid at Waseca, 1986.

Previous Crop	Hybrid	N rate (lb/A) 0	40	80	120	160	200
		Yield (bu/A)					
Cont. Corn (grain)	3906	68.3	94.4	112.1	131.7	148.8	160.0
	3732	75.8	97.8	111.8	135.6	153.0	153.6
Cont. Corn (silage)	3906	69.2	93.7	118.5	147.3	148.2	170.6
	3732	76.8	96.7	115.9	141.8	144.4	160.5
Soybeans	3906	108.0	134.2	147.8	166.0	174.1	177.7
	3732	106.0	141.8	145.8	169.0	175.0	180.3
Wheat	3906	80.7	111.1	143.4	169.4	170.3	172.3
	3732	85.3	111.9	141.5	165.0	174.1	174.0
Corn after soybeans	3906	56.4	84.1	104.9	139.8	153.1	160.6
	3732	63.2	89.1	110.9	138.3	148.1	152.3
		Leaf N (%)					
Cont. Corn (grain)	3906	1.30	1.39	1.77	2.07	2.27	2.42
	3732	1.33	1.48	1.77	2.20	2.54	2.62
Cont. Corn (silage)	3906	1.30	1.49	1.68	2.30	2.51	2.51
	3732	1.29	1.51	1.78	2.21	2.38	2.67
Soybeans	3906	1.45	1.84	2.28	2.63	2.57	2.84
	3732	1.55	2.01	2.27	2.62	2.73	2.80
Wheat	3906	1.34	1.76	2.07	2.35	2.74	2.65
	3732	1.43	1.67	2.07	2.65	2.75	2.89
Corn after soybeans	3906	1.16	1.38	1.60	2.12	2.43	2.60
	3732	1.18	1.41	1.81	2.29	2.34	2.66
		Grain N (%)					
Cont. Corn (grain)	3906	1.20	1.14	1.21	1.25	1.32	1.46
	3732	1.07	.96	1.01	1.09	1.18	1.25
Cont. Corn (silage)	3906	1.14	1.14	1.16	1.29	1.29	1.39
	3732	1.00	.96	.96	1.07	1.14	1.23
Soybeans	3906	1.13	1.19	1.22	1.33	1.36	1.49
	3732	.96	1.00	1.07	1.23	1.23	1.30
Wheat	3906	1.13	1.10	1.16	1.31	1.37	1.43
	3732	.96	.97	1.04	1.14	1.21	1.32
Corn after soybeans	3906	1.14	1.10	1.10	1.25	1.29	1.46
	3732	.97	.91	.97	1.08	1.13	1.24
		Grain N Removed (lb/A)					
Cont. Corn (grain)	3906	38.8	51.1	64.6	78.2	93.1	109.9
	3732	38.7	44.6	53.5	70.5	85.0	90.6
Cont. Corn (silage)	3906	37.2	50.4	65.0	90.1	90.7	112.2
	3732	36.7	44.0	52.6	71.8	78.0	93.2
Soybeans	3906	58.3	76.0	85.5	104.6	112.1	125.1
	3732	48.2	67.7	74.0	98.9	102.2	110.3
Wheat	3906	43.0	57.8	78.4	105.3	110.7	116.7
	3732	38.7	51.2	69.3	88.9	99.3	108.2
Corn after soybeans	3906	30.4	43.8	54.6	82.8	93.5	110.7
	3732	29.1	38.5	51.2	70.7	79.2	89.5
		Grain Moisture (%)					
Cont. Corn (grain)	3906	23.6	22.9	22.9	22.1	21.3	21.4
	3732	28.6	26.0	24.6	23.3	22.5	22.8
Cont. Corn (silage)	3906	24.0	23.2	22.8	22.1	21.9	21.4
	3732	28.9	26.1	25.1	24.1	23.3	22.8
Soybeans	3906	23.2	22.8	22.2	22.0	21.9	21.6
	3732	26.3	24.9	23.7	22.0	23.4	22.7
Wheat	3906	24.5	23.3	22.6	22.5	22.0	22.3
	3732	27.7	26.2	23.9	23.1	22.7	23.6
Corn after soybeans	3906	23.8	23.4	23.1	22.3	21.8	21.1
	3732	28.1	26.0	24.2	23.2	22.7	22.0

Table 3. Main factor and two-factor interaction averages for corn yield, grain moisture, grain N, grain N removal and leaf N in 1986.

Source		Grain Yield	Grain Moisture	Grain N	Grain N removed	Leaf N
		bu/A	------- %	--------	lb/A	%
MAIN FACTORS						
Sequence						
Cont. corn (grain)		120.2	23.5	1.18	68.2	1.93
Cont. corn (silage)		123.6	23.8	1.15	68.5	1.97
Sb-C		152.1	23.1	1.21	88.6	2.30
Wht-C		141.6	23.7	1.18	80.6	2.20
Sb-C-C*		116.7	23.5	1.14	64.5	1.91
Signif. Level (%):		99	55	96	99	99
BLSD (.05) :		7.9	--	.05	6.6	.10
N Rate (lb/A)						
0		79.0	25.9	1.07	39.9	1.33
40		105.5	24.5	1.05	52.5	1.59
80		125.3	23.5	1.09	64.9	1.91
120		150.4	22.8	1.21	86.2	2.34
160		158.9	22.4	1.25	94.4	2.53
200		166.2	22.2	1.36	106.6	2.67
Signif. Level (%):		99	99	99	99	99
BLSD (.05) :		4.8	0.3	0.03	2.9	0.08
Hybrid						
P 3906		130.6	22.5	1.25	79.0	2.03
P 3732		131.2	24.5	1.09	69.1	2.10
Signif. Level (%):		51	99	99	99	99
INTERACTIONS						
Sequence x N Rate						
CC(g)	0	72.1	26.1	1.13	38.7	1.32
	40	96.1	24.5	1.05	47.9	1.43
	80	111.9	23.8	1.11	59.1	1.77
	120	133.6	22.7	1.17	74.3	2.13
	160	150.9	21.9	1.25	89.1	2.40
	200	156.8	22.1	1.35	100.3	2.52
CC(s)	0	73.0	26.4	1.07	36.9	1.30
	40	95.2	24.7	1.05	47.2	1.50
	80	117.2	24.0	1.06	58.8	1.73
	120	144.6	23.1	1.18	81.0	2.26
	160	146.3	22.6	1.21	84.4	2.45
	200	165.5	22.1	1.31	102.7	2.59
Sb-C	0	107.0	24.8	1.04	53.2	1.50
	40	138.0	23.8	1.10	71.8	1.92
	80	146.8	22.9	1.15	79.7	2.28
	120	167.5	22.5	1.28	101.8	2.62
	160	174.6	22.7	1.30	107.2	2.65
	200	179.0	22.2	1.39	117.7	2.82
Wht-C	0	83.0	26.1	1.04	40.8	1.38
	40	111.5	24.7	1.03	54.5	1.72
	80	142.5	23.2	1.10	73.9	2.07
	120	167.2	22.8	1.23	97.1	2.50
	160	172.2	22.4	1.29	105.0	2.74
	200	173.1	22.9	1.37	112.4	2.77

Source		Yield	Grain Moisture	N	Grain N removed	Leaf N
		bu/A	------- % --------		lb/A	%
Sb-C-C*	0	59.8	25.9	1.05	29.7	1.17
	40	86.6	24.7	1.00	41.2	1.39
	80	107.9	23.6	1.04	52.9	1.71
	120	139.1	22.7	1.17	76.7	2.20
	160	150.6	22.2	1.21	86.4	2.38
	200	156.4	21.6	1.35	100.1	2.63
Signif. Level (%):		99	90	94	96	69
BLSD (.05) :		15.6	--	--	10.4	--
BLSD (.10) :		13.2	1.1	0.09	8.8	--
Sequence x Hybrid						
CC(g)	3906	119.2	22.4	1.26	72.6	1.87
	3732	121.2	24.6	1.09	63.8	1.99
CC(s)	3906	124.6	22.6	1.23	74.3	1.97
	3732	122.7	25.0	1.06	62.7	1.97
Sb-C	3906	151.3	22.3	1.29	93.6	2.27
	3732	153.0	24.0	1.13	83.6	2.33
Wht-C	3906	141.2	22.9	1.25	85.3	2.15
	3732	141.9	24.5	1.10	75.9	2.24
Sb-C-C*	3906	116.5	22.6	1.22	69.3	1.88
	3732	117.0	24.4	1.05	59.7	1.95
Signif. Level (%):		34	94	40	23	59
BLSD (.10) :		--	0.3	--	--	--
N rate x Hybrid						
0	3606	76.5	23.8	1.15	41.5	1.31
	3732	81.4	27.9	.99	38.3	1.36
40	3906	103.5	23.1	1.13	55.8	1.57
	3732	107.4	25.8	.96	49.2	1.61
80	3906	125.3	22.7	1.17	69.6	1.88
	3732	125.2	24.3	1.01	60.1	1.94
120	3906	150.8	22.2	1.29	92.2	2.29
	3732	150.0	23.3	1.12	80.1	2.39
160	3906	158.9	21.8	1.33	100.0	2.50
	3732	158.9	22.9	1.18	88.7	2.55
200	2906	168.2	21.6	1.44	114.9	2.61
	3732	164.2	22.8	1.27	98.4	2.73
Signif. Level (%):		96	99	23	99	28
BLSD (.05) :		4.2	0.5	--	3.2	--
Seq. x N rate x Hybrid						
Signif. Level (%):		29	4	39	74	90
BLSD (.10) :						.25
CV (%) :		5.8	3.8	4.8	8.0	7.7

* = Position in sequence for which measurements taken.

In summary, corn yields (averaged over hybrids) from the 200-lb rate were approximately 9% higher when following either soybeans or wheat compared to continuous corn (grain or silage). This advantage was slightly below the advantages shown in previous dry years. Also, contrary to reports from Purdue University, P3732 continued to respond to increasing N rates to 200 lb N/A. This same N rate also maximized the P3906 yield when averaged over sequences.

Grain Moisture

Grain moisture at harvest was unaffected by crop sequence but was reduced significantly by each N rate up through 160 lb/A. The shorter season hybrid (P3906) had significantly less moisture.

Interactions between crop sequence and N rate or hybrid were not significant at the 95% level. The highly significant interaction between N rate and hybrid was due to the greater difference in grain moisture betwwen the two hybrids at the low N rates (4.1 and 2.7 points at the 0 and 40-lb rates, respectively) compared to a 1.1 point difference at N rates ≥120 lb/A.

Grain N

Grain N concentrations were influenced by the crop sequence when averaged over N rates and hybrids. Highest N concentrations were found when corn followed soybeans while lowest levels occurred with second year corn after soybeans and CC(s). Grain N concentrations were increased by N rates up through 200 lb/A. The P3906 hybrid averaged 0.16% higher grain N or 1.0% higher protein than P3732 when averaged over sequence and N rate. The significant sequence by N rate interaction was due to the higher concentrations of N at N rates of ≥120 lb/A when corn followed soybeans or wheat compared to corn. At the low N rates, grain N concentrations were quite similar among the crop sequences except for CC(g) at the 0-lb rate. Interactions between sequence and hybrid and between N rate and hybrid were not found.

Grain N removed

Nitrogen removed in the grain crop was closely associated with both grain yield and grain N concentration. Highest grain N removal was when soybeans or wheat was the previous crop, when the 200-lb N rate was applied, and when P3906 was grown.

Nitrogen efficiency, as measured by grain N removed divided by fertilizer application rate, averaged 32, 30, 40, 47 and 35% for the N rates giving the highest yields (statistically) for the CC(g), CC(s), C-Sb, C-W, and Sb-C-C sequences, respectively. At the N rates where yields were maximized economically, the efficiency values were 31, 33, 32, 45, and 35%, respectively. Similar to 1985, N efficiency was highest in the corn-wheat sequence.

Leaf N

Concentrations in the earleaf at silking were significantly higher when corn followed either soybeans or wheat compared to following corn when averaged over N rates and hybrids. Leaf N was increased up through the 200-lb N rate when averaged over sequences and hybrids. Pioneer 3732 contained slightly more N in the earleaf than did P3906. Interactions among sequence, rate and hybrid were not significant (P = 95% level).

Silage production

Measurements were taken from the CC(s) crop sequence to determine fodder yield, fodder N concentration, fodder N uptake, silage yield, and total N uptake. Data shown in Table 4 indicate a significant effect of N up through the 120-lb rate on fodder yield. Similar to previous years, fodder yield of P3732 was significantly greater than P3906. The interaction between N rate and hybrid (P = 94% level) for fodder yield was due to P3906 responding to N rates up through 120 lb/A while P3732 only responded up through 80 lb/A. Fodder N concentration was maximized at the 200-lb rate and contrary to 1985 was significantly higher for P3732. Fodder N uptake was highest at the 200-lb N rate with an advantage for P3732 compared to P3906. The significant interaction between N rate and hybrid for fodder N concentration and uptake can be explained by P3906 maximizing both N concentration and uptake at the 120-lb rate while P3732 maximized both at the 200-lb rate.

Silage yields were increased significantly by N rates up through 160 lb/A and by the P3732 hybrid. Total N removed in the silage was increased with increasing N rates up through 200 lb/A. Equal amounts of N were removed by both hybrids. N efficiency with both hybrids fertilized at the 200-lb rate was 46%.

Summary - 1986

Corn grain yields averaged about 9% higher when corn followed either soybeans or wheat compared to continuous corn (grain or silage). Highest yields with minimum N input were found when corn followed either soybeans or wheat and were maximized at the 120-lb N rate. Yields with both P3732 and P3906 were maximized at the 160-lb N rate with the CC(g), CC(s), and Sb-C-C crop sequences. Grain N concentrations and grain N removal were significantly higher with the P3906 hybrid. Leaf N at silking was maximized at between 2.54% and 2.82% with the 200-lb rate for all crop sequences.

Table 4. Silage production as influenced by N rate and hybrid in a silage corn rotation at Waseca, 1986.

N rate	Hybrid	Fodder Yield	Fodder N	Fodder N Uptake	Silage Yield	Silage N Removal
lb/A		T DM/A	%	lb N/A	T DM/A	lb N/A
0	3906	1.55	.41	12.5	3.36	49.8
	3732	1.82	.42	15.2	3.86	53.6
40	3906	1.98	.34	13.3	4.48	63.9
	3732	2.44	.38	18.4	4.93	61.3
80	3906	2.35	.38	17.9	5.44	82.6
	3732	3.19	.38	24.3	6.41	82.2
120	3906	2.83	.42	23.6	6.53	106.7
	3732	3.18	.46	29.4	6.89	103.0
160	3906	2.90	.44	25.8	7.06	127.9
	3732	3.31	.44	29.5	7.64	127.6
200	3906	2.99	.45	26.9	7.29	142.0
	3732	3.39	.58	39.5	7.79	145.4
MAIN FACTORS						
N rate (lb/A)						
0		1.69	.41	13.9	3.66	51.7
40		2.21	.36	15.8	4.71	62.6
80		2.77	.38	21.1	5.93	82.4
120		3.01	.44	26.5	6.71	104.8
160		3.11	.44	27.6	7.35	127.8
200		3.19	.51	33.2	7.54	143.7
Signif. Level (%)[1/] :		99	99	99	99	99
BLSD (.05) :		.21	.04	3.0	.39	7.2
Hybrid						
3906		2.43	.40	20.0	5.69	95.5
3732		2.89	.44	26.0	6.27	95.5
Signif. Level (%)[1/] :		99	99	99	99	2
INTERACTION			Significance Level (%)[1/]			
N rate x Hybrid		94	99	97	55	11
CV (%) :		7.5	9.	14.	5.7	8.9

[1/] Probability level of significance

TWELVE-YEAR YIELD SUMMARY

Average corn yields over this 12-year period have been optimized with 175, 140, and 140 lb N/A for the continuous corn, corn-soybean, and corn-wheat sequences, respectively. At these N rates, yields for corn following soybeans and wheat where 15 and 13% higher than for continuous corn.

Table 5. Effect of previous crop on corn response to N from 1975-86 at Waseca.

N rate	Previous Crop: Corn(g)	Soybeans	Wheat
lb N/A	bu/A		
0	75	109	104
40	100	134	130
80	115	146	147
120	125	153	151
160	133	158	154
200	136	158	156

SPLIT APPLICATION OF N FOR CORN ON A WEBSTER SOIL

Waseca, 1986

G. W. Randall and P. L. Kelly

Improved nitrogen (N) efficiency is a goal of many corn producers because of the enhanced economic return to their fertilizer dollar. One potential method of improving the efficiency of N is to apply it closer to the period of greatest demand by the plant. For corn this is the period from three weeks prior to three weeks after tasseling. Applying N closer to this period limits the potential for N loss due to leaching or denitrification. Split applications of N have been shown to be quite beneficial on coarse-textured soils where leaching losses are common. The primary purpose of this study was to evaluate split applications of N to a naturally, poorly drained Webster clay loam where leaching is thought not to be a problem.

EXPERIMENTAL PROCEDURES

A poorly drained Webster clay loam soil with lateral tile lines at 75-foot spacings was the experimental site. Corn, which had been fall moldboard plowed, was the previous crop. Soil tests of the site showed a pH = 6.9, OM = High, Bray P_1 = 58 lb/A (VH), and exchangeable K = 358 lb/A (VH).

Sixteen N treatments were applied in a randomized, complete-block design with five replications (Table 1). Each plot measured 10' wide (4 - 30" rows) by 60' long. Split treatments consisted of either a 1/3-rate applied preplant with the remaining 2/3 sidedressed or 2/3 applied preplant and 1/3 sidedressed. Preplant treatments of anhydrous ammonia (AA) and urea-ammonium nitrate solution (UAN) were applied on April 24 and May 5, respectively. Anhydrous ammonia was injected while the UAN was broadcast applied on the soil surface. Immediately after UAN application, the entire experimental area was field cultivated.

Corn (Pioneer 3906) was planted at 30400 ppA on May 7. No starter fertilizer was used. Counter was used at a rate of 1 lb(ai)/A to control rootworms. Weeds were chemically controlled with a preemergence application of Lasso (3½ qt/A) plus Atrazine (3 qt/A). Rootworm and weed control were excellent.

The sidedress portions of the split treatments were applied at the 8-leaf stage (June 19). The AA was injected while the UAN was applied either in bands to the soil surface 6" from the row using a bicycle sprayer with no. 55 orifices or injected 4 to 5" deep using Yetter coulters and thin-profile knives. All plots were cultivated on the following day to incorporate the surface-applied UAN. On June 21 and 22, 2.46 and 2.18 inches of rain, respectively, fell to completely saturate the plots for a 7 to 10-day period.

Five randomly selected whole plants were harvested from the center two rows at the silk initiation stage (July 18 for the 60, 120 and 180-lb N rates and July 21 for the 0-lb rate), were chopped, dried and weighed for dry matter accumulation, and were analyzed for total N concentration. Stover and silage yields were obtained at physiological maturity (PM) (Sept. 8) by hand harvesting 15' of row. Grain yields were determined on October 1 by harvesting the center two rows with a modified JD3300 plot combine. Chemical analyses of the whole plants, stover, and grain were performed by the Research Analytical Laboratory, University of Minnesota.

RESULTS

Whole plant N at silking

Severe N deficiency symptoms were very apparent for the lower N rates at the silking stage. Whole plant N concentrations given in Table 1 show all N treatments with significantly more N than the control. Factorial comparisions of the treatments show a linear response to N rate when averaged over source-time of application. When averaged over N rates significantly less whole plant N was found with the preplant AA and the split applications of 1/3 + 2/3 UAN and 2/3 AA + 1/3 UAN treatments compared to the 1/3 UAN + 2/3 AA treatment.

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Whole plant dry matter at silking

Total dry matter accumulation at silking was increased significantly over the control by all N treatments (Table 1). Factorial comparison of the treatments shows a linear response to N rate when averaged over method of application. Highest DM accumulation occurred with the preplant AA and the 2/3 AA + 1/3 UAN split treatments. These two treatments also showed the lowest N concentrations, probably a result of plant dilution.

Table 1. Whole plant N, stover N, stover yield, and final population as influenced by split applications of N.

Nitrogen			Whole plant at silk		Stover		Final
Rate	Time[1/]	Source[2/]	N	DM	N	Yield	population
lbN/A			%	g/pl	%	TDM/A	ppA x 10^3
0	--	CHECK --	.68	73	.39	1.65	26.5
60	PP	AA	.95	95	.36	2.28	27.2
120	"	"	1.27	98	.42	2.56	28.9
180	"	"	1.37	99	.47	2.95	30.7
60	1/3PP+2/3SD	UAN(PP)+AA(SD)	1.26	89	.39	2.11	27.6
120	"	"	1.36	88	.42	2.30	28.3
180	"	"	1.48	89	.49	2.47	27.3
60	"	UAN(PP)+UAN(Drib.SD)	1.04	88	.36	2.09	27.8
120	"	"	1.26	92	.36	2.26	27.1
180	"	"	1.42	95	.42	2.75	28.4
60	"	UAN(PP)+UAN(Inj.SD)	1.11	85	.33	2.08	26.6
120	"	"	1.36	89	.40	2.46	27.7
180	"	"	1.38	98	.42	2.46	27.7
60	2/3PP+1/3SD	AA(PP)+UAN(Drib.SD)	1.06	91	.38	2.60	27.6
120	"	"	1.27	95	.40	2.54	28.6
180	"	"	1.37	102	.41	2.65	28.9
Signif. Level (%):[3/]			99	99	99	99	99
BLSD (.05) :			.10	7	.06	.28	1.1
CV (%) :			6.5	5.9	11.	8.6	2.9
FACTORIAL COMPARISONS							
Main Factors							
N Rate (lb/A)							
60			1.08	90	.37	2.23	27.4
120			1.30	92	.40	2.42	28.1
180			1.40	97	.44	2.65	28.6
Signif. Level (%):[3/]			99	99	99	99	99
BLSD (.05) :			.05	3	.02	.12	.47
Method (N Time-Source)							
PP - AA			1.20	97	.42	2.60	28.9
PP/SD - UAN/AA			1.37	88	.44	2.29	27.7
PP/SD - UAN/UAN (Dribble)			1.24	92	.38	2.37	27.8
PP/SD - UAN/UAN (Inject)			1.28	91	.38	2.33	27.3
PP/SD - AA/UAN (Dribble)			1.23	96	.40	2.60	28.4
Signif. Level (%):[3/]			99	99	99	99	99
BLSD (.05) :			.06	5	.04	.17	.63
Interaction			Significance Level (%)[3/]				
N Rate x Method			90	49	58	94	99

1/ PP = preplant, SD = sidedress applied at the 8-leaf stage.
2/ AA = anhydrous ammonia, UAN = 28-0-0, Inj = injected 4 to 5" deep, Drib = dribbled in a band next to row.
3/ Probability level of significance.

Stover N

Nitrogen concentrations in the stover at PM were increased linearly by the N rates from 60 to 180 lb/A (Table 1). Only the 180-lb rate of preplant AA and 1/3 UAN (PP) + 2/3 UAN (SD) resulted in stover N concentrations significantly higher than the check. This was probably due to higher yields with all of the N treatments, thus, leading to greater dilution in the stover and translocation of N to the grain. Slight N differences existed among the five methods but none were significantly different from the check.

Stover Yield

Stover yield was increased signficantly over the check by all of the N treatments (Table 1). Highest yields were obtained with the 180-lb rate regardless of source or time of application. Significantly higher yields were found when the preplant (PP) applications consisted of AA compared to UAN. Yield differences were not found between the sidedressed AA and UAN sources or between the method of UAN application (dribble vs injected).

Table 2. Corn grain and silage production as influenced by split applications of N.

Nitrogen			Grain				Silage	Total N
Rate	Time	Source	Yield	H_2O	N	N Removal	Yield	Uptake
lb/A			bu/A	---	% ---	lb/A	TDM/A	lb/A
0	--	CHECK --	50.7	24.1	1.20	28.8	3.21	42.0
60	PP	AA	89.4	23.5	1.17	49.5	4.85	65.7
120	"	"	123.4	22.1	1.34	77.8	6.07	99.6
180	"	"	138.2	21.2	1.54	100.3	6.79	127.8
60	1/3PP+2/3SD	UAN(PP)+AA(SD)	91.4	22.7	1.27	55.0	4.80	71.6
120	"	"	125.6	22.2	1.44	85.4	5.79	105.2
180	"	"	140.7	21.9	1.56	104.0	6.07	128.4
60	"	UAN(PP)+UAN(Drib.SD)	68.8	23.6	1.24	40.4	4.22	55.5
120	"	"	100.8	22.3	1.25	59.5	5.04	75.9
180	"	"	127.2	21.3	1.42	85.6	6.37	108.9
60	"	UAN(PP)+ UAN(Inj.SD)	80.3	22.9	1.24	47.0	4.39	60.7
120	"	"	107.4	22.7	1.31	66.9	5.59	86.6
180	"	"	128.7	21.1	1.49	91.1	5.93	112.0
60	2/3PP+1/3SD	AA(PP)+UAN(Drib.SD)	89.1	22.8	1.20	50.5	5.53	70.5
120	"	"	114.0	21.3	1.35	72.6	5.95	93.0
180	"	"	134.7	21.2	1.49	94.9	6.23	116.6
Signif. Level (%):			99	99	99	99	99	99
BLSD (.05) :			11.2	1.1	.07	7.8	.53	7.1
CV (%) :			8.2	3.5	3.9	8.8	7.6	6.3
FACTORIAL COMPARISONS								
Main Factors								
N Rate (lb/A)								
60			83.8	23.1	1.22	48.5	4.76	64.8
120			114.2	22.1	1.34	72.4	5.69	92.1
180			133.9	21.4	1.50	95.2	6.28	118.7
Signif. Level (%):			99	99	99	99	99	99
BLSD (.05) :			5.1	.5	.03	3.6	.24	3.2
Method (N Time - Source)								
PP - AA			117.0	22.3	1.35	75.9	5.90	97.7
PP/SD - UAN/AA			119.2	22.3	1.42	81.4	5.55	101.7
PP/SD - UAN/UAN (Dribble)			98.9	22.4	1.30	61.8	5.21	80.1
PP/SD - UAN/UAN (Inject)			105.5	22.2	1.35	68.3	5.30	86.4
PP/SD - AA/UAN (Dribble)			112.6	21.8	1.35	72.7	5.90	93.4
Signif. Level (%):			99	67	99	99	99	99
BLSD (.05) :			7.0		.04	4.7	.34	4.3
Interaction			Significance Level (%)					
N Rate x Method			17	67	96	32	96	91

Table 3. Time of N uptake as influenced by rates and split applications of N.

Nitrogen			Stover N Yield[1/]		Grain N Yield at PM			
Rate	Time	Source	Silk	PM	Total	OLD[2/]	NEW[3/]	NEW[3/]
lb/A			lb N/A					% of total
0	--	CHECK --	29.3	13.2	28.8	16.2	12.7	45
60	PP	AA	54.0	16.2	49.5	37.8	11.7	24
120	"	"	79.0	21.8	77.8	57.1	20.7	26
180	"	"	92.4	27.5	100.3	64.8	35.4	35
60	1/3PP+2/3SD	UAN(PP)+AA(SD)	67.6	16.6	55.0	50.9	4.0	6
120	"	"	74.4	19.8	85.4	54.5	30.8	36
180	"	"	79.4	24.4	104.0	55.0	49.0	46
60	"	UAN(PP)+UAN(Drib.SD)	56.3	15.2	40.4	41.1	-0.8	-
120	"	"	69.5	16.4	59.5	53.1	6.4	10
180	"	"	84.1	23.3	85.6	60.8	24.8	29
60	"	UAN(PP)+UAN(Inj.SD)	55.2	13.7	47.0	41.5	5.5	11
120	"	"	74.2	19.7	66.9	54.5	12.4	19
180	"	"	83.0	20.9	91.1	62.0	29.0	32
60	2/3PP+1/3SD	AA(PP)+UAN(Drib.SD)	58.9	20.0	50.5	39.0	11.6	23
120	"	"	76.5	20.4	72.6	56.1	16.5	24
180	"	"	88.4	21.7	94.9	66.8	28.2	29
Signif. Level (%):			99	99	99	99	99	99
BLSD (.05) :			8.5	3.6	7.8	10.0	11.7	15.
CV (%) :			9.4	13.7	8.8	14.9	46.8	45.0
FACTORIAL COMPARISONS								
Main Factors								
N Rate (lb/A)								
60			58.4	16.3	48.5	42.1	6.4	12
120			74.7	19.6	72.4	55.1	17.4	23
180			85.5	23.6	95.2	61.9	33.3	34
Signif. Level (%):			99	99	99	99	99	99
BLSD (.05) :			3.8	1.5	3.6	4.4	5.2	6
Method (N Time - Source)								
PP - AA			75.1	21.8	75.9	53.3	22.6	28
PP/SD - UAN/AA			73.8	20.3	81.4	53.5	28.0	30
PP/SD - UAN/UAN (Dribble)			70.0	18.3	61.8	51.6	10.1	12
PP/SD - UAN/UAN (Inject)			70.8	18.1	68.3	52.7	15.6	21
PP/SD - AA/UAN (Dribble)			74.6	20.7	72.7	53.9	18.8	25
Signif. Level (%):			75	99	99	4	99	99
BLSD (.05) :			-	2.3	4.7	-	7.2	9
Interaction			Significance Level (%)					
N Rate x Method			95	97	32	84	86	92

1/ Silk = silk stage, PM = physiological maturity.

2/ OLD N = N in stover at silk - N in stover at PM; the difference is assumed to be translocated to the grain.

3/ NEW N = Total N in grain - OLD N; the difference is assumed to be absorbed from the soil after silking and/or translocated from the roots.

Final Population

Final populations were higher with increasing rate of N (Table 1). Similar to stover yield, populations were highest with those treatments that received their preplant N as AA compared to UAN. Exact reasons for these relationships and the highly significant N rate x method interaction are not obvious.

Grain Yield

Grain yields were increased significantly over the control by all N treatments (Table 2). Highest yields were obtained at the 180-lb rate for all application methods. When averaged over N rates, there was no difference between the single preplant AA application and the split applications when AA was either applied PP or SD in combination with UAN. However, split applications of N where UAN was the only source produced significantly lower yields. Yields were approximately 5 to 20% lower when UAN was the sidedressed material. Injecting the UAN did not significantly improve grain yields over the dribbled application method. These results indicate that significant losses of N occurred with the sidedressed UAN treatments. It is quite likely that the 4.54" of rain 2 to 3 days after the SD treatments were applied and the subsequent saturated soils may have contributed to denitrification and/or leaching of the N applied as UAN. Under these conditions the AA would have been fixed to the exchange sites and would not have undergone significant nitrification during this period. Thus, it was not susceptible to either denitrification or leaching.

Grain Moisture

Grain moisture at harvest was reduced by all of the 120 and 180-lb N treatments but was not affected significantly by the method of application (Table 2).

Grain N

Grain N was increased significantly over the control by all of the 120- and 180-lb N treatments and increased linearly at N rates from 60 to 180 lb/A when averaged over methods of application (Table 2). Highest N concentration was found with the split application of preplant UAN and sidedressed AA. The split treatment using UAN for both PP and SD applications resulted in significantly lower N concentrations. The highly significant N rate x method interaction was probably due to the small differences between the 60 and 120-lb rates when UAN was the only N source.

Grain N Removal

Grain N removal (product of grain yield times grain N concentration) was increased significantly over the check and linearly by all N rates (Table 2). Highest N removals were associated with the 180-lb rate with the single PP application of AA and the split application where AA was sidedressed. When averaged over N rates, N removal was highest with the split application where AA was SD, intermediate with the single PP application of AA and the split treatment where AA was applied PP, and lowest with the split applications where UAN was the sole source.

Nitrogen efficiency based on grain N removal minus that removed by the check averaged 33, 36, and 37% for the 60, 120, and 180-lb rates, respectively. When averaged over N rates, methods of application ranked according to highest efficiency were: split with UAN + AA (44%), single with preplant AA (39%), split with AA + UAN (37%), split with UAN both PP and SD injected (33%), and split with UAN both PP and SD dribbled (28%).

Silage Yield

Similar to grain yields, silage yields were increased significantly by all N treatments and continued to increase up through the 180-lb N rate (Table 2). Application of AA either all PP or 2/3 PP resulted in yields significantly higher than the other treatments. Lowest silage yields occurred with the split treatments when UAN was the sole N source, regardless of application method.

Total N Uptake

Total N uptake by the corn was calculated by multiplying the stover N concentration times stover yield and adding it to grain N removal. Results of total N uptake were almost identical to those of grain N removal.

Nitrogen efficiency based on total N uptake minus that removed in the check averaged 38, 42, and 43% for the 60, 120, and 180-lb rates, respectively. When averaged over N rates, efficiency was 46, 50, 32, 37 and 43% for the single PP application of AA, split UAN + AA, split UAN + UAN dribble, split UAN + UAN injected, and split AA + UAN, respectively.

Time of N Uptake

To determine the effect of delayed/split applications of N on the time of N uptake relative to silking, whole plants (above-ground portions) were analyzed for total N at the silking stage and at PM (both grain and stover). Nitrogen uptake at the time of silking was increased linearly over the check by all N treatments (Table 3). Method of application did not affect pre-silk N uptake. The significant (P = 95% level) N rate x method interaction was due the minimal affect of N rate with the UAN(PP) + AA(SD) treatment compared to all other treatments.

Stover N yield was increased over the check by all of the 120 and 180-lb rates except the 120-lb UAN(PP) + UAN(Drib.SD) treatment (Table 3). Treatments that contained AA, either PP or SD, generally showed slightly more stover N than those that contained only UAN. The significant interaction between N rate and method was due to the lack of rate effect with the AA(PP) + UAN(SD) treatment in contrast to the significant rate effect with the other treatments. The difference between N yield at silking minus that at PM was assumed to be translocated to the grain and is termed OLD N. The amount of OLD N was increased linearly by N rate but was not affected by method of application (time-source).

NEW N is assumed to be that N taken up into the above-ground portion of the plant after silking and is calculated by substracting the OLD N from the total N in the grain at PM (Table 3). New N as a percent of the total N in the grain averaged 45% from the check treatment. This high amount was primarily due to the low N uptake by the N deficient plants prior to silking. NEW N was increased significantly with increasing rate of application and averaged 12, 23 and 34% with the 60, 120 and 180-lb rates, respectively. The method of application (time-source) had a highly significant effect on the time of N uptake. Averaged over N rates, NEW N ranged from a high of 30% with the UAN(PP) + AA(SD) treatment to a low of 12% with the UAN(PP) + UAN(Drib.SD) treatment. Highest NEW N levels were found with the treatments that contained AA. Injecting the sidedressed UAN resulted in significantly higher levels of NEW N compared to the dribbled application. Split applications of N did not result in greater amounts of late-season N uptake (NEW N) than the preplant AA treatment. These data further substantiate the poor efficiency of the split applications of UAN under these climatic conditions, especially when dribbled on the soil surface.

Residual Soil NO_3-N

Soil samples were taken in 1-foot increments to a depth of 5' from the check plots and all 180-lb N treatments to determine the effect of method (time-source) of N application on the amount of NO_3-N remaining in the soil after harvest. The data shown in Table 4 indicate only 22 to 35 lb/A more NO_3-N in the soil with the 180-lb rates compared to the check. Differences among methods of application were not significant for the total NO_3-N in the 0-5' profile.

Table 4. Residual soil NO_3-N in mid-Oct, 1986 as influenced by N application method.

Profile depth	Check	Application method 1/ Preplant AA	Split UAN+AA	Split UAN+UAN(D)	Split UAN+UAN(I)	Split AA+UAN(D)
feet	lb NO_3-N/A					
0 - 1	20.6	20.6	25.8	22.3	16.7	26.6
1 - 2	14.1	21.4	24.9	17.6	18.6	20.2
2 - 3	12.8	20.8	26.8	26.5	19.0	17.4
3 - 4	12.9	21.4	19.8	24.3	26.3	19.5
4 - 5	17.4	22.4	16.1	19.8	19.2	20.9
Total in 0 - 5' profile	78.	106.	113.	110.	100.	105.

1/ 180 lb N/A

N Recovery

A partial N budget can be obtained by adding the total N uptake shown in Table 2 to the residual NO_3-N shown in Table 4 for each 180-lb treatment, and then subtracting out the uptake plus residual from the check treatment. From this one can calculate the percent recovery at the end of the season by dividing by the rate of N application. At the optimum 180-lb N rate, the percent recovery averaged: preplant AA (63%), UAN + AA (67%), UAN + dribbled UAN (55%), UAN + injected UAN (51%), and AA + dribbled UAN (56%).

CONCLUSIONS

Corn production was not improved in 1986 by split application of N to this Webster soil. Highest yields and greatest efficiency were obtained with the single preplant application of AA and the split application of 1/3 UAN(PP) + 2/3 AA(SD). Poorest yields and N efficiency occurred with the split applications when UAN was the sole N source. Differences between dribbled and injected SD application of UAN generally did not exist. These tesults may have been heavily influenced by the 4+ inches of rain that fell 2 to 3 days after the SD treatments were applied. However, one would have thought that under these wet conditions split applications of N would have performed better than a single preplant application.

ACKNOWLEDGEMENT

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

NITROGEN SOURCES FOR CORN WITH CONSERVATION TILLAGE IN SOUTHERN MINNESOTA

1986

G. W. Randall, P. L. Kelly and C. Zadak

Conservation tillage, which leaves plant residues on the soil surface, is frequently being practiced in southern Minnesota. These residues have been shown to affect N losses. Hence, best management practices, including proper N sources, are necessary to minimize loss of N and maximize economic return. The purpose of this study was to evaluate various N sources for corn production with conservation tillage on two contrasting soils in southern Minnesota.

EXPERIMENTAL PROCEDURES

Two sites which had been ridge-planted in 1985 were seletected for this study. One location was on a Mount Carroll silt loam (Mollic Hapludalf) on the Doug Emerson farm in Goodhue County. This soil represents a large acreage of well-drained, low organic matter, loessial soils cropped to corn in southeastern Minnesota. The other location was at the Southern Experiment Station, University of Minnesota in Waseca County. This Webster clay loam (Typic Haplaquoll) has inherently poor drainage, high organic matter content, and is extensively cropped to corn and soybeans. It represents a large acreage of soils in Southern Minnesota and Northern Iowa.

Soybeans was the previous crop in Goodhue Co. while the Waseca site had been in continuous corn. Soil tests for the Goodhue and Waseca sites follow: pH = 5.7 and 7.1; Bray extractable P_1 = 28 and 42 lb/A (High and Very High); exchangeable K = 222 and 427 lb/A (Med-High and Very High); and extractable SO_4 - S = 8 and 8 ppm (both Medium), respectively, for the two locations. Nitrate-N totaled 48 and 42 lb/A in the 0-5' profile (40 and 35 lb NO_3-N/A in 0-3') profile at the two sites. These were very low residual NO_3 levels. Surface coverage by plant residues averaged 32 and 44% at the two sites, respectively. Ridge height averaged 5.4 inches at the Waseca site.

Sixteen N treatments were replicated four times at the Goodhue site while 13 treatments were replicated four times at the Waseca site. A randomized, complete-block design was used at each site. Each plot measured 10' wide (4 - 30' rows) x 40' long in Goodhue County and 10' wide x 60' long in Waseca County.

Corn (Pioneer 3737) was planted with a John Deere Max-Emerge planter at a population of 27700 plants/acre on May 8 in Goodhue Co. and on May 7 in Waseca Co. Excellent weed and corn rootworm control was obtained with proper chemicals at both sites.

Nitrogen treatments were broadcast applied on the soil surface on May 14 in Goodhue Co. and on May 7 in Waseca Co. Rainfall in the 10-day period following N application in Goodhue Co. totaled 0.30" with .10" on the 1st day and 0.20" on the 10th day following application. At Waseca, 2.99" rain occurred in the 10-day period with .02", .57", .36" 1.38", .11", .53" and .02" on the 1st, 2nd, 3rd, 4th, 6th, 7th and 10th days, respectively, following application. Three quarters of the N (75 lb/A) for the split application was sidedress applied on the soil surface at the 7-leaf stage (June 19) at Goodhue Co. On the next day 1.80" of rain fell to move the AN into the surface soil.

Ten randomly selected leaves opposite and below the ear were taken at silking for N and S analyses. Fodder and grain yields were obtained at physiological maturity by hand harvest techniques at the Goodhue location while plots were combine harvested at Waseca. All stover and grain analyses were conducted on samples gathered at harvest. Chemical analyses were performed by the Research Analytical Laboratory, University of Minnesota.

Soil samples were taken in 1-foot increments to a depth of 3' from the 0, 60, 120, 180, and 240-lb AN treatments on November 11 at the Goodhue Co. site. These samples were dried, ground, and analyzed for NO_3-N to determine the carryover and accumulation of NO_3 in the soil profile.

RESULTS AND DISCUSSION

Rainfall during the 1986 growing season was considerably above normal in Goodhue Co. and slightly above normal in Waseca Co. (Table 1). Conditions were exceptionally dry during the 5-week period

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from mid-July to mid-August at Waseca and resulted in lower yields than expected. Slight amounts of rain occurred on the first day following application at both locations. However, these amounts would not have been sufficient to incorporate the surface-applied N adequately and some volatilization may have occurred. In Goodhue Co. 0.20" and 0.75" of rain fell 10 and 12 days, respectively, after application and should have incorporated the N sufficiently. During the 10-day period following application at Waseca, 2.99" of rain occurred to incorporate the N. Saturated soils did result, however, and may have caused some denitrification.

Table 1. Rainfall during the May thru October growing season in Goodhue and Waseca Counties.

Month	Location	
	Goodhue	Waseca
	inches	
May	3.42	3.76 (0.00)[1/]
June	4.89	7.89 (+3.41)
July	6.61	3.90 (- .12)
August	2.30	2.41 (-1.58)
September	10.54	5.57 (+2.21)
October	2.85	2.83 (+ .75)
TOTAL	30.61	26.36 (+4.67)

1/ Departure from 30-year normal.

Goodhue County

Even though low levels of NO_3 occurred in the soil profile at the beginning of the growing season, the combination of soybeans as the previous crop along with extremely favorable growing conditions during the season resulted in a minimal corn response to the N treatments (Tables 2 and 3). These small differences made it difficult to clearly establish the effects of the N sources and their interaction with rate of N application.

Nitrogen Concentrations

Leaf and grain N concentrations were increased over the control by the 100-lb N/A application rate but generally not by the 50-lb rate (Table 2). When averaged over N rate, differences among the N sources were not significant at the P = 95% level. At the 50-lb rate leaf N was lowest with the urea + AS treatment while grain N was lowest with the UAN treatment. The 100-lb N rate averaged over the six sources increased leaf, stover, and grain N significantly (P = 95% level). Increasing the application rate of AN from 100 to 200-lb N/A increased leaf N significantly but did not influence stover or grain N. The split application of AN did not improve the N concentrations in the plant tissue over the single, preemergence application. Significant (P = 90% level) interactions between N source and N rate were not found for leaf N, stover N, and grain N. Final population was not influenced by N source or rate.

Yields

Stover, silage and grain yields were increased significantly over the check by most of the N treatments, especially the 100-lb N rate (Table 3). Only the 50-lb N rate as urea failed to increase silage and grain yields over the check. When averaged over N rates, highly significant differences were found among the N sources. Stover and silage yields were lowest with urea and highest with the UAN, UAN + S and AS treatments. Grain yields were lowest with the urea + AS treatment and highest with the AS and UAN + S treatments; although differences among the AN, AS, UAN, UAN + S and urea treatments were not significant. Based on these results with AS and UAN + AS, one can speculate as to a S response, although the lower yields with the urea + AS treatment clouds the picture. The 100-lb N rate significantly increased stover, silage and grain yields over the 50-lb rate. Yields were also increased over the 100-lb rate by the 150-lb rate but not by the 200-lb rate or by the split treatment. No interaction between N rate and source was observed.

N Uptake

Uptake of N (product of N concentration times either the grain or grain + stover dry matter yield) was increased significantly over the check by all of the treatments except the 50-lb N rate as urea

or UAN (Table 3). Both grain and total N uptake were consistently lowest with urea when averaged over N rates. Little difference in N uptake was found among the other N sources. Both grain and total plant uptake were increased by the 100-lb rate over the 50-lb rate. Grain and total N uptake were increased over the 100-lb rate by the 150-lb rate as AN but not by the 200-lb rate or the split application. There was no N source x rate interaction. The significant N source by N rate interaction was due to higher grain and total plant uptake at the 120-lb rate with the AS, UAN + S, urea, and urea + AS sources, while with AN and UAN, uptake was not affected by rate. Reasons for this interaction are not known at this time, but may merely reflect the variability in the data.

Table 2. Nitrogen concentration in corn tissue and final population as affected by N source and rate of application in Goodhue Co.

N Treatment		N concentration in			Final
Source[1/]	Rate	Leaf	Stover	Grain	population
	lb N/A	%			ppA x 10^3
CHECK	0	2.63	.51	1.18	21.7
AN	50	2.76	.59	1.27	21.5
"	100	3.02	.63	1.39	20.6
AS	50	2.73	.52	1.22	23.1
"	100	3.01	.57	1.38	23.2
UAN	50	2.76	.54	1.20	22.6
"	100	2.97	.55	1.39	21.1
UAN+S	50	2.84	.55	1.24	22.2
"	100	3.03	.60	1.38	22.3
Urea	50	2.88	.50	1.24	21.6
"	100	2.92	.55	1.30	21.2
½UR+½AS	50	2.72	.54	1.23	22.7
"	100	2.91	.65	1.35	22.4
AN	150	3.00	.64	1.42	23.5
"	200	3.15	.67	1.35	23.7
"	100 split[2/]	3.07	.64	1.39	22.1
Signif. Level (%):		99	96	99	42
BLSD (.05)	:	.18	.14	.07	
CV (%)	:	4.4	13.	4.3	8.6
INDIVIDUAL FACTORS					
N Source (50+100 lb)					
AN		2.89	.61	1.33	21.1
AS		2.87	.55	1.30	23.1
UAN		2.87	.55	1.30	21.9
UAN+S		2.93	.58	1.31	22.2
Urea		2.90	.52	1.27	21.4
½UR+½AS		2.82	.60	1.29	22.6
Signif. Level (%):		54	66	61	72
N Rate (lb/A)					
50		2.78	.54	1.23	22.3
100		2.98	.59	1.37	21.8
Signif. Level (%):		99	97	99	62
INTERACTION			Significance Level (%)		
Source x Rate		68	9	77	5

1/ AN = ammonium nitrate, AS = ammonium sulfate, UAN = urea-ammonium nitrate, UAN + S = UAN + 2% S as AS (25-0-0-2), and UR = urea.

2/ 25 lb at preemergence (May 14) and 75 lb at 7-leaf stage (June 19).

Table 3. Corn yields and N uptake as influenced by N source and rate of application in Goodhue Co.

N Treatment		Yields			Ear	N Uptake	
Source	Rate	Stover	Silage	Grain	Moisture	Grain	Total[1/]
	lb N/A	----- TDM/A -----		bu/A	%	----- lb N/A -----	
CHECK	0	2.36	6.42	152.3	36.8	85.4	109.7
AN	50	2.60	7.26	173.3	36.4	104.2	134.5
"	100	2.65	7.46	179.4	36.8	118.2	151.6
AS	50	2.67	7.46	179.0	36.2	103.4	131.4
"	100	2.93	8.01	188.9	36.4	123.4	156.9
UAN	50	2.53	7.16	173.1	35.9	98.4	126.0
"	100	3.19	8.20	186.5	36.4	122.9	158.2
UAN+S	50	2.82	7.51	175.6	36.3	103.0	134.0
"	100	3.00	8.13	191.6	35.7	125.4	161.8
Urea	50	2.49	6.82	161.6	36.3	94.8	119.9
"	100	2.52	7.15	172.8	35.1	106.6	134.2
½UR+½AS	50	2.72	7.38	174.4	36.7	102.0	131.4
"	100	2.77	7.55	177.7	36.6	113.4	149.5
AN	150	3.13	8.32	193.6	35.9	129.9	170.0
"	200	2.83	7.86	187.4	35.8	119.8	157.1
"	100 split	2.80	7.51	175.1	36.8	115.1	151.1
Signif. Level (%):		99	99	99	29	99	99
BLSD (.05)	:	.39	.67	16.5		12.5	17.1
CV (%)	:	9.2	6.2	6.2	2.9	8.3	8.8
INDIVIDUAL FACTORS							
N Source (50+100 lb)							
AN		2.63	7.36	176.4	36.6	111.2	143.0
AS		2.80	7.73	184.0	36.3	113.4	144.2
UAN		2.86	7.68	179.8	36.2	110.7	142.1
UAN+S		2.91	7.82	183.6	36.0	114.2	147.9
Urea		2.51	6.98	176.1	35.7	100.7	127.1
½UR+½AS		2.74	7.46	167.2	36.6	107.7	140.4
Signif. Level (%):		98	99	98	59	95	95
BLSD (.05)	:	.28	.46	11.7		10.6	15.3
N Rate (lb/A)							
50		2.64	7.27	172.8	36.3	101.0	129.5
100		2.84	7.75	182.8	36.2	118.3	152.1
Signif. Level (%):		99	99	99	34	99	99
INTERACTION				Significance Level (%)			
Source x Rate		88	65	17	47	45	30

1/ Grain + stover

Sulfur Concentrations

Sulfur applications totaled 114, 8, and 57 lb S/A with the AS, UAN + S, and urea + AS treatments, respectively. These amounts of S significantly increased leaf and stover S concentrations and S uptake at the P = 99% level and grain S at the P = 93% level (Table 4). Highest S concentrations and uptake were generally found with the 114-lb rate of S. The 8 lb/A S rate applied with UAN increased leaf S over the UAN alone treatment but did not affect stover or grain S concentrations or S uptake. Nitrogen:S ratios ranged from 10.8 to 14.3 for leaves, 7.6 to 9.7 for stover, and from 13.6 to 14.5 for grain. Lowest N:S ratios were associated with either the 114 or 57-lb S rates.

Table 4. Sulfur concentrations and uptake by corn as influenced by N sources in Goodhue Co.

N Source[1/]	Leaf S	Stover S	Grain S	Sulfur Uptake Grain	Sulfur Uptake Total
	---------- % ----------			----- lb S/A -----	
AN	.213	.065	.096	8.16	11.6
AS	.279	.075	.100	8.89	13.3
UAN	.207	.059	.097	8.56	12.3
UAN+S	.223	.067	.095	8.59	12.6
Urea	.210	.057	.093	7.64	10.5
½UR+½AS	.256	.077	.099	8.36	12.6
Signif. Level (%):	99	99	93	99	99
BLSD (.05) :	.011	.011		.53	1.0
CV (%) :	3.3	11.	3.2	4.1	5.7

1/ 100 lb N/A

Residual Nitrate - N

Samples taken to a 3-foot depth after harvest showed very little relationship between N application rate and the NO_3 remaining in the soil profile (Table 5). Nitrate-N levels were very low. Apparently most of the N not taken up by the plants was leached beyond the 3-foot depth. (Because of extremely wet conditions, it was impossible to get samples below this depth.)

Table 5. Residual soil NO_3-N in the soil profile in November as influenced by N rate in Goodhue Co.

Profile depth	N Application Rate (lb/A) 0	60	120	180	240
feet	---------- lb NO_3-N ----------				
0-1	10	12	15	20	18
1-2	4	4	5	13	11
2-3	4	4	6	9	7
Totals 0-3	18	20	26	42	36

Nitrogen Budget

A partial N budget can be obtained by adding the total N uptake shown in Table 3 to the residual NO_3-N shown in Table 5 for each treatment, and then subtracting out the uptake plus residual from the check treatment. From this one can calculate the percent recovery by dividing by the respective N application rate. Using this method, % recovery totaled 54, 50, 56 and 33% for the 50, 100, 150, and 200-lb N rates, respectively. These low recovery rates indicate that substantial amounts of fertilizer N were lost from the soil or immobilized into the soil organic matter during the 1986 season.

Waseca County

Nitrogen Concentrations

Leaf N was increased significantly over the check by all N treatments (Table 6). Grain N was increased significantly by all of the 150-lb treatments except with the UAN and urea + AS sources. Stover N concentrations were generally not increased over the check by any of the N treatments due to the high variability (CV = 14.0). Leaf, stover, and grain N concentrations with the 150-lb rate averaged 16, 27 and 12% lower at this site than with the 100-lb rate at the Goodhue site.

When averaged over N rates, leaf N was significantly higher with the AA and AS treatments compared to the UAN and UAN + S treatments with the urea treatments being intermediate. Stover N was highest with the AA and AS treatments. Grain N was not affected by source of N. When averaged over the six N sources, leaf and grain N were both increased significantly by the 150-lb N rate. Interactions between N source and N rate were not significant for leaf, stover, or grain N.

Table 6. Nitrogen concentration in corn tissue, final population, and plant height as affected by N source and rate of application in Waseca Co.

N Treatment Source[1/]	Rate	N concentration in Leaf	Stover	Grain	Final population	Plant height
	lb N/A	---------- %	----------	----------	ppA x 10^3	cm
CHECK	0	1.46	.39	1.01	23.7	90
AA	75	2.30	.44	1.05	24.2	103
"	150	2.65	.51	1.21	24.5	103
AS	75	2.15	.45	1.10	24.7	120
"	150	2.59	.44	1.25	24.8	120
UAN	75	1.91	.38	1.02	24.2	109
"	150	2.35	.38	1.14	25.8	114
UAN+S	75	1.75	.39	1.01	24.2	110
"	150	2.45	.43	1.20	24.4	120
Urea	75	2.01	.39	1.06	24.2	115
"	150	2.65	.43	1.21	24.3	112
½UR+½AS	75	2.06	.39	1.11	24.7	118
"	150	2.39	.37	1.15	24.9	119
Signif. Level (%):		99	95	99	26	99
BLSD (.05)	:	.29	.11	.15		6
CV (%)	:	9.7	14.	8.7	4.9	4.2
INDIVIDUAL FACTORS						
N Source						
AA		2.47	.48	1.13	24.4	103
AS		2.37	.45	1.18	24.7	120
UAN		2.13	.38	1.08	25.0	112
UAN+S		2.10	.41	1.11	24.3	115
Urea		2.33	.41	1.13	24.3	114
½UR+½AS		2.23	.38	1.13	24.8	119
Signif. Level (%):		99	99	50	24	99
BLSD (.05)	:	.23	.06			4
N Rate (lb/A)						
75		2.03	.41	1.06	24.3	112
150		2.51	.43	1.20	24.8	115
Signif. Level (%):		99	75	99	80	90
INTERACTION				Significance Level (%)		
Source x Rate		58	35	22	20	90

1/ AA = anhydrous ammonia, AS = ammonium sulfate, UAN = urea-ammonium nitrate, UAN + S = UAN + 2% S as AS(25-0-0-2), and UR = urea.

Final Population and Plant Height

Plant population was not influenced by any of the N treatments (Table 6). Plant height (extended leaves) data taken on June 26 show plants to be 13 to 30 cm (5 to 12") taller with all of the N treatments compared to the check (Table 6). Plants were tallest with the AS and Urea + AS treatments, intermediate with the UAN, UAN + S and urea treatments, and significantly shorter with AA when averaged over N rates. Difference between the two N rates was not significant at the P = 95% level.

Yields

Grain and silage yields were increased over the check by all of the N treatments while stover yields were increased by only the 150-lb treatments (Table 7). Grain moisture was reduced significantly from the check by all of the N treatments.

When averaged over N rate, significant differences (P = 90% level) in stover and silage yields were not found among the N source treatments. Grain yields were highest with the AA and AS treatments and were significantly reduced (about 13%) with the UAN and UAN + S treatments. Stover, silage, and grain yields were all increased significantly by the 150-lb N rate over the 75-lb rate. Interactions between N source and N rate were not significant at the P = 95% level.

Table 7. Corn yields and N uptake as influenced by N source and rate of application in Waseca Co.

N Treatment		Yields			Grain	N Uptake	
Source	Rate	Stover	Silage	Grain	Moisture	Grain	Total[1/]
	lb N/A	----- TDM/A -----		bu/A	%	---- lb N/A ----	
CHECK	0	1.37	3.53	67.4	24.3	32.4	43.2
AA	75	1.94	5.47	121.7	22.0	60.9	78.3
"	150	2.08	6.09	141.0	21.1	80.8	101.5
AS	75	2.36	5.76	120.6	21.5	63.1	84.3
"	150	2.23	6.07	143.2	20.4	84.8	104.2
UAN	75	1.90	5.16	102.9	22.2	49.9	64.4
"	150	2.32	6.05	122.4	20.8	66.2	84.4
UAN+S	75	1.74	4.57	104.4	21.4	50.4	63.9
"	150	2.38	6.34	129.9	21.0	74.7	94.8
Urea	75	1.83	4.88	108.9	22.7	55.0	69.4
"	150	2.61	6.68	143.0	22.2	82.3	104.6
½UR+½AS	75	1.98	5.31	124.4	21.9	66.0	81.4
"	150	2.19	5.85	131.3	20.3	72.0	88.5
Signif. Level (%):		99	99	99	99	99	99
BLSD (.05)	:	.59	.89	19.1	1.3	16.4	20.5
CV (%)	:	18.	12.	12.	4.1	18.	18.
INDIVIDUAL FACTORS							
N Source							
AA		2.01	5.78	131.3	21.5	70.9	89.9
AS		2.29	5.92	131.9	20.9	74.0	94.3
UAN		2.11	5.60	112.7	21.5	58.1	74.4
UAN+S		2.06	5.46	117.1	21.2	62.6	79.3
Urea		2.22	5.78	126.0	22.5	68.6	87.0
½UR+½AS		2.08	5.58	127.9	21.1	69.0	85.0
Signif. Level (%):		46	29	95	98	88	88
BLSD (.05)	:			16.8	.97		
N Rate (lb/A)							
75		1.96	5.19	113.8	21.9	57.5	73.6
150		2.30	6.18	135.1	20.9	76.8	96.4
Signif. Level (%):		99	99	99	99	99	99
INTERACTION				Significance Level (%)			
Source x Rate		91	91	45	26	43	51

1/ Grain + stover

N Uptake

Nitrogen uptake in both the grain and total plant (grain + stover) was increased (P = 95% level) over the check by all treatments (Table 7). When averaged over N rates, differences among N sources were not significant although N uptake was consistently lowest with the UAN and UAN + S treatments. Uptake of N was significantly (P = 99% level) increased by the 150-lb N rate over the 75-lb rate when averaged over N sources. There was no N source by N rate interaction.

Sulfur Concentrations

Sulfur application rates with the AS, UAN + S, and urea + AS treatments totaled 170, 12, and 85 lb S/A, respectively. The 170-lb S rate consistently resulted in highest leaf, stover, and grain S (Table 8). Leaf, stover, and grain S were also increased with the 85-lb rate. The 12-lb rate applied with UAN did not affect leaf S concentrations but did increase stover and grain S slightly. Sulfur uptake in the grain was only increased with the AS treatment (170 lb S/A) while total plant S uptake was increassed with both the 85- and 170-lb S rates. Nitrogen:S ratios ranged from 8.7 to 17.7 for leaves, 4.5 to 10.2 for stover, and 11.7 to 15.1 for grain. In all cases lowest N:S ratios were found with the 85 and 170-lb S rates as AS while highest N:S ratios occurred with the AA treatments. Slight reductions inthe N:S ratio were noted with the UAN + S treatment.

Table 8. Sulfur concentrations and uptake by corn as influenced by N sources in Waseca Co.

N Source[1/]	Leaf S	Stover S	Grain S	Sulfur Uptake Grain	Sulfur Uptake Total
	%			lb S/A	
AA	.150	.050	.080	5.38	7.42
AS	.297	.097	.104	7.07	11.38
UAN	.150	.042	.080	4.68	6.70
UAN+S	.162	.055	.089	5.50	8.04
Urea	.160	.043	.080	5.45	7.72
½UR+½AS	.235	.071	.098	6.13	9.36
Signif. Level (%):	99	99	99	99	99
BLSD (.05) :	.034	.010	.008	1.12	1.59
CV (%) :	13.	12.	6.1	12.	13.

1/ 150 lb N/A

SUMMARY

Although differences did exist among the N sources when averaged over N rates, these differences did not show a consistent advantage for any one particular source. In Goodhue Co. slight advantages appeared with AS and UAN + S while urea and urea + AS resulted in the poorest yields. In Waseca Co., highest yields and N uptake were obtained with AA and AS while UAN and UAN + S resulted in the lowest yields. Corn production was maximized by the 150-lb rate at both locations.

Corn production was not enhanced significantly by the sulfur in the N treatments although S concentrations in the plant and S uptake were increased at both locations. A nitrogen budget calculated from the plant N uptake and residual soil NO_3 data in Goodhue Co. indicated N recovery to range from 33 to 56%, indicating substantial loss of N in 1986. Since SO_4-S is mobile and is easily leached, the extremely wet conditions during the growing season may have accounted for the rather consistent increases in plant S concentrations and S uptake with the 57 and 114-lb rates of S applied as AS.

ACKNOWLEDGEMENT

Sincere appreciation is extended to Allied Corporation, Division of Fibers and Plastics, for their financial assistance in this project.

NITROGEN LOSS TO TILE LINES AS AFFECTED BY TILLAGE

Waseca, 1986

G. W. Randall and P. L. Kelly

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

EXPERIMENTAL PROCEDURES

A study was initiated in 1975 on a Webster clay loam at Waseca to monitor the movement of N into a tile line installed in each of 12 plots measuring 45' by 50'. Each plot is enclosed with plastic sheeting to a 6' depth. Annual N rates of 0, 100, 200, and 300 lb N/A were applied from 1975-1979. No N was applied for the 1980 and 1981 crops. Residual N from N applied over the 5-year period (75-79) was utilized by the 1980 and 1981 corn crops. Soil samples to 10' and tile water samples taken in late 1981 showed little remaining evidence of the previous treatments.

In the fall of 1981, eight plots with the most uniform tile flow rates over the 1975-81 period were selected. Two tillage treatments (fall moldboard plow and no tillage) were replicated four times and randomized over the previous plot histories. Corn was grown on these plots in 1982 through 1985. The stalks were chopped in October, 1985 and moldboard plots plowed.

On April 22, 180 lb N/A as ammonium nitrate was broadcast applied to the surface of all plots. The moldboard treatment was then field cultivated. Corn (Pioneer 3732) was planted on May 3 at a population of 27700 plants/A with a John Deere Max-Emerge planter equipped with ripple coulters. Starter fertilizer was not used because of the high soil tests. Counter was applied at 1 lb (ai)/A to control rootworms. Weeds were controlled with a preemergence application of Lasso (3½ lb/A) and atrazine (3 lb/A) applied May 15. Weed and insect control was excellent.

The leaf opposite and below the ear was taken from 10 randomly selected plants per plot at silking (Moldboard plow = July 18, No tillage = July 21) and was analyzed for N. Silage and grain yields were taken at physiological maturity by hand harvesting 30 and 60' of row, respectively, from each plot.

Tile lines began flowing in mid March, 1986 and continued to flow intermittently until mid-July. Conditions were extremely dry in late-July and August and no tile flow was recorded during this period. Tile lines commenced flowing again in late September and flowed throughout October. When tile lines were flowing, flow rates were measured daily and samples taken on a Monday, Friday, Wednesday two-week rotation for NO_3 analysis. All analyses were done by the Research Analytical Lab.

Soil NO_3-N in the 0-8' profile was determined from two cores/plot taken in 1-foot increments on October 23, 1986.

RESULTS

Although yields and N removal tended to be consistently higher with the moldboard plow (MP) system compared to the no tillage (NT) system, differences between the two tillage systems were not significant at the P = 90% level (Table 1). Leaf and grain N and final population were not influenced by tillage system. Experimental variability was low as indicated by CV's below 5 for yield. These end-of-season results are markedly different from what was expected in mid-July. At that time, the MP plots exhibited larger corn growth with a dark green color, and advanced maturity compared to the shorter corn that showed N deficiency symptoms on the NT plots.

Please refer to title page of this publication for information regarding application and use of this article.

Table 1. Influence of tillage system on corn production and N utilization at Waseca in 1986.

Tillage system	Final population	Leaf N	Silage Yield	Silage N uptake	Grain Yield	Grain N	Grain N removal
	x10^{-3}	%	T DM/A	lb N/A	bu/A	%	lb N/A
Moldboard Plow	27.2	2.38	7.19	129.3	143.4	1.32	90.0
No Tillage	28.2	2.45	7.10	123.5	136.1	1.25	80.6
Signif. Level (%): 1/	81	35	30	43	78	81	81
CV (%) :	2.8	7.8	4.0	10.	4.8	4.7	9.3

1/ Probability level of significance.

Precipitation for April, June and the September-October period was 1.5, 3.3 and 3.0 inches above normal, respectively. Thus, most of the tile flow shown in Table 2 occurred in April, May, June and October. Total tile flow was slightly higher from the NT plots, however, the flow-weighted NO_3-N concentration was slightly lower. Total NO_3-N lost via the tile lines was not different between the two tillage systems. Average NO_3-N concentrations in the tile water continued their upward movement from about 11 mg/L in 1984 to 12 mg/L in 1985 to between 12.8 and 14.0 mg/L in 1986.

Table 2. Influence of tillage system on tile flow, NO_3-N concentration and NO_3-N loss in 1986.

Tillage system	Tile flow	Nitrate-N Concentration 1/	Nitrate-N Loss
	acre inches	mg/L	lb N/A
Moldboard Plow	15.8	14.0	48.2
No Tillage	17.4	12.8	52.0

1/ Flow-weighted

Parameter		Mar	Apr	May	June	July	Sept	Oct	Nov	Total
		Month								
		acre-inches								
Tile Flow	MP	2.32	2.57	3.64	3.82	.34	.76	2.38	.01	15.83
	NT	1.46	3.50	4.29	4.26	.49	.53	2.82	.03	17.38
		mg/L								
NO_3-N Concentration	MP	12.7	13.2	13.3	15.6	14.7	12.6	15.0	15.0	14.0
	NT	9.9	11.1	12.3	17.8	14.0	13.6	13.3	10.8	12.8
		lb N/A								
NO_3-N Loss	MP	6.1	7.7	11.6	13.2	1.2	1.9	7.6	0.02	48.2
	NT	3.4	9.0	11.7	17.9	1.6	1.5	8.2	0.07	52.0

Residual NO_3-N in the soil profile at the end of the 1986 growing season showed about 80 lb/A more N remaining with the NT system (Table 3). Greater amounts of NO_3 were found at each 1-foot increment with the NT system. The largest differences between the two tillage systems occurred below 5' where substantially more NO_3 had accumulated with NT. These results are somewhat different from 1985 when only about 30 lb more N remained under the NT system.

Table 3. Influence of tillage systems on residual NO_3-N in the soil profile in Oct., 1986.

Profile depth	Tillage System	
	Mb. Plow	No Tillage
feet	-------- NO_3-N (lb/A)	--------
0-1	14.2	18.5
1-2	13.2	28.7
2-3	24.2	26.4
3-4	29.0	36.2
4-5	27.2	28.9
5-6	19.3	37.3
6-7	17.4	32.0
7-8	15.8	29.9
Total (lb NO_3-N/A 0-8')	160.3	237.9

FIVE-YEAR SUMMARY

The cumulative totals for the 5-year period (1982-1986) are shown in Table 4. Corn yields over this period have averaged 8 bu/A better with moldboard plow tillage. Approximately 10% more N has been removed in the grain with moldboard plow tillage. This has been due to both higher yields and slightly higher grain N concentrations with the moldboard tillage system some years. Even so, very little difference in applied N removed in the grain exists between the two treatments (48% vs 44% for MP vs NT, respectively). Even though total water flow and NO_3-N lost through the tile lines was about 10% higher with no tillage, this small difference is considered to be insignificant when considering tile flow variability among the eight plots over this 5-year period.

Table 4. Cumulative effects of the two tillage systems over the 5-year period.

Parameter	Tillage System	
	Mb. plow	No tillage
Fert. N applied (lb/A)	900	900
Corn grain removed (bu/A)	673	633
N removed in grain (lb/A)	436	396
N removed in grain as a percent of applied N (%)	48	44
Tile flow (acre inches)	56.9	61.1
Nitrate-N lost in tile (lb/A)	136.6	149.3
N lost via tile lines as a percent of applied N (%)	15	17

STARTER FERTILIZER PLACEMENT EFFECTS ON CORN PRODUCTION

Waseca, 1986

G. W. Randall and P. L. Kelly

Starter fertilizers will increase in popularity as farmers attempt to maximize return from their fertilizer dollar and as reduced tillage becomes more popular. However, with less spring secondary tillage, farmers sometimes encounter problems with the conventional disk opener systems when moist soil is dislodged by them and then sticks to the depth bands on the planter. The result can be uneven seeding depth. To correct this problem, farmers would like to remove the disk opener fertilizer attachment and instead place the starter fertilizer directly with the seed rather than in the conventional 2 x 2" placement. The purpose of this study was to evaluate seed placement versus 2 x 2" placement of three liquid fertilizers on the early growth, final stand, and yield of corn.

Experimental Procedures

A Nicollet clay loam soil planted to corn in 1985, moldboard plowed in the fall, and field cultivated in the spring was the experimental site. The soil tests were: pH = 6.4, OM = High, Bray P_1 = 72 lb/A (VH), and exchangeable K = 390 lb/A (VH).

A randomized, complete block design with four replications was used. Factorial treatments consisting of three liquid starter fertilizers (10-34-0, 9-18-9 and 7-21-7), three rates and two placement methods (directly with the seed and 2" to the side and below) plus a no starter fertilizer check were applied. The 10-34-0 and 7-21-7 were applied at rates of 5, 10 and 15 gal/A while the 9-18-9 was applied at 4, 8, and 12 gal/A to give similar salt rates among all three sources.

Corn (Pioneer 3732) was planted in 30" rows with a JD Max-Emerge planter at 27,700 plants per acre on May 3. The liquid materials were applied either directly on the seed by running the delivery tube between the double disk openers on the planter or in the 2 x 2" position with the starter fertilizer disk opener. Counter (1 lb ai/A) was used as the rootworm insecticide. Chemical weed control consisted of 3½ qt. Lasso and 3½ qt. Bladex/A applied preemergence.

Plant counts to obtain emergence rate and final stand were then taken daily from two rows each 55' long for 12 days beginning on the 9th day after planting. Grain yield was determined by harvesting each plot with a modified JD 3300 plot combine.

Results and Discussion

Growing conditions following planting were excellent for corn germination and emergence. Soil temperature at the 2" depth averaged well above 50°F (Table 1). Soil moisture in the seed zone was slightly below field moist capacity at planting. Six days after planting 0.57" of rain thoroughly wet the seed zone. This was followed by 1.74" on the next two days which more than likely leached much of the salt from the seed zone.

The salt rate ($N+K_2O$) of fertilizers has been shown to be important when applying fertilizer with the seed. Ammonia toxicity and/or salt burn can affect the germination of seedlings. A rule of thumb in Minnesota based on older research is not to apply more than 15 lb of $N+K_2O$/A. The $N+K_2O$ application rates with the various treatments are shown in Table 2. Salt levels are higher for 7-21-7 and 9-18-9 than for 10-34-0 because of the K component. Fifteen gallons of either 10-34-0 or 7-21-7 and 12 gal of 9-18-9 clearly exceeded the 15 lb/A threshold.

Please refer to title page of this publication for information regarding application and use of this article.

Table 1. Daily precipitation and average soil temperatures (2" depth) in the 2-week period following planting.

Days after planting	Avg. Soil temperature (2") °F	Precipitation inches
1	60	0
2	69	0
3	70	0
4	65	0
5	61	.02
6	59	.57
7	59	.36
8	56	1.38
9	62	0
10	66	.11
11	53	.53
12	60	0
13	57	T
14	56	.02

Table 2. Salt rate as influenced by starter fertilizer material and rate of application.

Application rate	Liquid fertilizer 7-21-7	10-34-0	9-18-9
gal/A	lb $N+K_2O$/A		
4			7.7
5	7.5	6	
8			15.4
10	15.0	12	
12			23.1
15	22.5	18	

Emergence rate was generally delayed by about 1 day by the seed-placed fertilizers, especially with the high rate of application (Table 3). Application of the high rate of all fertilizer materials with the seed resulted in less than 50% of the plants emerged on the 10th day following planting compared to about 75% with the 2 x 2" placement. Emergence rates did not appear to be affected differently by the three liquid fertilizers. By 14 days after planting emergence had approached 100% regardless of treatment.

Final populations of the starter fertilizer treatments were not significantly lower than the check treatment (Table 4). Factorial analyses (Table 5) showed no population differences among the three liquid fertilizer materials and the three application rates but did show a highly significant difference (P = 99% level) between the two placement positions. However, when averaged over materials and rates, seed placement reduced the final population by only 2% compared to 2 x 2" placement. Interactions between material and rate of application, material and placement, and rate and placement were not significant at the P = 90% level.

Grain yield and moisture were not affected significantly (P = 95% level) by any of the treatments (Tables 4 and 5). A yield response was not obtained over the check yield.

Conclusion

Application of 10-34-0, 7-21-7 and 9-18-9 at the higher rates with the seed resulted in about a 1-day delay in emergence and a 2% reduction in population but did not affect yield. Moist conditions at planting and the 2.33" of rain that occurred from 5 to 8 days after planting more than likely diluted and moved the salts out of the seed zone. To be on the safe side, however, we cannot recommend rates greater than 10 gal/A with these materials when applied with the seed. Rates should be reduced further if soil conditions are very dry at planting and/or soils are lower in organic matter and coarse to medium textured. Application of urea-containing starter fertilizers (9-18-9) is discouraged even at low rates because of potentially severe phytotoxicity of the urea.

Table 3. Influence of liquid starter fertilizer material, application rate, and placement on emergence rate of corn.

Treatment			Days after planting								
Material	Rate	Placement	9	10	11	12	13	14	16	18	20
	gal/A		% of final stand								
None	0	Check	16	72	89	99	99	99	99	100	100
7-21-7	5	Seed	8	59	79	89	95	97	97	98	100
"	"	2 x 2	12	78	91	99	100	100	100	100	100
"	10	Seed	1	35	57	87	95	97	98	99	100
"	"	2 x 2	8	77	92	97	100	100	100	100	100
"	15	Seed	5	48	66	90	97	100	100	100	100
"	"	2 x 2	20	77	91	98	99	100	100	100	100
10-34-0	5	Seed	17	77	91	99	99	99	99	100	100
"	"	2 x 2	20	80	89	97	99	99	100	100	100
"	10	Seed	8	49	69	93	98	98	99	100	100
"	"	2 x 2	15	67	89	98	100	100	100	100	100
"	15	Seed	4	44	61	90	95	99	100	100	100
"	"	2 x 2	10	75	89	98	100	100	100	100	100
9-18-9	4	Seed	11	69	87	95	97	98	99	100	100
"	"	2 x 2	5	69	87	94	95	97	99	100	100
"	8	Seed	5	62	82	93	99	100	100	100	100
"	"	2 x 2	11	68	87	94	99	99	100	100	100
"	12	Seed	6	46	66	85	93	98	97	99	100
"	"	2 x 2	17	79	93	99	99	99	100	100	100

Table 4. Influence of liquid starter fertilizer material, application rate and placement on plant population, grain moisture and corn grain yield.

Material	Rate	Placement	Final population	Corn grain Moisture	Corn grain Yield
	gal/A		ppA x 10^{-3}	%	bu/A
None	0	Check	27.1	22.3	144.6
7-21-7	5	Seed	27.1	21.1	139.3
"	"	2 x 2	26.9	21.7	145.4
"	10	Seed	26.2	21.7	137.3
"	"	2 x 2	27.3	22.3	144.7
"	15	Seed	26.1	21.8	138.9
"	"	2 x 2	27.1	21.4	146.4
10-34-0	5	Seed	26.1	21.4	137.8
"	"	2 x 2	27.7	21.7	141.8
"	10	Seed	27.1	21.9	151.3
"	"	2 x 2	27.0	21.6	147.4
"	15	Seed	26.2	21.6	143.9
"	"	2 x 2	26.6	21.7	143.9
9-18-9	4	Seed	27.1	21.7	143.4
"	"	2 x 2	27.0	22.0	152.3
"	8	Seed	26.2	21.7	142.3
"	"	2 x 2	27.3	22.1	141.5
"	12	Seed	26.4	20.7	144.5
"	"	2 x 2	27.5	21.4	141.6
Signif. Level (%): 1/			99	81	60
BLSD (.05)	:		1.2	-	-
CV (%)	:		2.5	3.0	5.4

1/ Probability level of significance.

Table 5. Factorial analyses of the effect of liquid starter fertilizer material, rate, and placement on corn production parameters.

Factors		Population	Corn grain Moisture	Corn grain Yield
MAIN FACTORS		ppA x 10^{-3}	%	bu/A
Material				
7-21-7		26.8	21.7	142.0
10-34-0		26.8	21.6	144.3
9-18-9		26.9	21.6	144.3
Signif. level (%):		27	8	51
Rate (gal/A)				
5/4		27.0	21.6	143.3
10/8		26.9	21.9	144.1
15/12		26.6	21.4	143.2
Signif. level (%):		75	94	9
Placement				
Seed		26.5	21.5	142.1
2 x 2		27.1	21.8	145.0
Signif. level (%):		99	91	89
INTERACTIONS				
Material x Rate				
7-21-7	5	27.0	21.4	142.3
"	10	26.8	22.0	141.0
"	15	26.6	21.6	142.6
10-34-0	5	26.9	21.5	139.8
"	10	27.1	21.7	149.4
"	15	26.4	21.7	143.9
9-18-9	4	27.0	21.9	147.9
"	8	26.7	21.9	141.9
"	12	27.0	21.1	143.1
Signif. level (%):		53	89	92
Material x Placement				
7-21-7	Seed	26.5	21.6	138.5
"	2 x 2	27.1	21.8	145.5
10-34-0	Seed	26.5	21.6	144.3
"	2 x 2	27.1	21.7	144.4
9-18-9	Seed	26.6	21.4	143.4
"	2 x 2	27.3	21.8	145.1
Signif. level (%):		4	56	73
Rate x Placement				
5/4	Seed	26.8	21.4	140.2
"	2 x 2	27.2	21.8	146.5
10/8	Seed	26.5	21.8	143.6
"	2 x 2	27.2	22.0	144.5
15/12	Seed	26.2	21.4	142.4
"	2 x 2	27.1	21.5	144.0
Signif. level (%):		40	19	58
			Significance level (%)	
Material x Rate x Placement		99	60	26

SOIL TEST COMPARISON STUDY

Waseca, 1986

G. W. Randall and P. L. Kelly

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

PROCEDURES

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

Four samples consisting of approximately 35 cores each from a 0-7" depth were taken from each site. All samples were oven dried at 95°F, crushed and mixed thoroughly. The samples were then subdivided and sent to five laboratories which test the majority of the soil samples from Southern Minnesota. The laboratories were: A & L Agricultural Laboratories, Inc., Omaha, NE; Harris Laboratories, Inc., Lincoln, NE; Minnesota Valley Testing Laboratories, Inc., New Ulm, MN; AMOCO/Cropmate Co., Reinbeck, IA; and University of Minnesota Soil Testing Laboratory, St., Paul, MN. Soil anslyses requested consisted of pH, OM, extractable P, exchangeable K, extractable S and the micronutrients generally tested by each laboratory. Based on the results from the U of M laboratory these two sites were then classified as being initially "very high" and "medium-high". The fertilizer recommendations given by the five laboratories were then applied as five treatments in the spring of 1980 for corn. An additional check (no fertilizer) treatment was included in the randomized, complete-block design with six replications. Each plot measures 15' wide and 55' long.

After the 1980 crop, soil samples (5 cores/plot times 6 replications yielding 30 cores per treatment) were taken yearly from each treatment and sent to the respective laboratory. This allowed us to follow the buildup or decline of nutrients in the soil as affected by the recommendations of a particular laboratory over time. After 6 years (1980-85) the "very high" fertility site was terminated.

Fertilizer amounts based on the analyses and recommendations from the summer 1985 samples were applied October 31 to the appropriate plots before moldboard plowing. These fertilizer recommendations were based on a soybean yield goal of 55 bu/A following corn. Soybeans (Hardin) were planted in 15" rows on May 22. Chemical weed control consisted of 3½ qt. Lasso and 6 qt. Amiben/A applied preemergence to all plots.

Seed yield and moisture were determined by harvesting each plot with a modified JD 3300 plot combine. Yields were converted to 13.5% moisture.

In August, 1986, 0-7" soil samples were taken from each treatment except Cropmate's and were sent to the laboratory of the respective treatment. (The Cropmate laboratory is no longer in operation.) The recommendations obtained from these samples will be used for the 1987 growing season.

Please refer to title page of this publication for information regarding application and use of this article.

Medium-high testing site

The soil test results and the accompanying recommended fertilizer program of each laboratory are shown in Table 1. While the numeric values of the five laboratories were generally similar the corresponding interpretation (whether the soil tested high, low, medium, deficient etc.) varied substantially. Phosphorus and K recommendations among the labs were quite different. Nitrogen was recommended by two of the labs. Also, sulfur and zinc were each recommended by a private lab. Only one of the four private labs recommended liming the soil.

Table 1. Soil test results and the recommended fertilizer program from each laboratory on the medium-high testing site at Waseca in 1986.

Test	Soil Test Laboratory				
	A&L	Harris	MVTL	Cropmate	U of M
	Soil Test Results[1/]				
pH	6.3	6.7	6.3	6.5	6.8
pH (buffer)	6.7	---	7.0	7.0	---
Phosphorus	22 H	24 L	27 VH	36 H	17 H
Potassium	187 M	132 D	135 H	100 L	145 H
Organic matter (%)	4.7 H	4.2 A	4.3 M	5.6	H
Calcium	3200 H	3471 E	4350	2410 H	---
Magnesium	540 VH	440 A	590	363 H	---
Sulfur	8 M	8 A	16 VH	21 H	4 LM
Iron	74 VH	44 E	39 S	---	---
Manganese	31 VH	20 E	16 S	2.1 VH	---
Zinc	3.3 H	1.3 E	1.2 H	1.6 M	1.3 M
Copper	1.5 H	1.0 A	1.1 S	---	---
Boron	1.7 H	---	1.4 S	---	---
ENR (lb/A)	96	---	---	112	---
C.E.C. (meq/100 g)	23.4	21.4	27	15.3	---

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

Nutrient	A&L	Harris	MVTL	Cropmate	U of M
	Recommended Fertilizer Program[2/]				
Nitrogen	10	20	0	0	0
Phosphorus (P_2O_5)	25	72[3/]	0	28	20
Potassium (K_2O)	40	215[3/]	43	124[3/]	40
Sulfur	10	--	--	--	--
Iron	--	--	--	--	--
Manganese	--	--	--	--	--
Zinc	--	1.5	--	--	--
Lime (T/A)	1.5	--	--	--	--

2/ All values indicate pounds of nutrients recommended per acre for a yield goal of 55 bushels of soybeans per acre.

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

The treatments that received fertilizer yielded significantly more than the unfertilized check (Table 2). However, there were no significant yield differences among the fertilizer treatments (recommendations).

Table 2. Effect of fertilizer recommendations on soybean seed yield on the medium-high testing site at Waseca in 1986.

Lab	Fertilizer Recommendations lb/A[1/]	Seed Yield bu/A	Seed Moisture %
A&L	10 N + 25 P + 40 K + 10 S	55.8	14.9
Harris	20 N + 72 P + 215 K + 1.5 ZN	57.3	15.0
MVTL	43 K	55.3	14.9
Cropmate	28 P + 124 K	55.1	15.0
U of M	20 P + 40 K	54.7	14.8
Check		48.9	14.7
	Signif. Level (%):[2/]	99	99
	BLSD (.05) :	3.0	.2
	CV (%) :	4.7	1.0

1/ P and K expressed on oxide basis.
2/ Probability level of significance.

SUMMARY - 1986

Substantial differences again existed among the laboratories fertilizer recommendations. High amounts of P were recommended by the Harris lab while high amounts of K were recommended by the Harris and Cropmate Labs. Nitrogen, micronutrients and sulfur were recommended by two of the four private labs.

Differences in grain yield were not observed among the five laboratories' recommendations. Yields were excellent.

Fertilization resulted in highest profit from the MVTL recommendations and no profit from the Harris recommendations (Table 3). Fertilizer costs ranged from $4/A with the MVTL recommendation to $39/A with the Harris recommendation.

Table 3. Effect of fertilizer recommendations on yield, value, fertilizer, cost and economic return on the medium-high testing site at Waseca in 1986.

Lab	Yield bu/A	Value @ 4.57/bu	Fert cost[1/] $/A	Return[2/]
A&L	55.8	255	13	19
Harris	57.3	262	39	0
MVTL	55.3	253	4	26
Cropmate	55.1	252	17	12
U of M	54.7	250	8	10
Check	48.9	223	--	--

1/ Using May, 1986 prices for each nutrient expressed as dollars/lb as follows: N, .18; P_2O_5, .20; K_2O, .09; S, .28; Zn, 1.09.
2/ Return yield value @4.57/bu - (fertilizer cost & value of check trt).

SEVEN-YEAR SUMMARY

Yield responses paid for the fertilizer recommendations made by all five laboratories (Table 4). However, net return was highest with the lowest cost fertilizer recommendations. The higher cost recommendations given by A&L, Harris, and Cropmate resulted in lowest economic return. It is interesting to note the very narrow range in crop value among the five laboratories over this 7-year period (a low of $2409/A to a high of $2421/A).

Table 4. Effect of fertilizer recommendations on total crop value, total fertilizer cost and resulting economics on the medium-high testing site at Waseca from 1980-86.

Lab	7-Yr Total Crop Value[1/]	7-Yr Total Fertilizer cost	Return[2/]
	$/A		
A&L	2409	384	+199
Harris	2421	474	+121
MVTL	2412	287	+299
Cropmate	2411	449	+136
U of M	2415	263	+326
Check	1826	0	---

1/ 3.00, 2.40, 3.00 and $2.07/bu used for corn in 1980, 1981, 1983 and 1985, respectively, and 5.50, 6.00 and $4.57/bu used for soybeans in 1982, 1984 and 1986, respectively, for a seven-year total crop value.

2/ Return over 7-year period = crop value - (fertilizer cost & value of check treatment.

CONSERVATION TILLAGE FOR CORN AND SOYBEAN PRODUCTION

Waseca, 1986

G. W. Randall and J. B. Swan

With increasing emphasis on controlling erosion and minimizing energy requirements (time, labor, and fuel), tillage practices have changed markedly over the last decade. Many of tillage practices have come to be known as "conservation tillage". To fit this definition, a tillage practice must leave 30% of the soil surface covered with residue after planting. The primary purpose of this study is to evaluate five conservation tillage (CT) systems in a long-term corn-soybean sequence. A secondary objective is to determine the value of starter fertilizers in CT systems.

EXPERIMENTAL PROCEDURES

To evaluate some of these CT practices an experiment was started in 1975 with continuous corn grown on a Webster clay loam at the Southern Experiment Station. Five tillage treatments (no tillage, fall moldboard plow, fall chisel plow, ridge-plant and till-plant [flat]) were replicated four times. Each plot was 20' wide by 125' long. Tile lines spaced 75' apart run perpendicular to the rows in all plots. Beginning in 1979 all plots were split into two, 4-row plots -- one with starter fertilizer and the other without.

After 8 years of continuous corn, soybeans were planted in 1983 to begin a long-term corn-soybean rotation. Tillage and starter fertilizer treatments remained the same except the till-plant (flat) treatment was changed to a spring-disk (20" disk blade) treatment (Table 1). Because of increased pressure of the grass weeds in the no tillage treatment, all plots were split so that either the front or rear half received a postemergence application of Poast at a rate of ¼ lb/A with 1 qt of oil concentrate in the years that soybeans were grown.

Ridges for the ridge plant treatment in 1986 were built in June, 1985. After the 1985 soybean harvest, the moldboard and chisel plow treatments were performed. On April 25 the moldboard and chisel plow treatments were field cultivated once and the spring disk treatment was disked twice. Ammonium nitrate was broadcast-applied at a rate of 160 lb N/A immediately before the secondary tillage. Ridges for 1987 soybeans were prepared on June 25.

Corn (Pioneer 3732) was planted in 30" rows at a rate of 30,400 plants/A on May 6. All treatments except no-till were planted with a John Deere 7100 planter equipped with 2" fluted coulters. B&H ridge cleaners were attached to the planter for the ridge-plant (RP) treatment. Because of high surface soil density with no tillage, seeding depth was not adequate with this planter. Thus, a JD 7000 planter was used to get better seeding depth on this tillage treatment. Ten gallons/A of 7-21-7 was used as the starter treatment.

Broadcast P and K were not applied for the 1986 corn crop because of very high soil tests. Soil tests on this site in 1984 averaged: pH = 6.7, $Bray_1$ extractable P = 60 lb/A and exchangeable K = 424 lb/A. Chemical weed control consisted of 3½ lb Lasso and 3½ lb Bladex/A applied preemergence. In order to evaluate the effectiveness of the preemergence herbicide application on weed control, a plastic sheet 18" wide and 6' long was placed between the 4th and 5th rows of each plot during herbicide spraying to prevent the application of herbicide onto the soil surface. Weed counts (grass and broadleaf) were taken on June 3 from sprayed and unsprayed areas. Treatments 2, 3, 4, and 5 were cultivated on June 13. Weed control was excellent on all cultivated plots.

Surface residue coverage was measured by the line-transect method on April 9 prior to spring tillage and on May 27 after planting. Planting depth was determined by cutting off the coleoptile at the soil surface from all the plants in a 10-foot length of row in each tillage plot 33 days after planting. The seeds were then excavated and the length of the coleoptile to the seed was measured. Early plant growth (EPG) was determined by harvesting the above ground portion of 10 random plants per plot 41 days after planting. On June 17 soil samples were taken to a 12" depth from both the starter and no starter portions of the no tillage (NT), moldboard plow (MP), and chisel plow (CP) systems. Eight cores were taken from each plot and after dividing into 0-2, 2-4, 4-6, 6-9, and 9-12" depths were composited. After drying at 100°F they were submitted to the University of Minensota Soil Testing Lab for pH, $Bray_1$ extractable P and exchangeable K analyses.

Please refer to title page of this publication for information regarding application and use of this article.

Corn leaf samples were taken on July 16 from all treatments except NT, which was sampled on July 18, by randomly sampling the leaf opposite and below the ear from the starter treatment within each tillage treatment. Yields were taken by combine harvesting the center two rows from each plot with a modified JD 3300 combine. Grain moisture and N concentrations were determined on each of these samples.

RESULTS

Since the 2-way and 3-way interactions at the bottom of Table 1 are non-significant (P = 90% level), the comparison of main effects (tillage, starter fertilizer, and previous Poast treatment) is appropriate.

Significant differences in final population, grain moisture and grain yield were found among the tillage treatments when averaged over starter fertilizer and previous Poast treatments (Table 1). Final population of the NT and RP plots averaged about 2500 plants/A fewer than with the other treatments. Differences in final stand did not exist among the MP, CP and spring disk (SD) treatments. Final population was slightly higher with the starter fertilizer treatments but was not affected by the previous application of Poast.

Grain moisture, an indication of maturity, was significantly higher with the NT treatment compared to the CP, RP and SD treatments (Table 1). This was consistent with previous years when both continuous corn and corn after soybeans were grown. Grain moisture for the MP, CP, RP and SD systems was not significantly different at the P = 95% level. Neither starter fertilizer nor the previous Poast treatments affected grain moisture.

Grain yields were not significantly different (P = 95% level) among the MP, CP, RP and SD systems when averaged over starter fertilizer and Poast treatments (Table 1). The NT yields were closer to those from the other tillage systems this year than in previous years but were still significantly lower than the MP, RP and SD systems. Starter fertilizer gave a highly significant 9.7 bu/A yield increase when averaged across tillage systems. Even though a statistically significant interaction between tillage system and starter fertilizer did not exist (18% level), largest responses to starter were obtained with NT (12.7 bu/A), CP (12.1 bu/A), and RP (10.8 bu/A). Yield response to starter fertilizer averaged only 8.7 and 4.2 bu/A for the SD and MP systems, respectively. The previous Poast treatments did show a 4.5 bu/A yield advantage which was significant at the P = 92% level. This should perhaps be discounted because there was no Poast x tillage interaction and weed control was excellent with all tillage treatments except NT.

Early plant growth was affected significantly by the tillage systems (Table 2). Plants were largest with the RP and CP systems, were intermediate in size with the MP and SD systems and were significantly smaller with NT. Starter fertilizer increased early plant weight by 9% when averaged across tillage systems. The interaction between tillage and starter fertilizer was not significant (57% level). The correlation between EPG and grain yield was not significant when starter fertilizer was used (r = +.397) but was significant at the 99% level when no starter was used (r = +.566). A linear rather than curvilinear relationship was best for each. These relationships agree well with those obtained in 1984.

Grain N was not influenced by tillage or starter fertilizer (Table 2.) However, N removal in the grain (product of grain N concentration and grain yield) was affected significantly by both tillage and starter fertilizer. This effect was due largely to the yield differences among the treatments, which resulted in lowest N removal with the NT system and the plots without starter fertilizer.

Residue measurements taken prior to planting showed significant differences among the treatments for percent of the soil surface covered with residue from the previous crops (Table 3). The treatments ranked NT SD RP = CP MP. After planting, surface residue measurements were taken both within the row and randomly across the plot area. All tillage treatments showed significantly more residue than the MP treatment. However, only the RP and NT systems exceeded 30% and therefore met the definition of "conservation tillage". Within the row measurements showed slightly less residue than random across the plot measurements for all tillage sytems except MP.

Planting depth was not affected significantly by the tillage systems (Table 3). This was not consistent with previous years. The variability in the seeding depth as measured by standard deviation and range in depths indicates least variability with the NT, CP, MP and SD systems and greatest variability with the RP system. Seed placement averaged between 1.6" and 1.8" for the five tillage systems. Even though these differences are less than in previous years with continuous corn, they do point out the need for careful adjustment of the planter even when following soybeans.

Table 1. Influence of tillage methods, starter fertilizer and previous Poast herbicide treatment on corn production at Waseca in 1986.

Treatment					
Tillage	Starter[1/] fert.	Poast[2/] herb.	Final population x 10^3	Grain Moisture %	Grain Yield bu/A
No tillage	S	P	30.1	22.2	151.3
"	S	NP	29.6	22.7	156.8
"	NS	P	26.8	22.8	141.6
"	NS	NP	30.0	23.9	141.1
Fall plow, f. cult.	S	P	32.3	22.3	171.7
" "	S	NP	32.0	22.6	155.4
" "	NS	P	30.8	21.7	158.4
" "	NS	NP	31.3	22.9	160.3
Fall chisel, f. cult.	S	P	32.0	21.7	167.3
" "	S	NP	31.6	21.9	160.6
" "	NS	P	30.4	21.6	154.5
" "	NS	NP	31.4	22.0	149.3
Ridge plant	S	P	30.2	21.8	172.1
" "	S	NP	29.7	21.8	166.1
" "	NS	P	28.8	21.8	164.0
" "	NS	NP	27.6	22.2	152.5
Spring disk	S	P	32.3	21.9	166.7
" "	S	NP	32.4	21.4	173.6
" "	NS	P	30.5	22.1	168.3
" "	NS	NP	30.9	22.2	155.1
INDIVIDUAL FACTORS					
Tillage					
No tillage			29.1	22.9	147.7
Fall plow			31.6	22.4	161.5
Fall chisel			31.4	21.7	157.9
Ridge plant			29.1	21.9	163.7
Spring disk			31.6	21.9	165.9
Significance Level (%):			99	97	95
BLSD (.05) :			1.6	0.8	13.3
Starter Fertilizer (SF)					
Starter			31.2	22.0	164.2
No starter			29.9	22.3	154.5
Significance Level (%):			99	86	99
Poast Herbicide					
Poast			30.4	22.0	161.6
No Poast			30.7	22.4	157.1
Significance Level (%):			41	93	92
Interactions			Significance Levels (%)		
Tillage x SF			3	45	18
Tillage x Poast			36	46	35
SF x Poast			78	76	37
Tillage x SF x Poast			27	3	79
CV (%)			6.4	4.2	7.0

1/ S = starter fertilizer used and NS = no starter fertilizer used.
2/ P = Poast herbicide used and NP = no Poast herbicide used in 1985.

Table 2. Influence of tillage methods and starter fertilizer on corn production at Waseca in 1986.

Treatment		Early	Grain	
Tillage	Starter[1/] fert.	plant growth	N	N Removal
		g/plant	%	lb/A
No tillage	S	7.9	1.41	100.7
No tillage	NS	6.7	1.38	92.7
Fall plow, f. cult.	S	9.9	1.32	107.4
Fall plow, f. cult.	NS	8.6	1.37	102.9
Fall chisel, f. cult.	S	9.9	1.39	109.6
Fall chisel, f. cult.	NS	9.5	1.38	100.7
Ridge plant	S	10.7	1.37	111.8
Ridge plant	NS	10.0	1.37	106.1
Spr. disk	S	9.1	1.40	110.4
Spr. disk	NS	8.8	1.41	112.2
INDIVIDUAL FACTORS				
Tillage				
No tillage		7.3	1.40	96.7
Fall plow		9.2	1.35	105.1
Fall chisel		9.7	1.38	105.1
Ridge plant		10.4	1.37	109.0
Spr. disk		8.9	1.40	111.3
Signif. Level (%):		99	61	92
BLSD (.05) (.10)*:		1.3		9.9*
Starter fertilizer				
Starter		9.5	1.38	108.0
No starter		8.7	1.38	102.9
Signif. Level (%):		99	23	96
Till x SF IA				
Signif. Level (%):		57	31	38
CV (%) :		7.0	3.9	6.9

1/ S = starter fertilizer used and NS = no starter fertilizer

Table 3. Influence of tillage methods for corn following soybeans on surface residue, seeding depth and leaf N at Waseca in 1986.

Treatment	Surface Residence			Planting Depth			Leaf
	Before planting	After Planting: Across plot	After Planting: Within row	Average	S	Range	nitrogen
	%			mm			%
No tillage	80	80	71	47	2.0	40-60	2.77
Fall plow	2	4	4	40	3.1	21-58	2.55
Fall chisel	20	28	16	47	4.7	38-64	2.65
Ridge plant	24	34	17	41	8.4	25-57	2.61
Spr. disk	56	24	21	42	4.3	30-51	2.63
Signif. Level (%):	99	99	99	75			83
BLSD (.05) :	9	6	7	-			-
CV (%) :	18.	13.	19.	13.			4.5

Nitrogen concentration of the earleaf at silking was not influenced significantly by tillage (Table 3). Visual N deficiency symptoms were more apparent on the MP plots than with the other tillage systems, however. The 4.54-inch rainfall that occurred on June 22 and 23 and the subsequent wet soil conditions over the next 7 to 10-day period were primarily responsible for the slight N deficiency.

The rate of seedling emergence was determined by counting the number of plants that had spiked thru in 100-feet of row/plot from the 9th to the 24th day after planting. Emergence, as a percent of final stand, shown in Table 4 indicates most rapid emergence with the RP system. Emergence was delayed about 2 days with the MP, CP and SD systems and about 3 days with the NT systems. These differences continued through about the 6 to 8-leaf stage, but by silking phenological differences among the RP, MP,CP and SD were not evident. The NT system, however, continued to be about 2 days behind at silking and reached physiological maturity a few days after the other tillage systems.

Table 4. Influence of tillage methods on the emergence progress of corn following soybeans at Waseca in 1986.

	Days Post Planting										
Treatment	9	10	11	12	13	14	15	16	17	21	24
	% emerged										
No tillage	0	0	1	12	37	60	89	94	98	100	100
Fall plow	0	0	6	30	67	81	97	98	99	100	100
Fall chisel	0	2	6	31	78	89	96	98	100	98	100
Ridge plant	7	35	50	81	95	97	99	99	99	100	100
Spring disk	0	1	4	25	69	83	96	97	99	100	100

Weed counts (broadleaf and grass) were taken between the 4th and 5th rows from randomly placed 1 ft sections/plot 18 days after preemergence herbicide application. Weed pressure from broadleaf weeds was not great, as counts were low from both herbicide treated and untreated areas (Table 5). Considering the grass weed pressure, grasses were controlled extremely well by the herbicides in all tillage systems. It should be noted that the RP and MP systems had the fewest grass weeds when no herbicide was applied and least weeds after herbicide application. Grass control was not as good in the NT system because of at least two reasons. Weed pressure without herbicides was extremely high and probably the greater surface residue accumulation prevented the preemergence herbicides from fully contacting the soil.

Table 5. Weed populations on June 3 as affected by tillage and herbicide for corn following soybeans at Waseca in 1986.

	Herbicide[1/]		No Herbicide	
Treatment	Grasses	Broadleaves	Grasses	Broadleaves
	plants/10 sq. ft.[2/]			
No tillage	27	1	2411	4
Fall plow	2	1	24	3
Fall chisel	16	2	361	5
Ridge plant	0	1	39	7
Spring disk	21	0	526	1

1/ 3½ lb Lasso and 3½ lb Bladex/A, preemergence
2/ Average over 4 replications

Soil samples taken in increments from the NT, MP and CP tillage systems indicate a tremendous drop in soil pH in the 0-2" surface layer of this well-buffered soil with NT and a slight drop with CP (Table 6). There was little difference in soil pH between the starter and no starter treatments except in NT where starter lowered the pH from 5.7 to 5.3 in the 0-2" layer. Phosphorus tended to accumulate in the 0-2" layer with both the CP and NT systems. As a result of the 8 years of starter vs no starter comparison, soil test P levels were slightly higher for the starter treatments in all tillage systems. Potassium accumulated in the 0-2" layer only with NT and did not show a relationship to the starter fertilizer treatments.

Table 6. Soil test pH, P and K after corn planting from the no-tillage, moldboard plow and chisel plow tillage treatments.

Profile depth	No Tillage		Moldboard Plow		Chisel plow	
	Starter	No Starter	Starter	No Starter	Starter	No Starter
inches	Soil pH					
0-2	5.3	5.7	6.6	6.8	6.4	6.3
2-4	6.2	6.3	6.7	6.8	6.6	6.5
4-6	6.6	6.7	6.8	6.8	6.9	6.7
6-9	6.7	6.8	6.9	6.8	6.9	6.9
9-12	6.8	6.8	7.0	7.0	7.0	6.9
	Soil P (ppm)					
0-2	50	41	33	23	44	32
2-4	27	30	35	22	25	25
4-6	20	20	28	20	15	16
6-9	18	18	23	13	10	12
9-12	11	13	9	10	7	7
	Soil K (ppm)					
0-2	315	317	240	216	250	331
2-4	247	259	238	220	201	212
4-6	200	194	212	204	161	168
6-9	162	167	190	168	153	145
9-12	140	147	148	136	144	138

SUMMARY - 1986

This was the second crop of corn grown after soybeans in this long-term study with continuous corn from 1975 through 1982, soybeans in 1983 and 1985, and corn in 1984. Surface residues prior to planting were greater than 50% with the NT and SD systems and remained above 30% after planting with the NT and RP systems. Plant emergence was fastest with RP, delayed by about 2 days with the MP, CP and SD systems, and by about 3 days with NT. Weed pressure was reduced considerably with the Lasso + Bladex preemergence application. Lowest weed pressure was noted with the RP and MP systems. Highest weed counts, primarily grasses, were found with the NT and SD systems. Early plant growth was greatest for the RP system and least for NT. Phenological plant development throughout the season continued to be a couple of days behind with the NT plants compared to plants grown on the other tillage systems. Leaf N was not affected by tillage or starter fertilizer. Yields among the MP, CP, RP and SD systems were not different but averaged about 8% higher than with NT. Starter fertilizer increased yields by 6% when averaged over tillage systems. However, yield increases due to starter were greatest with the NT, CP and RP systems. Soil samples taken from both the starter and no starter plots in the NT, MP and CP systems show a large drop in soil pH in the top 2" layer with NT, accumulation of high amounts of P in the top 2" with NT and CP, accumulation of K in the top 2" with NT and slightly higher soil P levels associated with the 8-year history of starter vs no starter comparison.

TWELVE-YEAR YIELD SUMMARY

Grain yields from the five tillage systems where starter fertilizer was used from 1975-1982 are shown in Table 7. The 8-year average yield shows a 5.3 bu/A yield advantage for the moldboard plow over the ridge-plant system. Some of this difference can be attributed to the 17 bushel advantage in 1980 for moldboard plowing. The chisel plow and till-plant (flat) systems showed intermediate yields while lowest yields were obtained with no tillage. Weed control was excellent in all treatments except no tillage. Postemergence herbicides were applied to no tillage in 1979 and 1980 and did provide better weed control.

Four-year data (1979-82) indicate some advantage for the use of starter fertilizer with the chisel plow (6 bu/A), ridge-plant (5 bu/A) and no tillage systems (5 bu/A). No reason can be given for the obvious difference in response to starter fertilizer between the no tillage and till-plant (flat) systems when both treatments represent the most severely reduced tillage systems.

Yields with no tillage continue to be significantly below the other tillage systems since converting to a corn/soybean sequence (Table 7). Corn yields in this sequence have not been significantly different among the MP, CP, RP and SD systems when starter fertilizer has been used. Without starter fertilizer, yields from the CP and RP systems have averaged about 7% less than from the MP and SD systems. Soybean yields in this sequence averaged about 6% higher with the moldboard plow system compared to the CP, RP, or SD systems with virtually no difference among the latter three systems.

Table 7. Influence of tillage methods and starter fertilizer on long-term corn and soybean yields at Waseca.

Treatment		Cont. Corn Yield		Soybeans	Corn
Tillage	Starter	1975-82	1979-82	1983 & 85	1984 & 86
		bu/A			
No tillage	Yes	129.2	140.6	36.6	145.6
"	No		136.0	35.4	133.4
Fall plow	Yes	154.5	170.9	48.4	159.3
"	No		170.8	47.8	160.5
Fall chisel	Yes	144.4	161.8	46.1	156.3
"	No		155.5	43.8	148.3
Ridge plant	Yes	149.2	161.5	45.8	158.6
"	No		156.4	45.0	147.8
Till plant (flat) 1/	Yes	144.9	154.8	45.3	163.2
"	No		157.4	45.6	158.0

1/ This treatment was converted to a spring disk (2x) beginning with the 1983 crop.

TILLAGE SYSTEMS FOR CORN AND SOYBEAN CROP SEQUENCES

Waseca, 1986

G. W. Randall, P. L. Kelly and R. R. Allmaras

Corn-soybean rotations have often been compared to continuous corn and soybean monocultures using a particular tillage system. Seldomly, however, have these comparisons been made over a range of primary tillage systems. The purpose of this study is to determine the effect of tillage on corn and soybean production when grown in a monoculture compared to a rotation.

Experimental Procedures

A study had been established on this Webster clay loam site in the fall of 1980 to determine the relationship between primary tillage and the incidence of corn and soybean diseases in continuous corn, continuous soybeans and a corn-soybean rotation. The tillage systems were fall moldboard plow (MP), fall chisel plow (CP), and no tillage (NT). After this 5-yr study was completed in 1985, the initial tillage plots and some of the monoculture plots were kept intact to take advantage of the past tillage and cropping history. Some of the monoculture plots were changed to a corn-soybean sequence so that there are now four cropping systems over each tillage system. The cropping systems are continuous corn (C-C), corn-soybean (C-Sb), soybean-corn (Sb-C), and continuous soybeans (Sb-Sb). Each treatment is replicated four times in a split-plot design with tillage as the main plot and crop system as the subplot.

Fall tillage was performed in October, 1985 after stalk chopping all corn plots. Spring secondary tillage consisted of disking the CP plots on April 25 and field cultivating the MP and CP plots on May 3.

Nitrogen was broadcast applied as ammonium nitrate prior to secondary tillage to all 1986 corn plots at a rate of 200 lb N/A regardless of previous crop. Broadcast P and K were not applied because of high soil test P and K levels. Starter fertilizer was not used.

Corn (Pioneer 3737) was planted on May 6 at a rate of 27700 ppA with a John Deere Max-Emerge 4-r planter equipped with 2" fluted coulters. Counter (1 lb ai/A) was applied to all corn plots at the time of planting. Weeds were chemically controlled with a combination of 3½ qts. Lasso and 3½ qts Bladex/A applied preemergence with no further row cultivation.

Soybeans (Hardin) were planted in 30" rows with the aforementioned planter at a rate of 9 beans/foot on May 22. Weeds were controlled with a preemergence application of Lasso (3½ qts/A) + Amiben (6 qts/A) with no additional cultivation.

A modified JD 3300 plot combine was used to harvest both the corn and soybeans. Corn and soybean yields are expressed at 15.5 and 13.5% moisture, respectively.

All wheel traffic during the season was confined to the same inter-row areas that were trafficked at the time of planting. This resulted in wheel traffic on one side of each row with the other side non-compacted by machinery operations.

Results and discussion

Corn yields were extremely good but were not affected significantly (P = 90% level) by tillage (Table 1). The 10.1 bu/A difference between the MP and NT systems was only significant at the P = 67% level even though a very low CV was present. A 17.8 bu/A advantage for corn following soybeans compared to continuous corn was highly significant (P = 99%). Grain moisture was significantly higher with NT but was not affected by crop sequence. Final plant population was not affected by either tillage or crop sequence. An interaction between tillage and crop sequence was not found (P = 90% level) for grain yield or plant population.

Soybean yields also were extremely good and were not affected by tillage (Table 2). The 13% yield reduction found with continuous soybeans compared to soybeans following corn was highly significant. Seed moisture content at harvest was not influenced by either tillage or crop sequence. Neither soybean yield nor seed moisture showed an interaction between tillage or crop sequence.

Please refer to title page of this publication for information regarding application and use of this article.

Table 1. Corn grain yield and moisture content and final population as affected by tillage and crop sequence.

Tillage	Crop Sequence	Grain Yield	Grain Moisture	Final population
		bu/A	%	x 10^{-3}
MP	C-C	175.3	18.1	27.2
"	C-Sb	192.4	18.5	27.2
CP	C-C	176.0	18.5	26.6
"	C-Sb	194.6	18.9	28.5
NT	C-C	185.0	19.7	27.8
"	C-Sb	202.9	19.0	27.3
FACTORIAL COMPARISONS				
Tillage				
MP		183.9	18.3	27.2
CP		185.3	18.7	27.6
NT		194.0	19.4	27.6
Signif. Level (%):[1/]		67	97	27
BLSD (.05) :			0.7	
Crop Sequence				
C-C		178.8	18.8	27.2
C-Sb		196.6	18.8	27.7
Signif. Level (%):[1/]		99	16	69
Tillage x Sequence Interaction				
Signif. Level (%):[1/]		2	90	89
CV (%) :		4.1	2.6	3.9

[1/] Probability level of significance.

Table 2. Soybean seed yield and moisture content as affected by tillage and crop sequence.

Tillage	Crop Sequence	Soybean Yield	Soybean Moisture
		bu/A	%
MP	Sb-Sb	50.6	14.7
"	Sb-C	55.5	14.6
CP	Sb-Sb	48.2	14.7
"	Sb-C	56.2	14.6
NT	Sb-Sb	47.3	15.0
"	Sb-C	56.0	14.8
FACTORIAL COMPARISONS			
Tillage			
MP		53.1	14.6
CP		52.2	14.7
NT		51.6	14.8
Signif. Level (%):		23	75
Crop Sequence			
Sb-Sb		48.7	14.8
Sb-C		55.9	14.6
Signif. Level (%):		99	89
Tillage x Sequence Interaction			
Signif. Level (%):		57	30
CV (%) :		5.7	1.2

Conclusions

These first-year results indicate no significant effect of tillage on either corn or soybean yields regardless of crop sequence. This is surprising since over the past 15 years continuous corn yields with NT have rarely matched those yields from MP in research conducted at Waseca. However, the effect of cropping sequence remained consistent with previous years results. Continuous corn and continuous soybean yields were depressed by 9 and 12%, respectively, compared to a corn-soybean rotation.

LIMING MATERIALS AND RATES OF APPLICATION FOR ALFALFA PRODUCTION ON AN ACID SANDY SOIL

G. Rehm, B. Anderson, and G. Cremers

Background and Justification:

The importance of lime for profitable alfalfa production on the acid soils of Minnesota has been recognized for many years. Agricultural limestone produced by several quarries in Minnesota has traditionally been used to supply lime when needed. In recent years some other liming materials have been introduced for sale. This study was established to evaluate various liming materials applied at several rates on the production of alfalfa grown on a sandy soil.

Experimental Procedure:

This study was initiated in Morrison County in 1984. Results of analysis of soil samples collected in April of 1984 are summarized in Table 1. The treatments used are listed in Table 2. Three liming materials (dolomitic, Ampel, liquid) were compared. The dolomitic lime is standard agricultural lime. The Ampel product is a pelletized, pure calcitic lime from a quarry in Iowa. The liquid material is finely ground calcitic material suspended in water with clay. Since the percentage of effective calcium carbonate was not the same for all materials, the products were applied to supply equal rates of effective calcium carbonate, ECC (3348, 6696, 10004 lb. per acre). The .5 ton/acre rate of Ampel is the standard rate recommended by the supplier to be broadcast to established stands of alfalfa. Magnesium as magnesium sulfate was added to the annual liquid lime treatment to determine if the alfalfa would respond to this nutrient.

Except for the treatments designated as annual applications, all liming materials were broadcast and incorporated in April of 1984. Corn was grown in 1984. Alfalfa was seeded with an oats companion crop in April, 1985. Adequate P, K, and S were broadcast and incorporated prior to the seeding of the oats and alfalfa. Treatments designated for annual application were applied in both 1985 and 1986. Adequate P, K, and S were topdressed to the established stand in April of 1986.

Three cuttings were harvested in 1986. Moisture samples were collected from each plot for each cutting. Yields are reported on a dry matter basis. Duncan's Multiple Range Test was used for separation of treatment means.

Results and Discussion:

Yield trends for individual cuttings were similar to trends shown by the total yield. Therefore, total yields are listed in Table 2.

Except for the treatment where 1,000 lb/acre of the Ampel material is applied each year, all lime applications increased the yield of alfalfa. There was no consistent increase in yield as rate of application increased. Although not statistically different from many treatments yields resulting from the annual applications of liquid lime tended to be lower.

It is not possible to make firm conclusion from yields collected for only one year. Firm conclusions regarding liming materials are highly dependent on an economic analysis of the data.

Table 1. Relevant soil test values (0-6 in.) for the experimental site.

Property	Value
pH	5.5
Buffer pH	6.5
P, (B & K #1), lb/acre	81
K, lb/acre	170
Mg, lb/acre	100
S, ppm	3
Organic matter	Medium
Texture	Loamy sand

Table 2. Influence of liming materials and rate of application on the yield of alfalfa grown on an acid sandy soil.

Liming Material	Material Applied	Ecc Applied	Yield
	ton/acre	lb/acre	ton/acre
Control	-	-	4.27 f*
dolomitic	3	3348	4.91 bcd
dolomitic	6	6696	5.06 bc
dolomitic	9	10004	5.05 bc
liquid (annual + 50 lb. Mg/acre)	.35	952	4.81 cde
liquid (annual + dolomitic)	.35 + 2	3162	4.98 bcd
liquid	1.86	3348	4.89 bcd
liquid	3.72	6696	5.22 ab
Ampel (annual)	.5	952	4.66 f
Ampel	1.76	3348	5.16 bc
Ampel	3.52	6696	4.66 de

* Treatment means followed by the same letter are not significantly different at the .05 confidence level.

LEAF TIPBURN IN CAULIFLOWER AS INFLUENCED BY GENOTYPE AND AND FOLIAR-APPLIED CALCIUM SPRAYS

C.J. Rosen and H.J. Buchite

Tipburn is a problem frequently encountered in cauliflower production. The disorder is characterized by tip necrosis of young leaves surrounding the curd. In severe cases, older leaves may be affected and the curd may show signs of browning. At later stages of development, secondary decay may occur and dead tissue may fall on the curd causing discoloration and loss of marketable heads. Although the cause of tipburn has been related to calcium nutrition, soil-applied Ca has not proved to be effective in reducing tipburn incidence. The objectives of the present experiment were to: 1) evaluate foliar-applied Ca sprays on cauliflower production and tipburn incidence and 2) characterize genotypic differences in development of tipburn symptoms.

Materials and Methods:

This experiment was conducted at the Sand Plains Research Farm in Becker, MN. The soil, a Hubbard loamy sand had the following soil chemical properties prior to planting: pH, 6.4; P, 103 lb/A; K, 280 lb/A; Mg, 375 lb/A and Ca, 1460 lb/A. The three cauliflower cultivars used were: 'Self-Blanche', 'Snow Crown', and 'Imperial 10-6'. Plants were initially seeded in the greenhouse in a 1:1:1 peat:sand:soil mixture on May 28, 1986. Two weeks after emergence, plants were fertilized with 100 ppm N, 44 ppm P and 81 ppm K at each irrigation. Following a spring crop of peas, plants were transplanted on June 30 and supplied with 0.13 gal soluble starter fertilizer (3 lb 12-48-8 plus micronutrients/50 gal water) per hole. Spacing was 16" within the row and 36" between rows. One week after planting, 150 lb/A 8-10-30 was banded 2" deep and 3" to the side of each plant. Additional N was sidedressed July 17 (50 lb/A), July 31 (75 lb/A), and August 14 (50 lb/A).

The three Ca foliar spray treatments included: water-sprayed control, Ca Chelate (Nutri-Cal 8% Ca), and calcium chloride (27% Ca). The Ca chelate was applied according to manufacturer's recommendation of 1 gal/A per application (0.9 lb Ca/A) diluted with 25 gal water/A. Calcium chloride was applied at the rate of 1.6 lb Ca/A per application mixed with 100 gal water/A. All treatments, including the water-sprayed control, were applied with 0.5 pint X-77/100 gal water, a surfactant. The first spray was applied July 28. Snow Crown was sprayed twice more at weekly intervals, and Self-Blanche and Imperial 10-6 were sprayed three more times at weekly intervals. A randomized complete block design with four replications was used.

Snow Crown was harvested on 4 dates from August 25 to September 5. Imperial 10-6 was harvested on September 24 and 29. Self-Blanche was harvested October 1 and 6. At each harvest date, head diameter, curd weight, hollow heart incidence, and the number of tipburned leaves per plant were recorded. Recently matured wrapper leaves surrounding the curd were sampled for elemental analyses. All percentage data were analyzed after transforming to the inverse sine. Non-transformed data are presented in the tables.

Results and Discussion:

Yield, % hollow stem, tipburn incidence, and curd diameter are presented in Table 1. Significant differences in yield were found due to variety but not Ca spray treatment. Although Imperial 10-6 had the highest total yield, the severe incidence of hollow stem in this cultivar significantly reduced the yield of marketable heads. Hollow stem incidence was low in Snow Crown and Self-Blanche was highly resistent to this disorder. Calcium chloride sprays tended to reduce the incidence of hollow stem. Tipburn severity was greatest in Snow Crown, least in Self-Blanche and intermediate in Imperial 10-6. In plants showing tipburn, Snow Crown had the greatest number of leaves that were affected. When averaged over all cultivars, calcium chloride sprays tended to reduce the percentage of plants showing tipburn. However, Snow Crown had a high incidence of tipburn regardless of Ca sprays. Other means of controlling tipburn must be found for this cultivar. Although tipburn was most severe with Snow Crown the reduction in

marketable yield due to tipburn was not that great. This may have been due to the fact that leaves surrounding the head were not tied in this experiment. Had leaves been tied, a more humid environment may have occurred resulting in more secondary infection and head discoloration. Head diameters were similar which indicates that harvest was relatively uniform for all cultivars.

Leaf elemental concentrations in recently mature wrapper leaves are presented in Table 2. Imperial 10-6 tended to have lower concentrations of all nutrients except Mn. The low B concentrations in Imperial 10-6 may have been associated with the high incidence of hollow heart in this cultivar. However, since many other nutrients were also lower, it is not possible to draw any conclusions about the association from this data. The fact that Snow Crown which had the highest tipburn incidence was highest in leaf Ca indicates that analysis of the whole leaf is not indicative of Ca nutritional status. Tipburn is apparently a localized Ca deficiency not necessarily detectable by whole leaf analysis. In addition, it may be that Snow Crown is less efficient in using Ca than the other two cultivars. Calcium sprays had no effect on leaf elemental concentrations. In particular, leaf Ca did not increase with foliar application of either Ca source. Because inner leaves were sampled, there may not have been direct contact with Ca sprays. Furthermore, the limited mobility of Ca within the plant, would prevent translocation of applied Ca to the inner leaves.

There seemed to be a relationship between harvest date and tipburn development. That is, the earlier harvest date (eg. Snow Crown), the greater the tipburn incidence. This suggests that warmer temperatures during head development may enhance symptoms. However, observations of Snow Crown planted at later dates and harvested in late September when temperatures were much cooler indicated that tipburn incidence was still high. The results of this experiment indicate that if tipburn is a problem, careful consideration should be given to cultivar selection.

The assistance of Glenn Titrud during the course of this experiment is gratefully acknowledged.

Table 1. Influence of plant genotype and foliar calcium sprays on cauliflower yield, hollow stem and tipburn incidence.

Treatment	Cultivar	Yield Total (T/A)	% Marketable	% Hollow Stem	% Tipburn Plants	Head Diam. (inches)	Average # leaves tipburned /tipburned plant
Check	Imperial 10-6	11.03	60.3	71.2	39.9	6.1	6.6
$CaCl_2$	Imperial 10-6	10.58	72.1	50.9	27.1	6.3	5.2
Ca Chelate	Imperial 10-6	10.52	65.7	61.7	38.6	5.9	4.2
Check	Snow Crown	9.97	94.6	12.5	100.0	6.0	8.2
$CaCl_2$	Snow Crown	8.54	96.9	3.1	94.8	6.0	9.1
Ca Chelate	Snow Crown	9.36	94.6	3.1	98.5	5.9	8.1
Check	Self-Blanche	10.86	96.8	0.0	19.5	5.9	3.2
$CaCl_2$	Self-Blanche	10.97	99.0	0.0	4.4	6.0	3.8
Ca Chelate	Self-Blanche	10.07	88.8	0.0	14.5	5.7	4.3
Statistics							
Main Effects							
Cultivar							
	Imperial 10-6	10.72	66.0	61.0	35.2	6.1	5.3
	Snow Crown	9.29	95.3	6.3	97.7	6.0	8.5
	Self-Blanche	10.58	94.9	0.0	12.8	5.9	3.8
	(Significance)	**	**	**	**	NS	**
Ca Treatments							
	Check	10.62	83.9	28.0	53.1	6.0	6.0
	$CaCl_2$	9.97	89.3	18.0	42.1	6.1	6.1
	Ca Chelate	10.04	83.0	22.0	50.5	5.8	5.5
	(Significance)	NS	+	++	++	+	NS
Interaction							
Ca Treatment x Cultivar		NS	NS	NS	NS	NS	NS

** = <.0.01, * = 0.01 -0.05, ++ = 0.05 -0.1, + = 0.1 -0.2, NS = >0.2

Table 2. Influence of plant genotype and foliar calcium sprays on cauliflower nutrient levels in recently mature leaves.

		%					ppm				
Treatment	Cultivar	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
Check	Imperial 10-6	3.32	0.46	3.03	0.60	0.20	54	35	27	6	19
$CaCl_2$	Imperial 10-6	3.28	0.46	3.00	0.59	0.20	49	54	29	5	20
Ca Chelate	Imperial 10-6	3.37	0.49	3.07	0.56	0.20	53	36	27	4	19
Check	Snow Crown	4.19	0.52	3.31	1.05	0.31	65	35	31	7	24
$CaCl_2$	Snow Crown	4.15	0.52	3.28	0.97	0.31	63	33	31	6	22
Ca Chelate	Snow Crown	3.98	0.52	3.22	0.85	0.29	60	31	31	5	23
Check	Self Blanche	4.19	0.56	3.40	0.72	0.27	67	37	31	6	25
$CaCl_2$	Self Blanche	4.09	0.55	3.42	0.75	0.27	65	44	31	7	25
Ca Chelate	Self Blanche	4.17	0.56	3.47	0.73	0.27	69	42	32	8	27
Statistics											
Main Effects											
Cultivar											
Imperial 10-6		3.23	0.47	3.03	0.58	0.20	52	42	27	5	19
Snow Crown		4.10	0.52	3.27	0.96	0.30	63	33	31	6	23
Self Blanche		4.15	0.56	3.43	0.74	0.27	67	41	31	7	26
(Significance)		**	**	**	**	**	**	+	**	**	**
Ca Treatments											
Check		3.90	0.52	3.25	0.79	0.26	62	36	30	7	23
Ca Cl_2		3.84	0.51	3.23	0.77	0.26	59	44	30	6	22
Ca Chelate		3.84	0.53	3.25	0.72	0.25	61	36	30	6	23
(Significance)		NS	NS	NS	NS	NS	NS	+	NS	NS	NS
Interaction											
Ca Treatment x Cultivar		NS	NS	NS	NS	NS	NS	NS	NS	++	NS

** = <.0.01, * = 0.01 -0.05, ++ = 0.05 -0.1, + = 0.1 -0.2, NS = >0.2

EVALUATION OF 'AGRI-BRAND' COMPOST AS A FERTILIZER SOURCE FOR PROCESSING SWEET CORN AND SNAP BEANS

C. J. Rosen and H. J. Buchite

Interest in using compost as a fertilizer source and soil amendment has increased in recent years. In part, this is due to the need for finding safe, efficient, and economical methods of disposing of waste material. 'Agri-Brand' compost is dervived from composted turkey manure and bedding. The objectives of this experiment were to 1) compare the effects of 'Agri-Brand' compost and commercial fertilizer on yield and quality of processing vegetable crops and 2) optimize fertilizer management practices when using 'Agri-Brand' compost.

Materials and Methods:

The experimental sites were located at the Sand Plains Research Farm in Becker, MN. One experiment was conducted with sweet corn and a second with snap beans. Each site, a Hubbard loamy sand, had the following soil chemical properties (0-6") prior to fertilizer application:

	Sweet Corn	Snap Bean
pH	6.6	6.5
P (lb/A)	83	93
K (lb/A)	192	282

Following a previous crop of rye, sweet corn (Jubilee) was planted on 16 May at a population of 24,000 plants/A (30" between rows) and snap bean (Eagle) was planted on 22 May at a population of 105,000 plants/A (30" between rows). Lasso and Bladex were used to control weeds in the sweet corn plots and Treflan was used in the snap bean plots. The treatments included:

Sweet Corn:

1. 50 lb N/A preplant, 100 lb N/A sidedressed 11 June
2. 50 lb N/A preplant, 100 lb N/A sidedressed 11 June, 100 lb K_2O/A preplant
3. 1.5 T/A compost preplant, 75 lb N/A sidedressed 11 June
4. 1.5 T/A compost preplant, 140 lb/A 11-52-0 starter, 60 lb N/A sidedressed 11 June
5. 1.5 T/A compost preplant, 75 lb N/A sidedressed 11 June, 50 lb K_2O/A preplant
6. 1.5 T/A compost preplant, 140 lb/A 11-52-0 starter, 60 lb N/A sidedressed 11 June, 50 lb K_2O/A preplant
7. 2.0 T/A compost preplant, 50 lb N/A sidedressed 11 June

Snap Bean:

1. Control
2. 40 lb N/A preplant
3. 1.0 T/A compost preplant
4. 1.5 T/A compost preplant
5. 2.0 T/A compost preplant
6. 1.5 T/A compost preplant, 25 lb N/A preplant

The commercial N source was urea (46-0-0) and K_2O source was potassium chloride (0-0-60). All preplant applications were broadcast and rototilled to a depth of 6". The compost used had a nutrient content of 50 lb N/T, 75 lb P_2O_5/T and 50 lb K_2O/T. Compost treatments were selected based on N content. Starter fertilizer used was monoammonium phosphate (11-48-0). Sidedressed fertilizer was irrigated in immediately after application. Whole sweet corn plants at the 6-8 leaf stage were sampled on 11 June prior to the sidedress N application. Ear leaf samples were collected at mid-silk (17 July). Snap bean first trifoliate leaves were sampled at the onset of flowering (2 July). Each plot consisted of four 40' rows.

The harvested area consisted of 15' from each of the center two rows for sweet corn and 10' from each of the center two rows for snap beans. The harvest date was 22 July for snap beans and 11 August for sweet corn.

Results:

Sweet Corn:

Starter fertilizer significantly increased early growth of sweet corn (Table 1). Compost at 1.5 or 2.0 T/A tended to promote an increase in early plant growth compared to 50 lb N/A preplant broadcast. None of the treatments had any significant effect on green or husked yield. Maturity as measured by % kernel moisture was hastened when compost was used. Treatments did not affect percentage of usable ears. Starter fertilizer significantly increased early plant N and P concentrations (Table 2). However, by silking, plants that received starter fertilizer were lowest in ear leaf N and were not significantly different in ear leaf P compared to plants that did not receive starter fertilizer (Table 3). All plants regardless of treatment appeared N deficient at harvest. Plants sampled at the 6-8 leaf stage were lower in Ca and Mg when supplied with compost compared to non-compost treatments. These differences in Ca and Mg were not detected in ear leaf samples.

The results from this experiment indicate that sidedressed urea was not sufficient to meet the nitrogen demands of sweet corn on a sandy soil. Because measurements were not made, it is not possible to determine whether urea was lost through leaching or volatilization. Furthermore, N release from the compost at the rates applied was not great enough to supply the needs of sweet corn. Soil levels of nitrate-N decreased to low levels during ear development (Table 4). Ammonium-N levels in the soil were relatively low at both sampling dates. There was no difference in nitrate-N or ammonium-N due to the applied treatments.

A future study should be conducted to determine how much of the total N in 'Agri-Brand' compost is available to the crop during the season in which it is applied. Starter fertilizer promoted a dramatic increase in early plant growth; however, because N was limiting during later stages of growth, the effect on final yield cannot be assessed. It appeared that because of the stimulation in early growth and subsequent lack of N availability, N concentrations were diluted in plants that received starter fertilizer. Potassium fertilizer had no significant effect on plant growth or yields. Any effects due to K were probably masked by N deficiency.

Snap Bean:

Snap bean yields were not significantly affected by fertilizer or compost treatments (Table 5). Vine yields increased significantly with both commercial and compost sources of N. Higher N rates appeared to promote vegetative growth at the expense of pod production. Nodules were apparently effective in providing a substantial portion of the N required for plant growth. There was no difference in nodule production due to treatment. It is possible that at the time of harvest, plots receiving the higher rates of N were not as physiologically mature as those receiving the lower N rates. Sieve size distribution, however, was not affected by treatment indicating that maturity of the harvested pods was similar (Table 6). A multiple harvest procedure should be used to follow pod maturity in future experiments. Nitrogen concentrations in first trifoliate leaves were not significantly affected by treatment (Table 7). Concentrations of leaf K were higher in plants receiving the compost treatment. Leaf Mg was highest in the compost plus urea treatment.

Soil nitrate levels decreased over the course of the growing season while ammonium-N increased (Table 8). The increase in ammonium-N was probably due to that released from the bean roots. Samples were taken in the row. There were no differences in levels of ammonium-N and nitrate-N due to the compost or fertilizer treatments.

Table 1. Influence of compost, potassium and starter fertilizer on early plant growth (6-8 leaf stage), sweet corn yield, and ear quality.

Treatment	Whole plant 6-8 leaf (g dw/plant)	Green yield ------T/A------	Husked yield	Kernel moisture (%)	COC Eligible (%)
150 lb N/A	0.80	5.88	4.18	72.9	90.6
150 lb N/A + K_2O	0.65	6.10	4.11	74.6	87.1
1.5 T/A compost + 75 lb N/A	0.99	6.13	4.44	69.5	88.0
1.5 T/A compost + 75 lb N/A + starter	1.58	5.82	4.23	68.7	78.3
1.5 T/A compost + 75 lb N/A + K_2O	0.77	5.83	4.03	71.2	82.3
1.5 T/A compost + 75 lb N/A + K_2O + starter	1.59	5.83	4.35	70.0	85.4
2.0 T/A compost + 50 lb N/A	1.03	5.23	3.71	70.3	77.9
Significance	**	NS	NS	**	NS
BLSD (0.05)	0.27	-	-	2.2	-

Table 2. Influence of compost, starter fertilizer and potassium on nutrient composition of whole plants sampled at the 6-8 leaf stage.

Treatment	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	---------- % ----------					---------- ppm ----------				
150 lb N/A	4.54	0.37	4.95	0.71	0.69	207	65	84	7	15
150 lb N/A + K_2O (U of M)	4.34	0.29	4.86	0.74	0.67	191	60	77	6	16
1.5 T/A compost + 75 lb N/A	4.38	0.36	5.38	0.59	0.52	206	54	72	6	12
1.5 T/A compost + 75 lb N/A + starter	4.98	0.70	4.80	0.52	0.55	187	64	66	7	9
1.5 T/A compost + 75 lb N/A + K_2O	4.39	0.35	5.52	0.63	0.51	200	63	73	6	14
1.5 T/A compost + 75 lb N/A + K_2O + starter	4.95	0.75	4.86	0.54	0.53	204	67	66	6	11
2.0 T/A compost + 50 lb N/A	4.56	0.43	5.52	0.60	0.60	205	51	71	7	14
Significance	**	**	NS	**	**	NS	NS	NS	NS	NS
BLSD (0.05)		.07	-	.07	.13	-	-	-	-	-

Table 3. Influence of compost, starter fertilizer, and potassium on nutrient composition of ear leaf samples collected during silking.

Treatment	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
150 lb N/A	2.64	0.20	2.71	0.58	0.45	92	54	37	7	9
150 lb N/A + K_2O	2.52	0.28	2.72	0.53	0.41	88	50	33	6	10
1.5 T/A compost + 75 lb N/A	2.50	0.26	2.59	0.48	0.34	80	45	29	5	9
1.5 T/A compost + 75 lb N/A + starter	2.17	0.30	2.73	0.54	0.42	80	44	26	5	9
1.5 T/A compost + 75 lb N/A + K_2O	2.57	0.29	2.87	0.52	0.36	87	54	32	6	9
1.5 T/A compost + 75 lb N/A + K_2O + starter	2.22	0.29	2.66	0.53	0.39	81	45	26	4	11
2.0 T/A compost + 50 lb N/A	2.28	0.29	2.99	0.55	0.40	87	44	30	6	9
Significance	**	NS	NS	NS	NS	*	NS	*	**	NS
BLSD (0.05)	0.21	-	-	-	-	10	-	7	1	NS

Table 4. Influence of compost, starter fertilizer and potassium on KCl extractable NO_3-N and NH_4-N (0-12") - sweet corn.

Treatment	Sampling Date			
	July 2		July 25	
	NO_3-N	NH_4-N	NO_3-N	NH_4-N
	ppm			
150 lb N/A	10.4	0.4	3.2	0.6
150 lb N/A + K_2O	11.2	0.6	2.9	0.5
1.5 T/A compost + 75 lb N/A	7.1	0.4	2.8	0.5
1.5 T/A compost + 75 lb N/A + starter	7.2	0.5	3.7	0.6
1.5 T/A compost + 75 lb N/A + K_2O	7.9	1.0	3.3	0.6
1.5 T/A compost + 75 lb N/A + K_2O + starter	6.5	0.8	3.0	0.6
2.0 T/A compost + 50 lb N/A	7.7	0.5	3.2	0.5
Significance	NS	NS	NS	NS

Table 5. Effect of compost treatments on snap bean yields, vine yields, leaf nitrogen and nodulation.

Treatment	Pod Yield T/A	Vine Yield T/A	g dw nodules/ g dw roots
Control	4.35	6.40	0.172
40 lb N/A	4.66	7.78	0.135
1 Ton Compost/A	4.95	7.49	0.203
1.5 Ton Compost/A	4.74	8.23	0.229
2.0 Ton Compost/A	4.33	8.67	0.181
1.5 Ton Compost/A + 25 lb N/A	4.43	8.09	0.293
Significance	NS	*	NS
BLSD (0.05)	-	1.20	-

Table 6. Effect of compost treatments on snap bean sieve size distribution.

	Sieve Size					
	1	2	3	4	5	6
	%					
Treatment						
Control	2.5	11.5	13.4	39.3	32.1	1.3
40 lb N/A	3.3	13.2	13.4	37.6	31.9	0.0
1 Ton Compost/A	2.5	9.9	17.4	50.5	23.8	0.0
1.5 Ton Compost/A	4.0	15.2	18.8	43.1	19.0	0.0
2.0 Ton Compost/A	1.4	12.7	21.4	35.5	32.9	1.3
1.5 Ton Compost/A + 25 lb N/A	3.1	9.6	23.0	40.9	22.7	0.7
Significance	NS	NS	NS	NS	NS	NS

Table 7. Influence of compost and ammonium nitrate on leaf composition of the first trifoliate leaves sampled.

Treatment	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
Number	%					ppm				
Control	2.68	0.22	3.14	3.39	0.77	230	82	25	76	26
40 lb N/A	2.75	0.18	3.11	3.17	0.68	182	79	24	95	26
1 Ton Compost/A	2.63	0.20	3.43	3.49	0.76	227	85	24	61	30
1.5 Ton Compost/A	2.58	0.19	3.50	3.48	0.78	216	85	23	51	29
2.0 Ton Compost/A	2.60	0.20	3.56	3.50	0.79	196	88	24	72	27
1.5 Ton Compost/A + 25 lb N/A	2.77	0.19	3.40	3.56	0.84	197	93	23	51	25
Significance	NS	NS	*	NS	*	NS	NS	NS	NS	NS
BLSD (0.05)	-	-	0.41	-	0.12	-	-	-	-	-

Table 8. Influence of compost treatments on KCl estractable NO_3-N and NH_4-N (0-12")-snap beans.

Treatment	Sampling Date			
	July 2		July 25	
	NO_3-N	NH_4-N	NO_3-N	NH_4-N
	ppm			
Control	5.1	0.5	2.1	3.2
40 lb N/A	6.7	0.6	2.3	3.1
1 Ton Compost/A	6.3	0.6	2.2	2.9
1.5 Ton Compost/A	6.8	0.5	2.9	4.8
2.0 Ton Compost/A	8.1	0.6	2.4	2.7
1.5 Ton Compost/A + 25 lb N/A	7.8	0.5	2.4	2.9
Sigificance	NS	NS	NS	NS

DECLINE RATES OF SOIL TEST P AND K IN A CORN-SOYBEAN ROTATION

1986

G. W. Randall and S. D. Evans

With good fertilization practices over the last 20 to 30 years, many farmers throughout the Cornbelt have built their P and K soil tests to high and very high levels. Studies conducted over the last 12 years have not shown corn and soybean yield increases from additional broadcast P and K at these high to very high test levels. Consequently, a number of farmers have curtailed P and K fertilization on these high testing soils. Two commonly asked questions in this scenario are: (1) How fast will my soil test drop if I don't continue to add fertilizer P and K? and (2) At what test level should I begin to add P and K to maintain fertility at an optimum level for efficient and economical production? The purposes of this study are to determine (1) the decline rates of soil test P and K and (2) the optimum soil test level which should be maintained for economical corn and soybean production.

EXPERIMENTAL PROCEDURES

High rates of P and K were applied over a 12-year period (1973-84) in studies at the Southern Experiment Station at Waseca (Table 2) and the West Central Experiment Station at Morris (Table 3). These rates created a wide range of soil test values upon which we can evaluate the decline rates of soil test P and K when no additional fertilizer is added. Treatments 2, 3, and 4 did not receive additional P in 1985 while treatments 6 and 7 at Waseca did not receive K. The K treatments were not included at Morris because of very high native soil test K levels. Treatment 5, which had a moderately high level of fertilization prior to 1985, continues to receive P and K, and thus, serves as the high fertility control.

The P and K materials (0-46-0 and 0-0-60) were broadcast on the soil surface and incorporated by moldboard plowing the corn residue in the fall of 1985. Specific experimental procedures used for soybeans at the two locations are presented in Table 1. Management practices providing for optimum yields were employed at each location. Starter fertilizer was not used. Planting was delayed somewhat at both locations by wet weather in mid-May.

Table 1. Experimental procedures for soybeans on the high P and K rate study at the two branch stations in 1986.

Variable	Location: Morris	Location: Waseca
Planting date	5/20	5/22
Row spacing	6"	15"
Planting rate	3 beans/foot	4½ beans/foot
Variety	Evans	Hardin
Herbicide	3# Lasso + 2½# Amiben/A (Bdct)	3½# Lasso + 3# Amiben/A (Bdct)
Harvest date	10/1	10/8
Soil type	Aastad clay loam	Webster clay loam

RESULTS AND DISCUSSION

Total phosphate (P_2O_5) and potash (K_2O) applied over the 12-yr period ranged from 0 to 1200 lb/A (Tables 2 and 3). These application rates plus the 1985 rates resulted in highly significant differences in soil test P at both locations but no significant difference in soil test K at Waseca. At Waseca soil test P ranged from 14 to 100 lb P/A (Table 2). Soybean yields were increased significantly by P but plateaued at soil P levels higher than 46 lb/A. Slightly lower yields were seen at the 255 lb K/A test compared to the control (trt 5), but this yield depression (3.2 bu/A) was not significant at the P = 95% level.

At Morris, Bray P_1 ranged from 10 to 75 lb/A while Olsen's $NaHCO_3$ test ranged from 12 to 79 lb P/A (Table 3). Increasing Bray P_1 from 10 to 35 lb/A resulted in a highly significant 22.1 bu/A yield response. No additional yield response was noted with the 75 lb/A soil test level compared to the 35-lb level. Leaf P was significantly lower at the 14 lb/A soil P level compared to levels of

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35 lb/A and above (Table 4.) Increasing soil test P over 35 lb/A did not further increase leaf P concentration. Phosphorus deficient soybean plants showed slightly elevated concentrations of Fe and Zn in the leaves. None of the other nutrient concentrations were affected by the P treatments.

Table 2. Soil test values, soybean seed moisture, and soybean yield as influenced by 13 years' application of P and K at Waseca.

	P and K Treatments		Soil Test 2/			Soybean seed	
	Total						
No.	1973-84	1985 1/	pH	P	K	Moisture	Yield
	----- lb P_2O_5 + K_2O/A -----			--- lb/A ---		%	bu/A
2	0 + 1200	0 + 100	6.8	14	305	14.8	45.7
3	600 + 1200	0 + 100	6.6	46	290	15.0	49.1
4	1200 + 1200	0 + 100	6.6	85	295	14.9	50.4
5	600 + 1200	100 + 100	6.7	50	290	15.0	50.8
6	1200 + 0	100 + 0	6.7	100	255	14.7	47.6
7	1200 + 600	100 + 0	6.7	99	270	14.8	49.7
	Signif. Level (%):		17	99	35	94	95
	BLSD (.05)	:		21			3.7
	CV (%)	:	2.9	19.	13.	0.9	3.7

1/ Treatments applied Fall of 1985 for 1986 crop.
2/ Samples were taken in October before 1986 treatments were applied.

Table 3. Soil test values, soybean seed moisture, and soybean yield as influenced by 13 years' application of P and K at Morris.

	P and K Treatments		Soil Test 2/				Soybean seed	
	Total							
No.	1973-84	1985 1/	pH	P_1	P_{01}	K	Moisture	Yield
	---- lb P_2O_5 + K_2O/A -----			------ lb/A -------			%	bu/A
2	0 + 1200	0 + 100	7.9	10	12	590	13.9	28.1
3	600 + 1200	0 + 100	7.7	35	36	530	14.4	50.2
4	1200 + 1200	0 + 100	7.8	75	79	545	14.4	50.7
5	600 + 1200	100 + 100	7.8	32	34	530	14.6	47.0
	Signif. Level (%):		78	99	99	79	99	99
	BLSD (.05)	:		19.	21.		0.3	11.2
	CV (%)	:	1.1	32.	33.	7.5	1.3	16.

1/ Treatments applied Fall of 1985 for 1986 crop.
2/ Samples were taken in October before 1986 treatments were applied.

Table 4. Effect of high P and K rates on the nutrient concentrations in the soybean leaves at Morris in 1986.

1985 Treatment		Nutrient Concentration 1/								
No.	P & K Rate	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb P_2O_5 + K_2O/A	---------- % ----------				---------- ppm ----------				
2	0 + 100	.37	2.40	.87	.45	165	82	47	10.9	47
3	0 + 100	.55	2.49	.80	.44	132	79	43	9.9	45
4	0 + 100	.56	2.61	.80	.43	134	85	40	9.9	44
5	100 + 100	.53	2.47	.79	.45	136	81	42	9.2	46
	Signif. Level (%):	99	87	67	44	99	58	96	73	61
	BLSD (.05) :	.09	-	-	-	21	-	4	-	-
	CV (%) :	12.	4.5	8.3	4.7	8.8	5.7	5.9	11.	5.5

1/ Uppermost, mature trifoliate at the R2 stage.

CONCLUSIONS

Long-term (12-yr) P additions to these two soils created a wide range in soil test P levels. Soybean yields were optimized over the no P treatments at soil test P levels of 35 lb/A at Morris and 46 lb/A at Waseca. In this first year of the study following the 12-year P and K applications, we were not able to detect consistent decline rates in soil test P and K when these materials were not added. Additional years will be needed to determine these decline rates.

NITROGEN SOURCES AND RATES FOR CONTINUOUS CORN IN GOODHUE COUNTY

1986

G. W. Randall and P. L. Kelly

The purpose of this investigation was to continue a study which had been started in 1985 to determine the influence of various N sources and N rates on corn production and residual soil NO_3-N in a silt loam soil.

EXPERIMENTAL PROCEDURES

This study was located at the Roger and Doug Kleese farm on a Mount Carroll silt loam (Mollic Hapludalf) that had been planted to continuous corn. The field had been chisel plowed annually until the spring of 1986 when it was moldboard plowed. Soil tests in 1985 indicated: pH = 6.2, Bray P_1 = 48 lb/A (VH), exchangeable K = 374 lb/A (VH), and extractable SO_4-S = 7 ppm (Medium).

Sixteen N treatments (Table 1) were applied in May, 1985 and were applied again to the same plots in 1986. A randomized, complete-block design with four replications was used. Each plot measured 10' wide (4 - 30" rows) x 35' long.

Corn (Pioneer 3737) was planted on May 6 with 100 lb of 9-23-30/A applied in a 2 x 2" band with the planter. Excellent weed and rootworm control were obtained with Bicep and Counter, respectively.

Nitrogen treatments were broadcast on the soil surface on May 14 and were not incorporated. (Surface residues were absent.) An additional 30 lb N/A as AN was split applied as a sidedress treatment to one of the existing 120-lb treatments at the 8-leaf stage (June 19).

Soil samples were taken from the AN treatments in 1-foot increments to 8 feet on April 22 (prior to application of the N) and again on November 11. All samples were dried, ground and analyzed for NO_3-N. Grain yields were taken on October 10 by hand harvesting.

RESULTS AND DISCUSSION

Growing conditions during 1986 were excellent. Rainfall for the growing season totaled over 27 inches. Under these conditions one would predict high yields and downward movement of NO_3-N.

Corn grain yields shown in Table 1 were increased over the check by all of the N treatments even though the ckeck yielded 159.6 bu/A. This high yield without N was probably due to a number of factors: an excellent growing season, favorable conditions for soil mineralization to supply N, and stimulated mineralization due to the moldboard plowing of the site which had been chisel plowed for a number of years. Yields continued to increase significantly with each increment of N up to 180 lb N/A. The 240-lb rate did not increase yield additionally. Split application of 150 lb N/A did not significantly increase yields over the single preemergence application of 120 lb/A and did not match the yield of the 180-lb rate. When averaged over N rates, significant yield differences (P = 90% level) among the N sources were not found. There was no N source x N rate interaction.

Ear moisture was lowered by most of the N treatments compared to the check (Table 1). Although slight population differences existed, they were not influenced by N rate or source.

Residual NO_3-N in the 0-8' soil profile in April, 1986 from the 1985 N treatments indicate a linear relationship to N rate up through 180 lb N/A (Table 2). These amounts are 18, 7, 28, 18, and 40% lower than from samples taken from the same 0, 60, 120, 180 and 240-lb N rate plots in mid-November, 1985. This indicates that significant amounts of NO_3 were lost from this soil profile over the winter and early spring, most likely by leaching.

Amounts of residual NO_3-N remaining in the 0-6' profile at the end of the 1986 growing season were very low (Table 3). Slight increases were found at the 180- and 240-lb N rates, but these were still low when considering the high rate of application and the small yield response over the 120-lb N rate. These data suggest that under these high-rainfall conditions substantial amounts of NO_3 were leached from the rooting profile of these well drained, silt loam soils.

Please refer to title page of this publication for information regarding application and use of this article.

Table 1. Corn yields and final population as influenced by N rource and rate of application.

N Treatment Source[1/]	Rate	Grain Yield	Ear Moisture	Final population
	lb N/A	bu/A	%	ppA x 10^3
CHECK	0	159.6	34.6	27.2
AN	60	193.1	32.9	27.2
"	120	207.4	31.7	27.1
AS	60	192.6	32.2	26.4
"	120	202.2	33.2	26.4
UAN	60	188.0	31.9	26.4
"	120	207.0	31.4	27.0
UAN+S	60	199.8	31.8	26.8
"	120	213.3	32.1	28.1
Urea	60	186.1	31.7	26.0
"	120	201.8	31.8	27.1
½UR+½AS	60	190.4	32.4	27.5
"	120	202.6	31.8	26.7
AN	180	214.2	32.2	27.8
"	240	214.7	31.8	27.9
"	150 split[2/]	203.3	32.5	26.4
Signif. Level (%):		99	96	99
BLSD (.05) :		9.3	2.0	1.2
CV (%) :		3.6	3.4	2.8
INDIVIDUAL FACTORS				
N Source (50 + 100 lb)				
AN		200.2	32.3	27.2
AS		197.4	32.7	26.4
UAN		197.5	31.6	26.7
UAN+S		206.6	32.0	27.4
Urea		196.5	32.1	27.1
½UR+½AS		194.0	31.8	26.6
Signif. Level (%):		87	46	86
N Rate (lb/A)				
60		191.7	32.1	26.7
120		205.7	32.0	27.1
Signif. Level (%):		99	34	85
INTERACTION			Significance Level (%)	
Source x Rate		14	53	87

1/ AN = ammonium nitrate, AS = ammonium sulfate, UAN = urea-ammonium nitrate, UAN + 2% S as AS(25-0-0-2), and UR = urea.

2/ 120 lb N/A applied 5/14 + 30 lb N/A applied 6/19 at 8-leaf stage.

Table 2. Residual soil NO_3-N in the soil profile in April, 1986 as influenced by N rate applied in May, 1985.

Profile depth	N Application Rate (lb/A)				
	0	60	120	180	240
feet	lb NO_3-N/foot				
0-1	18	18	17	32	23
1-2	7	13	13	27	26
2-3	11	18	25	28	33
3-4	9	22	25	37	27
4-5	8	15	19	15	19
5-6	9	15	12	18	20
6-7	9	12	16	15	13
7-8	11	13	15	13	11
Totals					
0-5'	53	86	99	139	128
5-8'	29	40	43	46	44
0-8'	82	126	142	185	172

Table 3. Residual soil NO_3-N in the soil profile in November, 1986 as influenced by N rate applied in May, 1986.

Profile depth	N Application Rate (lb/A)				
	0	60	120	180	240
feet	lb NO_3-N/foot				
0-1	16	15	18	17	20
1-2	4	5	6	22	19
2-3	2	2	4	15	23
3-4	5	6	5	11	14
4-5	8	11	7	12	11
5-6	8	11	9	12	10
Totals	43	50	49	89	97

CONCLUSIONS

Excellent growing conditions during 1986 resulted in very high corn yields (160 bu/A) when no N was added but were significantly increased up to 214 bu/A with 180 lb N/A. No differences among sources of N were found. Significant amounts of NO_3-N were lost from the 0-8' soil profile during the winter of 85-86 with substantial losses from the 0-6' profile during the 1986 growing season.

INFLUENCE OF CROP HISTORY AND MANURE USE ON NITROGEN RATES FOR CORN PRODUCTION IN SOUTHEASTERN MINNESOTA

G. Rehm, G. Cremers, B. Anderson

Background and Justification:

Detection of nitrate-nitrogen (NO_3-N) and some agricultural chemicals in the groundwater in Minnesota continues to be a major concern. Because of the karst topography in southeastern Minnesota, the region is vulnerable to rather rapid movement of NO_3-N to the ground water if this NO_3-N moves out of the root zone. While it is impossible to eliminate completely the leaching of NO_3-N to the groundwater, it is possible to keep additions to an absolute minimum. To do this, strict attention to N management is a necessity.

Selection of an adequate, but not excessive, rate of fertilizer N is the major management consideration in any attempt to prevent any increase in the NO_3-N concentration in the groundwater. Choice of an appropriate N rate is largely influenced by yield goal, organic matter content of the soil, use of legumes in rotation and manure usage. The study was conducted for the purpose of determining the influence of legumes in the crop rotation and manure use on fertilizer N requirements for corn production in southeast Minnesota.

Experimental Procedures:

Three sites were selected in April, 1986. The history of each site is as follows:

#1 - corn following alfalfa heavily manured in the past
#2 - corn following corn heavily manured in the past
#3 - corn following continuous corn where no manure had been used

Soil samples were collected from 0-6, 6-12, 12-24, 24-36, 36-48, and 48-60 inch increments from each site. Four samples were collected from sites 1 and 3. Because of the history of manure use, 28 samples were collected from site 2. Results of analysis of these samples are summarized in Table 1.

Table 1. Soil properties of the experimental sites in Winona County, 1986.

Site No.	Property	Depth (in.) 0-6	6-12	12-24	24-36	36-48	48-60	Total
1	pH	6.7	-	-	-	-	-	-
	P, lb/A	73	-	-	-	-	-	-
	K, lb/A	293	-	-	-	-	-	-
	NO_3-N, lb/A	17.5	7.0	6.5	11.5	8.3	4.7	55.5
	O.M., %	4.5	3.1	1.6	.7	.5	.5	-
2	pH	6.7	-	-	-	-	-	-
	P, lb/A	86	-	-	-	-	-	-
	K, lb/A	286	-	-	-	-	-	-
	NO_3-N, lb/A	13.9	12.7	26.2	21.8	15.7	8.8	99.1
	O.M., %	4.0	2.8	1.2	.4	.3	.3	-
3	pH	6.9	-	-	-	-	-	-
	P, lb/A	38	-	-	-	-	-	-
	K, lb/A	296	-	-	-	-	-	-
	NO_3-N, lb/A	12.5	7.4	18.7	19.2	13.7	11.4	82.9
	O.M., %	3.9	2.9	1.4	.5	.4	.2	-

There was not a large amount of variability in the results from sites 1 and 3. There was, however, a substantial amount of variation in the amount of NO_3-N to a depth of 5 feet at site 2. Total amount of NO_3-N measured varied from 45 to 191 lb. per acre. This variability is attributed to the previous heavy use of manure.

Seven rates of fertilizer N supplied as 46-0-0 were broadcast and incorporated at each site. Rates were the same at sites 1 and 3. Because of an error in equipment calibration, higher rates were applied at site 2.

Management practices needed to achieve high yields were used at all sites. Cooperating farmers were responsible for planting and cultivating. Grain yields were measured by hand harvest techniques in mid-October. Soil samples were collected from 0-6, 6-12, 12-24, 24-36, 36-48, and 48-60 inches from each plot in early November and analyzed for NO_3-N.

Results and Discussion:

Results from site 1 are summarized in Table 2. Even though yields were high, there was no statistically significant increase from added fertilizer N. These results indicate that substantial amounts of N were derived from mineralization of the organic N sources supplied by the previous crop of alfalfa and past applications of manure.

The amounts of NO_3-N found in the root zone at the end of the growing season were relatively low. There was some increase as rate of fertilizer N increased, but these increases were small. It's important to note that amounts of NO_3-N found in November were higher than the amount found at the initiation of the study in April. This is added evidence for substantial N derived from mineralization of the soil organic matter.

Table 2. Effect of rate of applied N on corn yield and NO_3-N in the root zone at the end of the 1986 growing season at site 1.

N Applied	Grain Yield	NO_3-N to 5 feet
lb/acre	bu/acre	lb/acre
0	215	80
40	223	84
80	209	86
120	211	91
160	207	94
200	212	102
240	214	101

There was a response to the use of fertilizer N at site 2 (Table 3). Statistical analysis of the data shows that the use of 100 lb. N per acre produced maximum yield at this site. With the high yields recorded, substantial amounts of N were apparently supplied from residual NO_3-N and mineralization of the organic nitrogen supplied by previous application of manure.

Table 3. Effect of rate of applied N on corn yield and NO_3-N in the root zone at the end of the 1986 growing season at site 2.

N Applied	Grain Yield	NO_3-N to 5 feet
lb/acre	bu/acre	lb/acre
0	176	74
50	192	83
100	202	74
150	192	98
200	188	100
250	199	127
300	193	149

The amount of NO_3-N in the root zone measured in November also increased with rate of applied N. The amounts measured were not as high as recorded in the April sampling.

Delayed planting reduced the yield level at site 3 (Table 4). Statistical analysis of the data showed that a rate of 160 lb. N per acre was necessary to achieve highest yield. The amount of residual NO_3-N to 5 feet also increased with rate of applied N but increases were small.

Table 4. Effect of rate of applied N on corn yield and NO_3-N in the root at the end of the 1986 growing season at site 3.

N Applied	Grain Yield	NO_3-N to 5 feet
lb/acre	bu/acre	lb/acre
0	107	55
40	124	57
80	138	70
120	139	65
160	139	71
200	148	64
240	144	71

In western Minnesota, measurement of residual NO_3-N in the root zone (soil nitrate test) is widely used as a management tool to predict the rate of fertilizer N needed for both corn and small grain production. Some have asked if this test could be used in eastern and southeastern Minnesota. The results of this study indicate that this test would not be useful in this part of the state.

Before planting, residual NO_3-N was 56 lb. per acre at site 1 and 83 lb. per acre at site 3. There was no response to fertilizer N at site 1 while a rate of 160 lb. N per acre was needed at site 3. It's apparent that additional work is needed to develop a soil test procedure that will predict the rate of fertilizer N needed for corn production on the well drained soils of southeastern Minnesota.

Summary:

It is not possible to draw specific conclusions from the results of one year of field research. Yet, there are some general comments that can be made. These are:

- Fertilizer N is still needed for profitable corn production on the majority of the fields in southeastern Minnesota.

- Rate of fertilizer N needed is highly influenced by apparent easily mineralizable N in the soil organic matter.

- Measurement of residual NO_3-N does not improve our ability to make more accurate prediction of the amount of fertilizer N needed for corn production.

EVALUATION OF THE RELATIONSHIP BETWEEN TILLAGE AND PLACEMENT OF P AND K IN A CORN-SOYBEAN ROTATION

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

Background and Justification

Recent changes in American agriculture have stimulated thinking about placement of phosphate and potash fertilizers for both corn and soybean production. In recent years, the emphasis in fertilizer use has switched from broadcasting whenever possible to developing placement alternatives that allow for maximum efficiency in fertilizer use. There has also been an increase in the rate of adoption of conservation tillage systems. Because of concerns over stratification of immobile nutrients, growers are seeking alternatives to broadcast application of phosphate and/or potash in these tillage systems.

Until recently, growers could apply needed phosphate and potash in a starter at planting, as a broadcast and incorporated application before planting or as a combination of these two methods. With modern advances in application equipment, alternatives to broadcast and starter placement of phosphate and potash fertilizers are now available. This study was designed to answer some of the questions that deal with placement of phosphate and potash fertilizers in a corn-soybean rotation.

Objectives:

1. To determine the effect of the interaction between tillage system and placement of P and K on soybean yield in a corn-soybean rotation.

2. To measure the effect of placement of P and K on nutrient uptake by soybeans grown in two contrasting tillage systems.

3. To quantify the distribution of P and K in the root zone after the positioning of these nutrients by selected placement methods. This distribution will be determined only after these two nutrients have been applied for a period of several years.

4. To evaluate practical sampling procedures which can be used to accurately predict requirements for P and K as affected by both fertilizer placement and tillage system used. The collection of both soil and plant samples will be used to develop a sampling procedure which will accurately predict the requirements for fertilizer P and K.

Experimental Procedures:

This study was initiated at three branch experiment stations of the University of Minnesota (Waseca, Lamberton, Morris) in the fall of 1983. Relevant soil properties measured at the initiation of the study are listed in Table 1. Corn was the test crop in 1984 and 1985. Soybeans were grown on all plots in 1986.

Four factors (tillage system, rate of applied P_2O_5 and K_2O, placement of P_2O_5 and K_2O, and starter fertilizer use) are being evaluated at the Waseca and Morris locations. Space limitations dictated that fewer treatments be used at the Lamberton location. Therefore, only one rate of P_2O_5 and K_2O was used at Lamberton. The study was conducted on both low fertility and high fertility sites at Waseca and Lamberton. Only one site (high fertility) was used at Morris.

Table 1. Selected soil properties (0-6 in.) for the experimental sites measured at the initiation of the study.

Soil Property	Location and Fertility Level				
	Waseca		Lamberton		Morris
	High	Low	High	Low	High
pH	6.6	6.1	5.8	6.0	7.5
P, (B&K #1), lb/acre	48	14	33	14	39
K, (1N $NH_4C_2H_3O_2$), lb/acre	433	190	305	222	259
Organic Matter, %	3.5	3.5+	3.0	3.0	3.5+
Texture	CL*	CL	CL	CL	SiL

* CL - clay loam; SiL - silt loam

A suspension fertilizer, 4-12-24, was used to supply two combinations of P_2O_5 and K_2O. One rate, 44 lb. P_2O_5 and 87 lb. K_2O per acre, approximates removal of P and K by a typical corn crop. The second rate used was 1.5 times greater than this initial rate.

The fertilizer materials were either broadcast on the soil surface, applied in a band on the soil surface in the middle of existing rows or knifed in to a depth of 5-6 inches below the soil surface in the middle of existing rows. These treatments are repeated on initial plots each year. Treatments were applied in late October and early November. The fall chisel tillage operation is completed after fertilizer application.

There is no tillage operation prior to planting for the ridge-till system. The fall chisel plots are disked in the spring prior to planting. A 7-21-7 at 100 lb. per acre is used as a starter fertilizer at the Waseca and Lamberton locations. At Morris, a 10-34-0 applied at 117 lb. per acre is used as a starter fertilizer. Every effort is made to use management practices that will contribute to the highest yield at each location.

Soybeans grown in 1986 were sampled at early to mid bloom. The most recently matured trifoliate was taken from 50 plants in each plot. These samples were dried, ground, and analyzed for P and K by standardized ICP procedures. Soybean yields were measured with plot combines at all locations. Yields are corrected to a 13.5% moisture basis before reporting.

Results and Discussion

Morris Trials

Soybean yields at this location were not influenced by tillage system, fertilizer placement, rate of application, or starter fertilizer use. Since rate of application did not affect yields, results from the use of the lower rate are summarized in Table 2.

Table 2. Effect of tillage system, fertilizer placement, and starter fertilizer use on soybean yield at Morris when 44 lb. P_2O_5 and 87 lb. K_2O per acre were applied.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	bu/acre					
Broadcast	43.3	42.2	42.8	42.0	45.3	43.7
Surface Band	42.8	42.6	42.7	44.4	43.3	43.9
Subsurface Band	43.0	44.1	43.6	41.7	44.0	42.9
Avg.	43.0	43.0		42.7	44.2	

When averaged over placement, rate of application and starter fertilizer use, soybeans grown in the ridge-till system yielded 43.1 bu. per acre while those grown in the fall chisel management system yielded 42.3 bu. per acre.

The most recently matured leaves (petioles removed) were collected at early to mid bloom in an effort to evaluate the effect of study variables on uptake of P and K by the soybean plant. Phosphorus and potassium concentrations resulting from the low rate of fertilizer applied are summarized in Tables 3 and 4 respectively.

The P concentration in the soybean tissue was significantly affected by tillage system only. When averaged over the other variables in the study, the P concentration was .358% when the fall chisel production system was used and .403% for the ridge-till planting system. Both values are adequate concentrations for soybean growth. Since there was no significant difference in yield due to tillage system, this observation indicates that soybean plants were able to absorb more P when planted with the ridge-till system at this location.

Table 3. Effect of tillage system, P and K placement, and starter fertilizer use on the P concentration of the most recently matured trifoliate at early to mid bloom when 44 lb. P_2O_5 and 87 lb. K_2O per acre were applied at Morris.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	No Starter	No Starter	Avg.	Starter	Starter	Avg.
	% P					
Broadcast	.431	.382	.407	.362	.368	.365
Surface Band	.405	.376	.391	.367	.342	.355
Subsurface Band	.407	.382	.395	.313	.361	.337
Avg.	.414	.380		.347	.357	

The K concentration in the soybean leaf tissue was significantly affected by the tillage system used and fertilizer placement (Table 4). Concentration of K was higher with the ridge-till management system when averaged over the other factors in the study. Considering placement, the broadcast application produced the highest value, while the use of the subsurface band resulted in the lowest K percentage. The tillage x placement interaction was not significant.

Table 4. Effect of tillage system, P and K placement, and starter fertilizer use on the K concentration of the most recently matured trifoliate at early to mid-bloom when 44 lb. P_2O_5 and 87 lb. K_2O per acre were applied at Morris.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	No Starter	Starter	Avg.	Starter	No Starter	Avg.
	% K					
Broadcast	2.34	2.27	2.31	2.17	2.22	2.20
Surface Band	2.21	2.29	2.25	2.08	2.02	2.05
Subsurface Band	2.16	2.17	2.17	1.95	2.01	1.98
AVG.	2.24	2.24		2.07	2.08	

Lamberton Trials

Space limitation prevented the use of two fertilizer rates at this location. Therefore, the 44 lb. P_2O_5 and 87 lb. K_2O per acre rate was used at both the high and low fertility sites.

In 1986, soybean yield at both the high and low fertility sites was not significantly affected by tillage system, fertilizer placement or starter fertilizer use (Tables 5, 6). There was a significant tillage x placement interaction at the low fertility site.

Table 5. Effect of tillage system, P and K placement and starter fertilizer use on soybean yield at the low fertility site at Lamberton.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	bu/acre					
Broadcast	42.5	44.5	43.5	45.0	47.0	46.0
Surface Band	46.6	44.1	45.4	48.5	44.5	46.5
Subsurface Band	41.6	44.8	43.2	41.6	42.3	42.0
Avg.	43.6	44.5		45.0	44.6	

The yield from the non-fertilized control at the low fertility site was 32.4 bu. per acre for the ridge-till system and 34.5 bu. per acre for the fall chisel planting system. These yields were significantly lower than yields resulting from use of fertilizer in all other treatments.

At the high fertility site, yield from the non-fertilized control was 47.0 bu. per acre in the ridge-till system and 46.6 bu. per acre in the fall chisel system. These yields were not significantly different from yields resulting from the use of other fertilizer treatments at this site.

Table 6. Effect of tillage system, P and K placement and starter fertilizer use on soybean yield at the high fertility site at Lamberton.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	bu/acre					
Broadcast	48.8	49.1	49.0	48.7	48.9	48.8
Surface Band	46.4	47.6	47.0	47.6	47.8	47.7
Subsurface Band	50.4	48.8	49.6	48.0	46.8	47.4
Avg.	48.5	48.5		48.1	47.8	

Concentration of P in the trifoliate tissue from the low fertility site was significantly affected by tillage system, fertilizer placement, and starter use (Table 7). There were no significant interactions among these three variables at this site. Considering placement, the P concentration was highest when fertilizer was broadcast. The lowest P percentage was associated with the surface band application.

Phosphorus concentration was highest when the ridge-till system was used and fertilizer was applied. These results are consistent with those from the Morris high fertility location. As might be expected at a low fertility site, the P concentration in the soybean leaf tissue was higher when starter fertilizer was used. The P concentration in tissue from the control treatment was .286% for the ridge-till system and .291% for the fall chisel system at this low fertility site.

Table 7. Effect of tillage system, P and K placement and starter fertilizer use on the P concentration of the most recently matured trifoliate at early to mid-bloom at the low fertility site at Lamberton.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	No Starter	Starter	Avg.	Starter	No Starter	Avg.
	% P					
Broadcast	.381	.363	.372	.378	.304	.341
Surface Band	.362	.316	.339	.316	.311	.314
Subsurface Band	.365	.342	.354	.316	.298	.307
AVG.	.369	.340		.337	.304	

At the high fertility site, P concentration in the soybean tissue was significantly affected by tillage system and starter fertilizer use (Table 8). Fertilizer placement had no significant effect on P concentration at this site and there were no significant interactions.

When averaged over other variables, P concentration was higher in the ridge-till management system. This is again consistent with results from other locations. The P concentration was also higher where starter fertilizer was used. For the high fertility site, the P concentration from the non-fertilized control was .347% for the ridge-till system and .331% for the fall chisel system.

Table 8. Effect of tillage system, P and K placement, and starter fertilizer use on the P concentration of the most recently matured trifoliate at early to mid-bloom at the high fertility site at Lamberton.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	% P					
Broadcast	.384	.312	.348	.339	.299	.319
Surface Band	.395	.356	.376	.321	.343	.332
Subsurface Band	.370	.348	.359	.318	.333	.326
Avg.	.383	.339		.326	.325	

The K concentration in the soybean trifoliate tissue from the low fertility site was affected only by tillage system (Table 9). As was the case with P, concentration of K was higher in the ridge-till management system. The K percentage from the control treatment at this site was 1.92% for the ridge-till system and 1.87% for the fall chisel management system.

Table 9. Effect of tillage system, P and K placement, and starter fertilizer use on the K concentration of the most recently matured trifoliate at early to mid-bloom at the low fertility site at Lamberton.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	% K					
Broadcast	2.05	2.09	2.07	2.10	1.92	2.01
Surface Band	2.03	2.00	2.02	2.05	1.90	1.98
Subsurface Band	2.09	2.03	2.06	1.93	1.82	1.88
Avg.	2.06	2.04		2.03	1.88	

The treatment applied had no significant effect on the K concentration of the soybean trifoliate tissue at the high fertility site (Table 10). The K concentration in the non-fertilized control was 1.98% for the ridge-till management system and 1.89% for the fall chisel management system.

Table 10. Effect of tillage system, P and K placement, and starter fertilizer use on the K concentration of the most recently matured trifoliate at early to mid-bloom at the high fertility site at Lamberton.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	% K					
Broadcast	2.05	1.77	1.90	1.98	1.82	1.90
Surface Band	2.04	1.90	1.97	1.85	1.96	1.91
Subsurface Band	2.02	1.98	2.00	1.83	1.96	1.90
Avg.	2.04	1.88		1.89	1.91	

Waseca Trials

Soybean yield at the low fertility site was significantly affected by tillage system and the tillage x placement interaction was significant at the 91% confidence level (Table 11). When averaged over all other variables, yield was higher for the ridge-till planting system. Yield from the control treatment at this site was 45.2 bu. per acre for the ridge-till system and 45.0 bu. per acre when the fall chisel system was used. For both tillage systems yield was not increased by the use of starter only. Rate had no effect on yield and results from the low rate are shown in Table 11.

Table 11. Effect of tillage system, P and K placement, and starter fertilizer use on soybean yield at the low fertility site at Waseca.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	bu/acre					
Broadcast	50.4	49.7	50.1	48.6	48.8	48.7
Surface Band	52.1	51.8	52.0	48.7	49.4	49.1
Subsurface Band	49.5	50.6	50.1	49.1	49.6	49.4
Avg.	50.7	50.7		48.8	49.3	

None of the variables used in the study had a significant effect on yield at the high fertility site (Table 12). For this site, yield from the control treatment was 54.9 bu. per acre for the ridge-till system and 55.8 bu. per acre for the fall chisel system. Use of starter only at this site had no significant effect on yield.

Table 12. Effect of tillage system, P and K placement and starter fertilizer use on soybean yield at the high fertility site at Waseca.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	bu/acre					
Broadcast	55.5	57.0	56.3	56.6	55.5	56.1
Surface Band	55.7	57.1	56.4	57.8	56.6	57.2
Subsurface Band	57.3	56.7	57.0	58.5	58.3	58.4
Avg.	56.2	56.9		57.6	56.8	

The P concentration in the soybean trifoliate tissue was significantly affected by the tillage system used at the low fertility site (Table 13). Consistent with results from other locations, the P concentration was higher for the ridge-till planting system. Starter use and placement of P and K had no effect on this percentage. There was a significant tillage x placement interaction. The P concentration in the tissue from the control treatment was .367% for the ridge-till planting system and .350% for the fall chisel management system.

Table 13. Effect of tillage system, P and K placement, and starter fertilizer use on the P concentration of the most recently matured trifoliate at early to mid-bloom at the low fertility site at Waseca.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	% P					
Broadcast	.367	.387	.377	.362	.347	.355
Surface Band	.382	.394	.388	.376	.367	.372
Subsurface Band	.370	.365	.368	.376	.377	.377
Avg.	.373	.382		.371	.364	

Except for the tillage system, none of the variables used had a significant effect on the P concentrations in the trifoliate tissue at the high fertility site (Table 14). The P concentration was higher when soybeans were grown in the ridge-till management system (PR>F = .0934). For this site, the P concentration in the tissue from the control treatment was .406% for the ridge-till planting system and .406% for the fall chisel management system.

Table 14. Effect of tillage system, P and K placement, and starter fertilizer use on the P concentration of the most recently matured trifoliate at early to mid-bloom at the high fertility site at Waseca.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	% P					
Broadcast	.398	.414	.406	.403	.389	.396
Surface Band	.409	.411	.410	.399	.401	.400
Subsurface Band	.410	.410	.410	.400	.394	.397
Avg.	.406	.412		.401	.395	

Except for tillage system, none of the variables used in this study had a significant effect on the K concentration in the soybean trifoliate tissue at both fertility sites as Waseca (Tables 15 and 16).

Table 15. Effect of tillage system, P and K placement and starter fertilizer use on the K concentration of the most recently matured trifoliate at early to mid-bloom at the low fertility site at Waseca.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	% K					
Broadcast	1.93	1.95	1.94	1.90	1.83	1.87
Surface Band	1.96	2.00	1.98	1.92	1.88	1.90
Subsurface Band	1.85	1.88	1.87	1.89	1.93	1.91
Avg.	1.91	1.94		1.90	1.88	

Tillage system had no effect on this percentage at the low fertility site but K concentration was higher in the ridge-till system at the high fertility site. The data collected is not adequate to explain this observation at this time. The K concentration in the tissue from the control treatment was 1.60% for the ridge-till and 1.40% for the fall chisel system at the low fertility site. Corresponding values for the high fertility site were 2.11% and 2.16%.

Table 16. Effect of tillage system, P and K placement, and starter fertilizer use on the K concentration of the most recently matured trifoliate at early to mid-bloom at the high fertility site at Waseca.

	Tillage System					
	Ridge till			Fall Chisel		
Placement	Starter	No Starter	Avg.	Starter	No Starter	Avg.
	% K					
Broadcast	2.18	2.28	2.23	2.19	2.20	2.20
Surface Band	2.28	2.32	2.30	2.24	2.21	2.23
Subsurface Band	2.29	2.29	2.29	2.23	2.22	2.23
Avg.	2.25	2.30		2.22	2.21	

Summary

The results of the trials conducted in 1986 can be summarized as follows.

1. The effect of tillage system on soybean yield was inconsistent. Yields were higher when the ridge-till system was used at the low fertility site at Waseca. Yield was not affected by tillage at all other sites.

2. Concentration of P and K in the most recently matured trifoliate at early to mid-bloom was influenced by the tillage system used. Concentrations were generally higher when soybeans were grown in the ridge-till rather than the fall chisel management system.

3. In contrast to corn, use of starter fertilizer had no effect on soybean yield in both tillage systems.

4. Except for the low fertility site at Waseca, placement of P and K had no significant effect on soybean yield. Soybeans responded to fertilization at the low fertility sites, but response was not affected by placement.

EFFECT OF POTASSIUM PLACEMENT ON CORN PRODUCTION IN A HIGH YIELD ENVIRONMENT IN SOUTHEAST MINNESOTA

G. Rehm, B. Anderson, G. Cremers

Background and Justification:

The interest in the use of conservation tillage systems for corn production continues to increase in southeastern Minnesota. Soil test values for K are usually medium to low for the majority of soils in this region. These low soil test values create several questions that relate to management of K fertilizers. This study is designed to evaluate the effect of rate and placement of fertilizer K with and without the use of K in a starter fertilizer on corn production with two tillage systems.

Experimental Procedure:

This study was initiated in the spring of 1984 in a farmer's field in Wabasha County. Treatments were reapplied in the spring of 1985 and again in the spring of 1986. The soil is classified as a Fayette silt loam and is characteristic of soils in the region. The initial pH was 6.5. The Bray and Kurtz #1 test showed 72 lb. P per acre while the 1 N $NH_4C_2H_3O_2$ extraction showed 219 lb. per acre.

Tillage system (ridge-till, chisel), rate of applied K (0, 40, 80, 120 lb. per acre), placement (broadcast, subsurface band, and starter with and without K are the factors included in the study. A randomized complete block design is used with 4 replications.

Treatments were applied in late April in 1986. The K for both subsurface band and broadcast application was 0-0-60. A 7-21-7 fluid fertilizer at a rate of 14 gal. per acre was used to supply K in a starter fertilizer. The fluid product, 10-34-0, at 10 gal. per acre was used as a starter for plots that did not receive K in a starter. All starter fertilizer materials were placed approximately 2 inches to the side of and 2 inches below the seed at planting.

Corn was planted on May 7, 1986 at a population of 29,000 plants per acre in 38 inch rows. The variety was Pioneer 3737. Counter was used for corn rootworm control and a Lasso (3 qt. per acre) and Bladex (2 qt. per acre) combination was applied preemergence for weed control. Corn was cultivated 2 times. All plots received 180 lb. N per acre as a sidedress treatment (supplied as 28-0-0) just prior to the last cultivation.

Whole plant samples (4 plants per plot) were collected approximately 4 weeks after emergence. Ear leaf samples were collected at silking. Total dry matter production was measured at physiological maturity and samples were collected for analysis at this time. All plant samples were dried, weighed when appropriate, ground, and analyzed for K. Grain yields were harvested in late October and corrected to 15.5% moisture.

Results and Discussion:

The 1986 growing season was well suited for corn production and grain yields were well above average. A complete factorial design was used for analysis of all data collected in the study. Therefore, values for the complete control and starter only treatments were not included in the statistical analysis. The standard "t" test was used to compare means for these two treatments to means of other selected treatments in the study. The results of this statistical comparison will be presented whenever appropriate.

Grain yield was significantly affected by the tillage system used (Tables 1, 2). Placement of K, rate of application and use of K in a starter had no effect on grain yield. When averaged over the other factors studied, yield was 197.8 bu. per acre in the chisel system and 188.8 bu. per acre in the ridge-till management system.

Compared to the control treatment, use of K in a starter (8.6 lb. K/acre) without additional broadcast on

banded K produced a significant increase in grain yield for both tillage systems. The yield resulting from the broadcast application was significantly higher than the yield from the control treatment in the fall chisel system. This was not true for the ridge-till system where broadcast K would probably not reach the root system until cultivation.

With the ridge-till system, higher yields resulted from the use of K in a starter when compared to 40 lb. K per acre broadcast. Both treatments had an equal effect on yield in the fall chisel management system.

Table 1. Effect of K rate, placement of K, and use of K in a starter fertilizer on yield of corn grown in the ridge-till management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		bu/acre			
-	No	183.9	-	-	-
-	Yes	199.7	-	-	-
Broadcast	No	-	180.9	194.2	189.8
Broadcast	Yes	-	185.7	193.5	189.5
Subsurface Band	No	-	201.5	188.7	174.8
Subsurface Band	Yes	-	192.4	182.1	186.2

Table 2. Effect of K rate, placement of K, and use of K in a starter fertilizer on yield of corn grown in the fall chisel management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		bu/acre			
-	No	187.0	-	-	-
-	Yes	197.6	-	-	-
Broadcast	No	-	201.9	192.2	202.8
Broadcast	Yes	-	196.2	199.4	198.2
Subsurface Band	No	-	202.2	209.3	206.1
Subsurface Band	Yes	-	183.9	196.8	196.2

The effects of variables used in this study on total dry matter yield measured at physiological maturity were similar to the effects of these variables on grain yield (Table 3, 4). Tillage system was the only variable that had a significant effect on dry matter production. Dry matter yield was 7.2 tons per acre in the ridge-till system and 7.6 tons per acre in the fall chisel management system.

Use of K in a starter without additional broadcast on banded K increased dry matter yield in the fall chisel system but not in the ridge-till management system. Dry matter yield from the broadcast application of 40 lb. K per acre was also significantly higher than the yield from the control treatment in the fall chisel system. This increase was not measured in the ridge-till management system. Dry matter yields were equal when the starter only and 40 lb. K per acre broadcast treatments were compared in both tillage systems.

Table 3. Effect of K rate, placement of K, and use of K in a starter fertilizer on dry matter yield of corn grown in the ridge-till management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		---------- ton/acre ----------			
-	No	7.1	-	-	-
-	Yes	7.1	-	-	-
Broadcast	No	-	7.0	7.5	7.1
Broadcast	Yes	-	7.3	6.8	7.3
Subsurface Band	No	-	7.8	7.1	7.4
Subsurface Band	Yes	-	6.8	7.4	6.9

Table 4. Effect of K rate, placement of K, and use of K in a starter fertilizer on dry matter yield of corn grown in the fall chisel management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		---------- ton/acre ----------			
-	No	7.2	-	-	-
-	Yes	7.6	-	-	-
Broadcast	No	-	7.7	7.8	7.4
Broadcast	Yes	-	7.5	7.4	7.0
Subsurface Band	No	-	7.4	7.5	7.1
Subsurface Band	Yes	-	8.3	7.6	8.4

The main effects of the variables included in this study had no significant effect on early plant growth measured at approximately 4 weeks after emergence (Tables 5, 6). The tillage x starter interaction, however, was highly significant. Early growth was increased when K was added to the starter in the ridge-till system. Early growth was reduced when K was added to the starter in the fall chisel system. There is no apparent explanation for this interaction.

The placement x starter interaction was also highly significant. Early growth was increased when K in a starter was combined with K in a subsurface band indicating that roots of the young plants had not reached the band applied at a depth of 6-8 inches in the middle of 38 inch rows.

Table 5. Effect of K rate, placement of K, and use of K in a starter fertilizer on early growth of corn in the ridge-till management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		---------- weight of 4 plants (gm) ----------			
-	No	22.8	-	-	-
-	Yes	19.8	-	-	-
Broadcast	No	-	22.0	21.0	20.5
Broadcast	Yes	-	21.0	21.0	20.8
Subsurface Band	No	-	20.5	17.5	20.0
Subsurface Band	Yes	-	21.3	20.8	21.0

Table 6. Effect of K rate, placement of K, and use of K in a starter fertilizer on early growth of corn in the fall chisel management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		---------- weight of 4 plants (gm) ----------			
-	No	21.8	-	-	-
-	Yes	18.8	-	-	-
Broadcast	No	-	24.0	21.3	22.0
Broadcast	Yes	-	17.8	18.8	16.5
Subsurface Band	No	-	22.5	25.3	20.5
Subsurface Band	Yes	-	22.5	19.0	22.5

The K concentration in the young corn plants was significantly influenced by tillage system, rate of applied K, placement of K and use of K in a starter fertilizer (Tables 7, 8). There were, however, no interactions among the variables included in the study.

Considering tillage system, the highest K concentration was produced in the fall chisel management system. As would be expected, K concentration in the corn tissue increased with rate of K application.

The availability of K in the starter fertilizer is illustrated by the higher K concentration where K was applied in a starter. This was true for both tillage systems.

When averaged over all other variables, the percentage of K in the young plants was higher where fertilizer K was broadcast rather than applied in a subsurface band. These data provide further evidence that roots of the young plants had not reached the subsurface band applied in the center of the 38 inch rows. This observation could be more meaningful for soils with lower soil test values for K. In this study, the K content of the soil was such that only a small amount of K in a starter fertilizer was necessary for the highest yield.

As would be expected, use of K in a starter fertilizer without additional broadcast or banded K increased the concentration of K in the tissue of young corn plants in both tillage systems. In the fall chisel management system, use of 40 lb. K per acre broadcast increased the K concentration when compared to the control treatment; but there was no difference in K concentration if the starter only treatment is compared to the 40 lb. K per acre broadcast treatment.

In the ridge-till management system, the broadcast application of 40 lb. K per acre did not increase the K concentration in young plants. Since broadcast K was not incorporated in this system, it is not surprising that K concentration was not increased.

Table 7. Effect of K rate, placement of K, and use of K in a starter fertilizer on the K concentration in young corn plants in the ridge-till management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		% K			
-	No	2.71	-	-	-
-	Yes	2.97	-	-	-
Broadcast	No	-	2.80	3.46	3.60
Broadcast	Yes	-	3.19	3.66	3.74
Subsurface Band	No	-	2.93	2.81	3.38
Subsurface Band	Yes	-	3.29	3.33	3.83

Table 8. Effect of K rate, placement of K, and use of K in a starter fertilizer on the K concentration on young corn plants grown in the fall chisel management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		% K			
-	No	2.80	-	-	-
-	Yes	3.35	-	-	-
Broadcast	No	-	3.59	3.70	4.11
Broadcast	Yes	-	3.80	4.09	4.20
Subsurface Band	No	-	3.48	3.64	3.91
Subsurface Band	Yes	-	3.76	3.71	3.80

The significant influence of tillage system and rate of applied K on the K concentration in corn tissue persisted at the time of silking (Tables 9, 10). At this growth stage, the effect of K applied in a starter fertilizer was no longer evident. Placement of K fertilizer had no effect on the K concentration in the ear leaf tissue at silking indicating that roots were absorbing K applied in the subsurface bands. These roots had apparently reached the bands sometime between 4 weeks after emergence and silking. It's important to point out that the percentage of K in ear leaf tissue was greater than 2.0% for all treatments used. Considering the K concentrations in this ear leaf tissue, a large yield increase from applied K fertilizer would not be expected.

Table 9. Effect of K rate, placement of K, and use of K in a starter fertilizer on the K concentration of the ear leaf at silking for corn grown in the ridge-till management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		% K			
-	No	2.32	-	-	-
-	Yes	2.29	-	-	-
Broadcast	No	-	2.45	2.50	2.64
Broadcast	Yes	-	2.49	2.61	2.60
Subsurface Band	No	-	2.38	2.38	2.57
Subsurface Band	Yes	-	2.53	2.46	2.67

Table 10. Effect of K rate, placement of K, and use of K in a starter fertilizer on the K concentration of the ear leaf at silking for corn grown in the fall chisel management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		% K			
-	No	2.42	-	-	-
-	Yes	2.60	-	-	-
Broadcast	No	-	2.62	2.61	2.87
Broadcast	Yes	-	2.67	2.66	2.68
Subsurface Band	No	-	2.68	2.75	2.76
Subsurface Band	Yes	-	2.69	2.77	2.76

For the fall chisel management system, use of K in the starter without additional broadcast or banded K increased the K concentration in the ear leaf tissue when compared to the control treatment. This effect was not measured in the ridge-till management system. Compared to the control in the fall chisel system, K concentration in the ear leaf tissue was higher when a rate of 40 lb. K per acre was broadcast and incorporated before planting. Broadcast application of K had no effect on the K concentration of the ear leaf tissue in the ridge-till management system.

Of the variables used in the study, only K placement had a significant effect on the K concentration in whole plant tissue at physiological maturity (Tables 11, 12). When averaged over tillage system, K rate, and use of K in a starter, the K percentage in the mature tissue was slightly higher when broadcast rather than applied in a band. This difference, however, was very small.

There was also a highly significant placement x rate interaction. The K percentage was higher when 40 and 120 lb. K per acre were broadcast. Application of 80 lb. K per acre produced a higher percentage when applied in a subsurface band. There is no apparent explanation for this observation.

Table 11. Effect of K rate, placement of K, and use of K in a starter fertilizer on the K concentration of corn tissue at physiological maturity for corn grown in the ridge-till management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		% K			
-	No	.99	-	-	-
-	Yes	1.03	-	-	-
Broadcast	No	-	1.03	.95	1.16
Broadcast	Yes	-	1.02	.97	1.22
Subsurface Band	No	-	.96	1.07	.98
Subsurface Band	Yes	-	1.04	.93	.99

Table 12. Effect of K rate, placement of K, and use of K in a starter fertilizer on the K concentration of corn tissue at physiological maturity for corn grown in a fall chisel management system.

K Placement	K in Starter	K Applied (lb/acre) 0	40	80	120
		% K			
-	No	1.01	-	-	-
-	Yes	.98	-	-	-
Broadcast	No	-	1.06	1.00	1.18
Broadcast	Yes	-	1.09	1.08	1.17
Subsurface Band	No	-	1.02	1.09	.96
Subsurface Band	Yes	-	1.01	1.11	.93

The amount of K applied in a starter only did not have any significant effect on the concentration of K in mature corn tissue in both tillage systems. The K percentage was relatively low at this stage of growth and relatively high application rates would be needed to bring about significant changes in this percentage.

Summary

This study was conducted to measure the effect of tillage system, placement of K fertilizer, rate of K applied and use of K in a starter fertilizer on corn growth and yield on an eroded silt loam with a medium level of soil test K. The conclusions from the data collected in 1986 can be summarized as follows.

- Grain and dry matter yields were higher when corn was planted in the fall chisel rather than the ridge-till system.

- Neither rate of K applied nor placement of the K fertilizer had a significant effect on both grain and stover yield.

- Use of K in a starter fertilizer added in combination with either broadcast or band applied K had no significant effect on grain and dry matter production.

- The addition of K (8.6 lb. per acre) in a starter fertilizer only increased both grain and stover yield when compared with the control. These data indicate that a relatively small amount of K when applied in a concentrated band near the seed will supply the necessary K for optimum corn production on a soil with a medium K test.

- Concentration of K in young plants approximately 4 weeks after emergence was significantly affected by tillage system placement of K, rate of applied K, and use of K in a starter fertilizer.

- Tillage system and rate of applied K had a significant effect on the K concentration in the ear leaf tissue.

- Placement of K had a significant effect on the K concentration in the tissue at physiological maturity, but differences were small.

INFLUENCE OF SEED INOCULATION, NITROGEN SOURCE, AND NITROGEN RATE ON PRODUCTIVITY OF PROCESSING PEAS

C. J. Rosen, H. J. Buchite and C. Kahrmann

Over the past 10 years, Minnesota has consistently ranked second or third nationally in the production of processing peas. Despite the relatively large acreage and economic importance of this crop, little attention has been given to the response of processing peas to N. Increases in pea yields have been reported with N fertilizer applications at low rates as well as with inoculation of pea seed with Rhizobium. However, the conditions under which seed inoculation and N fertilizer may be beneficial for pea production have not been adequately defined. The objective of the present study was to determine the effect of seed inoculation, N rate, and N source on nodulation, nutrition, and yield of processing peas grown on an irrigated sand inherently low in N.

Materials and Methods:

The experiment was conducted at the Sand Plains Research Farm in Becker, MN. There was no record of peas being grown on this site in the history of the Research Farm. The soil, a Hubbard loamy sand, had the following soil test values (0-6"): pH, 6.4; (lb/A): P, 98; K, 198; Mg, 375; Ca, 1425. Treatments included three N rates, (0, 40, 80 lb N/A), two N sources (urea or ammonium nitrate), inoculation (inoculated or noninoculated) and two varieties (Venus or Target). A factorial 3 X 2 X 2 X 2 split-split plot treatment arrangement was used with 4 replications. Inoculation and variety were main plots with N source and rate as subplots. Nitrogen was applied and incorporated 2 days before planting. Half the seeds were inoculated with "C" pea inoculum (mixed strains of R. leguminosarum) supplied by Nitragin Co. prior to planting. Following a previous crop of rye, both varieties were planted on 17 April with a Van Brundt grain drill (6" between rows) at a population of 500,000 plants/A. When necessary, irrigation supplemented rainfall to supply approximately 1" of water per week. Soil samples were collected 4 weeks after planting and stored moist at 4 C until extracted with 2N KCl for nitrate and ammonium determination. Whole plant shoot samples for Kjeldahl N determination were collected 7 weeks after planting. In addition, root samples were collected with a golf course cup cutter (4" diameter x 6" depth) to determine extent of nodulation 7 weeks after planting. Both varieties were harvested 23 June. Harvested vines were placed in a viner to separate peas from the shells and vine plant material. Subsamples of peas and vines were taken for N determination and % moisture. Subsamples of peas were also obtained for tenderometer readings.

Results and Discussion:

Averaged over all factors, pea yields increased quadratically with N application (Table 1). For both varieties, maximum yields were obtained with 40 lbs N/A although Target yields decreased to a greater extent at 80 lbs N/A than did Venus yields. Overall, N source had little effect on pea yields except that urea tended to decrease yields when seeds were inoculated. Tenderometer (TD) readings tended to decrease with N rate (Table 2). This effect was more prominent with Target than for Venus. In general, TD readings were 10 - 20 points higher than desired for processing. This indicates that peas were one to two days over mature when harvested. Vine yield was similar to the trend for pea yield with a maximum response at 40 lb N/A (Table 3). Inoculation and N source did not significantly affect vine yield. Vine production was greater with Venus than with Target.

Inoculation of seed with commercial inoculum significantly increased nodule production on pea roots (Table 4). Increasing N rate significantly decreased nodule production with the greatest decrease occurring in inoculated plants. With noninoculated plants, an increase in nodulation was occasionally apparent with 40 lb N/A. Nitrogen source did not significantly affect nodulation. Increasing N rate increased soil nitrate-N levels (Table 5). At the time of sampling, nitrate-N was higher with urea than ammonium

nitrate. This was probably due to greater leaching potential of nitrate from the ammonium nitrate source. Soil ammonium-N levels tended to increase with N rate when urea was used (Table 6); however, the dominant differences in soil N were due to nitrate-N not ammonium-N.

Treatments had inconsistent effects on N composition of whole plants sampled 7 weeks after planting. From the present experiment, it is not possible to single out any one factor that controlled N composition of pea plants sampled during initial flowering. Nitrogen composition of peas sampled at harvest tended to decrease with N rate in noninoculated plants but stayed relatively constant with N rate in inoculated plants (Table 8). Venus had higher concentrations of N than Target. Concentrations of N in vines decreased with N rate. The reason for lower N concentrations with higher N rates may be due to inhibition of nodulation by applied N during the early part of the growing season. Because of the sandy texture of this soil, most of the applied N had probably leached out of the root zone by the time of pod fill. In addition, nodules were either not present or ineffective in N fixation when N was needed for pod fill. Thus, lower levels of soil N during pod fill coupled with ineffective nodules may be the reason why yields were depressed at 80 lb N/A. Total N removed in peas at harvest ranged from 30 - 60 lb/A (Table 10). Total N in vines ranged from 90 - 115 lb/A (Table 11). This indicates that a substantial amount of organic N can be added to the soil when vines are returned and incorporated.

In summary, yield of processing peas tended to be highest with 40 lb N/A as a preplant broadcast application compared to 0 and 80 lb N/A treatments. This low level of applied N (40 lb/A) was probably beneficial for plant growth prior to nodulation. Nitrogen source, urea vs. ammonium nitrate, had no effect on yields. Although seed inoculation with commercially available inoculum increased nodulation, there was no significant effect of inoculation on final yield. Increasing N fertilizer rate increased soil nitrate-N at 4 weeks after planting and decreased nodulation at 7 weeks after planting. Lower levels of N in tissue at harvest with 80 lb N/A suggest that applied N had leached from the root zone by pod fill and that nodules present were ineffective in fixing N due to previously high nitrate-N soil levels. Native Rhizobium at this site appeared to be effective in fixing N and were able to supply the majority of N required for processing pea production.

Table 1. Influence of inoculation, N source, and N rate on pea yields.

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	T/A							
0	3.09	2.50	2.84	3.06	3.18	2.65	2.75	2.91
40	3.43	3.19	3.21	3.04	3.08	2.77	3.00	3.09
80	2.59	2.41	2.46	2.86	2.93	3.00	3.03	2.75

Statistics

Main effects		Significance	Interactions	Significance
Variety		NS	rate x source	NS
Target	2.89		rate x variety	**
Venus	2.93		rate x inoculation	NS
Inoculation		+	source x variety	NS
noninoculated	2.97		source x inoculation	**
inoculated	2.85		variety x inoculation	NS
Source		NS	rate x source x variety	+
urea	2.90		rate x source x inoculation	+
ammonium nitrate	2.92		rate x variety x inoculation	NS
N rate		**	source x variety x inoculation	NS
0	2.87		rate x source x variety x inoculation	+
40	3.10			
80	2.76			
linear		+		
quad.		**		

Table 2. Influence of inoculation, N source, and N rate on tenderometer readings at harvest.

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	TD							
0	138	142	141	142	122	117	114	119
40	142	141	133	143	115	118	119	115
80	135	131	135	130	119	113	116	123

Statistics

Main effects		Significance	Interactions	Significance
Variety		**	rate x source	NS
Target	138		rate x variety	**
Venus	118		rate x inoculation	NS
Inoculation		NS	source x variety	NS
noninoculated	128		source x inoculation	NS
inoculated	128		variety x inoculation	NS
Source		NS	rate x source x variety	NS
urea	128		rate x source x inoculation	NS
ammonium nitrate	128		rate x variety x inoculation	NS
N rate		+	source x variety x inoculation	NS
0	129		rate x source x variety x inoculation	NS
40	128			
80	126			
linear		++		
quad.		NS		

** = <.01, * =.01 -.05, ++ =.05 -.1, + =.1 -.2, NS = >.2

Table 3. Influence of inoculation, N source, and N rate on vine and shell yield.

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	T/A							
0	13.3	10.6	12.0	13.2	13.8	12.7	12.9	13.5
40	14.6	13.8	14.2	13.0	15.1	13.5	13.8	14.7
80	12.6	12.3	12.1	13.7	14.1	14.6	14.5	12.9

Statistics

Main effects		Significance	Interactions	Significance
Variety		*	rate x source	NS
Target	13.0		rate x variety	NS
Venus	13.8		rate x inoculation	NS
Inoculation		NS	source x variety	NS
noninoculated	13.6		source x inoculation	*
inoculated	13.2		variety x inoculation	NS
Source		NS	rate x source x variety	NS
urea	13.4		rate x source x inoculation	+
ammonium nitrate	13.4		rate x variety x inoculation	NS
N rate		**	source x variety x inoculation	NS
0	12.7		rate x source x variety x inoculation	++
40	14.1			
80	13.4			
linear		+		
quad.		**		

Table 4. Influence of inoculation, N source, and N rate on nodulation of pea roots sampled 7 weeks after planting.

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	mg nodules/plant							
0	22.7	80.3	22.7	76.2	26.3	72.8	27.2	72.4
40	29.0	62.3	20.4	47.7	38.4	39.2	30.3	41.1
80	5.4	9.6	10.9	45.3	12.9	44.3	28.3	40.5

Statistics

Main effects		Significance	Interactions	Significance
Variety		NS	rate x source	++
Target	36.0		rate x variety	+
Venus	39.4		rate x inoculation	**
Inoculation		**	source x variety	NS
noninoculated	22.9		source x inoculation	NS
inoculated	52.7		variety x inoculation	NS
Source		NS	rate x source x variety	NS
urea	36.9		rate x source x inoculation	NS
ammonium nitrate	38.6		rate x variety x inoculation	NS
N rate		**	source x variety x inoculation	NS
0	50.0		rate x source x variety x inoculation	NS
40	38.6			
80	24.7			
linear		**		
quad.		NS		

** = <.01, * =.01 -.05, ++ =.05 -.1, + =.1 -.2, NS = >.2

Table 5. Influence of inoculation, N source, and N rate on soil nitrate-N levels 4 weeks after planting (0-12").

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	lb N/A							
0	12.1	13.6	13.8	14.0	15.4	15.9	13.3	11.0
40	19.1	27.9	25.4	24.7	28.2	24.4	19.8	18.4
80	39.6	40.8	30.5	25.6	47.9	63.5	32.6	25.5

Statistics

Main effects		Significance	Interactions	Significance
Variety		NS	rate x source	**
Target	24.0		rate x variety	NS
Venus	26.4		rate x inoculation	NS
Inoculation		NS	source x variety	*
noninoculated	24.8		source x inoculation	+
inoculated	25.5		variety x inoculation	NS
Source		**	rate x source x variety	NS
urea	29.0		rate x source x inoculation	NS
ammonium nitrate	21.2		rate x variety x inoculation	NS
N rate		**	source x variety x inoculation	NS
0	13.6		rate x source x variety x inoculation	NS
40	23.5			
80	38.3			
linear		**		
quad.		NS		

Table 6. Influence of inoculation, N source, and N rate on soil ammonium-N levels 4 weeks after planting (0-12").

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	lb N/A							
0	4.6	5.3	6.2	7.8	5.5	5.2	5.0	5.0
40	4.6	13.2	5.3	6.3	4.2	6.3	5.6	3.5
80	6.4	7.0	6.3	6.2	10.7	23.4	5.1	4.5

Statistics:

Main effects		Significance	Interactions	Significance
Variety		NS	rate x source	+
Target	6.6		rate x variety	NS
Venus	7.0		rate x inoculation	NS
Inoculation		NS	source x variety	NS
noninoculated	5.8		source x inoculation	NS
inoculated	7.8		variety x inoculation	NS
Source		+	rate x source x variety	NS
urea	8.0		rate x source x inoculation	NS
ammonium nitrate	5.6		rate x variety x inoculation	NS
N rate		NS	source x variety x inoculation	NS
0	5.6		rate x source x variety x inoculation	NS
40	6.1			
80	8.7			
linear		+		
quad.		NS		

** = <.01, * =.01 -.05, ++ =.05 -.1, + =.1 -.2, NS = >.2

Table 7. Influence of inoculation, N source, and N rate on N composition of whole plants sampled 7 weeks after planting.

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	% N							
0	3.55	3.46	3.25	3.64	3.78	3.38	3.67	3.64
40	3.36	3.72	3.62	3.49	3.51	3.62	3.50	3.62
80	3.74	4.13	3.43	3.68	3.39	3.60	3.34	3.47

Statistics

Main effects		Significance	Interactions	Significance
Variety		NS	rate x source	++
Target	3.59		rate x variety	**
Venus	3.54		rate x inoculation	++
Inoculation		+	source x variety	+
noninoculated	3.51		source x inoculation	NS
inoculated	3.62		variety x inoculation	NS
Source		+	rate x source x variety	NS
urea	3.60		rate x source x inoculation	*
ammonium nitrate	3.53		rate x variety x inoculation	NS
N rate		NS	source x variety x inoculation	NS
0	3.55		rate x source x variety x inoculation	NS
40	3.56			
80	3.60			
linear		NS		
quad.		NS		

Table 8. Influence of inoculation, N source, and N rate on N composition of peas sampled during harvest.

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	% N							
0	4.22	3.80	4.19	3.98	4.39	4.65	4.44	4.42
40	3.93	3.75	4.15	3.95	4.57	4.52	4.41	4.52
80	3.83	3.96	3.86	4.02	4.29	4.37	4.45	4.71

Statistics

Main effects		Significance	Interactions	Significance
Variety		**	rate x source	NS
Target	3.97		rate x variety	NS
Venus	4.48		rate x inoculation	**
Inoculation		NS	source x variety	NS
noninoculated	4.23		source x inoculation	NS
inoculated	4.22		variety x inoculation	**
Source		++	rate x source x variety	*
urea	4.19		rate x source x inoculation	NS
ammonium nitrate	4.26		rate x variety x inoculation	++
N rate		NS	source x variety x inoculation	NS
0	4.26		rate x source x variety x inoculation	+
40	4.22			
80	4.19			
linear		++		
quad.		NS		

** = <.01, * =.01 -.05, ++ =.05 -.1, + =.1 -.2, NS = >.2

Table 9. Influence of inoculation, N source, and N rate on N concentrations in vines and shells sampled during harvest.

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	% N							
0	2.69	2.40	2.81	2.43	2.64	2.81	2.68	2.65
40	2.58	2.48	2.52	2.36	2.51	2.67	2.75	2.59
80	2.33	2.48	2.53	2.37	2.45	2.62	2.50	2.57

Statistics

Main effects		Significance	Interactions	Significance
Variety		**	rate x source	NS
Target	2.50		rate x variety	NS
Venus	2.62		rate x inoculation	+
Inoculation		NS	source x variety	NS
noninoculated	2.58		source x inoculation	*
inoculated	2.54		variety x inoculation	*
Source		NS	rate x source x variety	NS
urea	2.56		rate x source x inoculation	NS
ammonium nitrate	2.56		rate x variety x inoculation	NS
N rate		**	source x variety x inoculation	NS
0	2.64		rate x source x variety x inoculation	NS
40	2.56			
80	2.48			
linear		**		
quad.		NS		

Table 10. Influence of inoculation, N source, and N rate on total N removed in peas.

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	lb N/A							
0	46.7	34.2	46.6	46.3	59.6	49.9	49.0	54.4
40	49.5	42.7	50.2	44.2	57.4	54.8	54.3	58.0
80	33.5	27.9	31.5	35.5	53.6	52.4	53.1	52.9

Statistics

Main effects		Significance	Interactions	Significance
Variety		**	rate x source	NS
Target	40.8		rate x variety	*
Venus	54.1		rate x inoculation	NS
Inoculation		+	source x variety	NS
noninoculated	48.7		source x inoculation	*
inoculated	46.1		variety x inoculation	NS
Source		NS	rate x source x variety	NS
urea	46.8		rate x source x inoculation	NS
ammonium nitrate	48.0		rate x variety x inoculation	NS
N rate		**	source x variety x inoculation	NS
0	48.3		rate x source x variety x inoculation	NS
40	51.4			
80	42.5			
linear		**		
quad.		**		

** = <.01, * =.01 -.05, ++ =.05 -.1, + =.1 -.2, NS = >.2

Table 11. Influence of inoculation, N source, and N rate on total N removed in vines and shells.

	Target				Venus			
	Urea		AN		Urea		AN	
N rate	NI	I	NI	I	NI	I	NI	I
lb/A	lb N/A							
0	115.9	80.7	106.3	102.5	104.6	98.3	99.7	98.6
40	114.9	106.8	105.6	99.6	109.3	100.6	93.4	98.9
80	93.1	92.3	90.9	104.0	94.1	104.2	103.4	91.6

Statistics

Main effects		Significance	Interactions	Significance
Variety		NS	rate x source	NS
Target	101.0		rate x variety	NS
Venus	99.7		rate x inoculation	NS
Inoculation		NS	source x variety	NS
noninoculated	102.5		source x inoculation	NS
inoculated	98.2		variety x inoculation	NS
Source		NS	rate x source x variety	NS
urea	101.1		rate x source x inoculation	NS
ammonium nitrate	99.5		rate x variety x inoculation	+
N rate		NS	source x variety x inoculation	NS
0	100.7		rate x source x variety x inoculation	NS
40	103.7			
80	96.7			
linear		NS		
quad.		+		

** = <.01, * =.01 -.05, ++ =.05 -.1, + =.1 -.2, NS = >.2

NITROGEN FERTILIZER RATE AND TIMING STUDIES ON IRRIGATED POTATOES

C. J. Rosen, N. A. Anderson and H. J. Buchite

Nitrogen is generally applied to potatoes on sandy soils at planting; emergence, and hilling. Split N applications are essential because of the leaching potential of nitrate on these soils coupled with a shallow potato root system. The question of whether N should be applied after hilling is still a matter of debate. Late season N has been reported to cause knobby potatoes and excessive vegetative growth. Conversely, some growers have observed that late applications of N have delayed early dieback symptoms and consequently enhanced yields. Early dieback in potato is thought to be due to verticillium wilt although other diseases may also be involved. The objective of this study was to determine the influence of nitrogen rate and application times on potato yield and early dieback.

Procedures

The experiment was conducted in Big Lake, MN on a Hubbard loamy sand. An alternate year corn - potato rotation has been practiced at this location for the past several years. 'Norland' and 'Russet Burbank' were planted in separate plots. A 2 X 2 factorial treatment arrangement was used with 4 replications in a randomized complete block design. N treatments were as follows:

Russet Burbank

	Date and Time of Application					
Treatment	4/11 Planting	5/2 Emergence	6/2 Hilling	6/13 2 WAH[1]	6/2 4WAH	7/11 6WAH
lb N/A	lb N/A					
210	70	40	100	0	0	0
210 - Late N	70	40	20	20	20	40
290	70	40	180	0	0	0
290 - Late N	70	40	100	20	20	40

[1] WAH = weeks after hilling

Norland

	Date and Time of Application					
Treatment	4/22 Planting	5/2 Emergence	6/2 Hilling	6/13 2 WAH[1]	6/27 4WAH	7/11 6WAH
lb N/A	lb N/A					
180	70	40	70	0	0	0
180 - Late N	70	40	20	20	15	15
230	70	40	120	0	0	0
230 - Late N	70	40	70	20	15	15

[1] WAH = weeks after hilling

Initial soil tests at each site were as follows (0-6"):

	Russet Burbank	Norland
pH	5.4	5.3
P (lb/A)	200+	200+
K (lb/A)	214	179
Ca (lb/A)	880	510
Mg (lb/A)	140	110
S (ppm)	1	3
Zn (ppm)	2.6	0.9
Mn (ppm)	28	13

At planting, both varieties received 1000 lb/A 7-18-29, 4S, 2Mg, .5 Zn as a band application. Spacing was 36" between rows and 12" within the row. All sidedressed N was applied as ammonium nitrate and irrigated in after application. The most recently matured leaves and basal stems were sampled 4 times at two week intervals starting at hilling. Leaves were dried, ground and analyzed for total Kjeldahl N. Stem samples were kept cool until exudate was plated out for Verticillium. Norland was harvested on 8/29 and Russet Burbank on 9/4.

RESULTS

Total yield of Norland potatoes was increased to a greater extent by N rate than late season N applications (Table 1). The yield effect was primarily due to an increase in tuber size. For the first two sampling dates, tissue N was higher in plants receiving the final N application at hilling compared to late season N applications (Table 2). By the third sampling date, 7/11, the higher N rate regardless of timing increased tissue N. By the last sampling date, the plants had already started to die back and differences in tissue N were not detected. The results of this experiment suggest that maintaining high levels of tissue N for Norland potatoes 2-3 weeks before dieback may promote greater tuber size. Verticillium was not detected in stem sap exudates at any of the sampling dates. The N rates and times of application did not appear to promote knobby tubers.

Russet Burbank total yields were not significantly affected by N rate or timing; however, the higher N rate increased yield of tubers in the > 7 oz category (Table 3). The higher N rate and late season N applications increased incidence of hollow heart in > 7 oz tubers. Verticillium was detected in stem sap exudates at the last sampling date; however, levels were below those considered an economic threat to production (data not presented). Similar to the results with the Norland, tissue N in Russet Burbank was higher the first two sampling dates in plants receiving the final N application at hilling compared to late season N applications. Additionally, tissue N was higher at all sampling dates with the higher N rate. Late season N applications promoted higher N concentrations at the last sampling date; however, in this study, N rate appeared to be the more important factor for increased size. Maintaining adequate tissue N at mid-July appeared to favor increased tuber size.

Table 1. Influence of nitrogen rate and timing on yield - Norland.

Treatment lb N/A	Size Distribution <2"	>2"	Total
	cwt/A		
180	59	302	361
180 Late N	72	315	385
230	64	339	403
230 Late N	62	334	397
Statistics			
Rate effect	NS[1]	++	++
Late N effect	+	NS	NS
Interaction	++	NS	NS

[1] ** = <.01, * = .01 -.05, ++ = .05 -.1, + = .1 -.2, NS = >.2

Table 2. Influence of nitrogen rate and timing on N concentrations in recently matured leaves - Norland.

Treatment lb N/A	Sampling Date 6/13	6/27	7/11	7/25
	% N			
180	6.28	5.31	4.60	3.61
180 Late N	5.94	4.83	4.49	3.65
230	6.27	5.30	5.13	3.64
230 Late N	6.11	5.08	5.00	3.74
Statistics				
Rate effect	NS[1]	NS	**	NS
Late N effect	++	**	NS	NS
Interaction	NS	NS	NS	NS

[1] ** = <.01, * = .01 -.05, ++ = .05 -.1, + = .1 -.2, NS = >.2

Table 3. Influence of nitrogen rate and timing on yield - Russet Burbank.

Treatment lb N/A	Size Distribution					Hollow Heart[1]
	Culls	<3 oz.	3-7 oz.	>7 oz.	Total	
	cwt/A					
210	26	83	271	72	452	20.8
210 Late N	17	90	281	98	486	29.1
290	20	71	273	120	485	37.5
290 Late N	22	83	259	119	481	79.1
Statistics						
Rate effect	NS[2]	NS	NS	**	NS	**
Late N effect	NS	NS	NS	NS	NS	*
Interaction	NS	NS	NS	NS	NS	+

[1] % of tubers >7 oz. having hollow heart.
[2] ** = <.01, * = .01 -.05, ++ = .05 -.1, + = .1 -.2, NS = >.2

Table 4. Influence of nitrogen rate and timing on N concentrations in recently matured leaves - Russet Burbank.

Treatment	Sampling Date			
	6/13	6/27	7/11	7/25
	% N			
210	5.82	4.43	4.43	3.29
210 Late N	5.15	4.13	4.41	3.73
290	5.89	5.11	4.91	3.63
290 Late N	5.82	4.73	4.81	3.88
Statistics				
Rate effect	**[1]	**	**	*
Late N effect	**	**	NS	**
Interaction	**	NS	NS	NS

[1] ** = <.01, * = .01 -.05, ++ = .05 -.1, + = .1 -.2, NS = >.2

VARIATION IN FOLIAR NUTRIENT COMPOSITION OF STRAWBERRY AS INFLUENCED BY GENOTYPE AND LOCATION

C. Rosen, J. Luby, H. Meredith, D. Wildung, W. Gray, and D. Bedford

The objective of this experiment was to determine the effect of cultivar and location on nutrient composition of strawberry leaves.

Materials and Methods:

Leaf samples were collected from 10 cultivars grown at 3 locations where identical strawberry variety trials were being conducted. All plantings were in their second fruiting season. The cultivars included (in order of fruiting maturation): Annapolis, Veestar, Veeglow, Crimson King, Honeoye, Redcoat, Glooscap, Kent, Jewell, and Bounty. The locations were: Excelsior, Morris, and Grand Rapids. Selected soil properties (0-6") at each location are as follows:

	Grand Rapids	Excelsior	Morris
Texture	loamy sand	silt loam	silt loam
Relative organic matter	low	medium	high
pH	5.8	6.4	7.2
P (lb/A)	200+	136	169
K (lb/A)	308	404	600+
Ca (lb/A)	1030	3850	4999+
Mg (lb/A)	210	630	999+
Zn (ppm)	6	30	2
Cu (ppm)	1.3	1.2	0.9
B (ppm)	0.3	0.5	1.5
Fe (ppm)	49	66	25
Mn (ppm)	9	32	19

As is evident form the soil analyses, relative fertility levels were high. Fertilizer was applied according to soil test recommendations during renovation. Nitrogen (30 lb/A) was applied in the spring at Grand Rapids. The youngest fully expanded mature leaves were sampled during the latter part of fruit fill, but before the first ripe fruit appeared. Within each location, all cultivars were sampled on the same day.

Results and Discussion:

Because of significant location by cultivar interactions for most elements, data are presented separately for each location (Tables 1, 2, and 3). Yields are also presented but were not statistically separated. In general, yields were high at Excelsior, but low at Morris due to late spring frost and at Grand Rapids for unknown reasons. The large fruit size at Grand Rapids coupled with low yields suggests that flower initiation may have been impaired at this location.

Leaf N concentrations ranged from 2.03 % to 2.51 %. Annapolis and Glooscap tended to be highest in % N while Redcoat and Jewell tended to be lowest. Plants growing at Excelsior had lower N concentrations than those at Grand Rapids or Morris. There did not appear to be any relationship between N concentration and maturity. Within each cultivar, higher yields tend to be related to lower N concentrations. Concentrations of leaf P did not vary greatly among cultivars. Jewell had highest leaf P concentrations while Kent had lowest P concentrations. Plants growing at Grand Rapids had the lowest P accumulation and those at Excelsior the highest. Potassium concentrations in strawberry leaves varied with location as

well as cultivar. No specific trends could be detected except that leaf K was higher at Excelsior than Grand Rapids or Morris. Even though soil test K at Morris was over twice that at Grand Rapids, leaf K was very similar at these locations. Annapolis tended to concentrate highest levels of Ca and Mg at all three locations. This was the most consistent trend in the entire experiment. Veestar, Veeglow, and Redcoat accumulated the least Ca and Mg. Concentrations of leaf Fe were lowest in Redcoat at all three locations. At the high end, leaf Fe depended on location. Leaf Mn concentrations ranged from 73 ppm to 213 ppm and were dependent on location and cultivar. Leaf Zn correlated well with soil test Zn levels. Highest leaf Zn was at Excelsior and lowest at Morris. Crimson King tended to concentrate highest levels of leaf Zn and Veeglow the lowest. Concentrations of leaf Zn, Mn, and Fe were generally lowest at the Morris due to the high soil pH at this location. Leaf Cu ranged from 3 to 6 ppm and depended on location and cultivar. Crimson King consistently was lowest in leaf B, while Jewell and Glooscap tended to be high B accumulators.

In summary, significant differences in leaf nutrient composition among strawberry cultivars were detected. Although interactions with location prevented a ranking of cultivars for each element, these data can be used as a general reference for nutritional diagnostic purposes.

Table 1. Effect of cultivar on nutrient composition of strawberry leaves sampled during fruiting - Excelsior 1986.

Variety and Maturity	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Yield (1000 lb/A)	Berry Wt. (g/fruit)
	%					ppm								
Early Season														
Annapolis	2.29	0.37	2.43	0.99	0.37	30	81	3	213	36	5	33	11.6	8.1
Veestar	2.15	0.35	2.02	0.61	0.29	23	54	4	106	29	4	34	9.1	7.4
Veeglow	2.08	0.34	2.26	0.66	0.28	24	53	8	114	25	4	30	9.6	7.8
Crimson King	2.23	0.38	2.27	0.76	0.31	27	68	3	119	41	5	27	8.7	8.7
Early Midseason														
Honeoye	2.12	0.38	2.13	0.84	0.32	30	55	6	102	33	5	38	13.1	8.3
Redcoat	2.12	0.37	2.22	0.68	0.31	24	45	4	102	31	4	32	15.3	6.9
Late Midseason														
Glooscap	2.33	0.38	2.28	0.89	0.33	28	73	7	159	32	5	39	20.2	8.9
Kent	2.23	0.33	2.29	0.71	0.29	26	56	4	148	34	6	32	12.4	8.2
Jewell	2.11	0.37	2.05	0.90	0.32	29	65	4	89	30	6	42	13.6	9.6
Late Season														
Bounty	2.25	0.36	2.34	0.85	0.36	29	76	8	119	28	6	36	11.3	8.1
Statistics														
Significance	NS	**	**	**	**	**	**	**	**	**	**	**		
BLSD (0.05)	-	0.02	0.22	0.01	0.03	2	13	2	33	4	0.5	9		

Table 2. Effects of cultivar on nutrient composition of strawberry leaves sampled during fruiting - Grand Rapids 1986.

Variety and Maturity	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Yield (1000 lb/A)	Berry Wt. (g/fruit)
	%					ppm								
Early Season														
Annapolis	2.31	0.28	1.48	1.77	0.54	44	83	193	91	24	3	36	6.3	15.2
Veestar	2.27	0.25	1.42	1.02	0.38	38	74	168	138	19	3	35	3.5	10.1
Veeglow	2.28	0.26	1.50	1.13	0.38	41	78	183	103	17	3	32	2.3	9.3
Crimson King	2.44	0.30	1.63	1.13	0.38	46	80	210	88	23	3	30	2.5	12.0
Early Midseason														
Honeoye	2.37	0.28	1.36	1.30	0.40	45	80	155	98	21	5	30	6.7	14.1
Redcoat	2.23	0.28	1.74	1.11	0.39	42	73	178	106	20	3	35	2.4	8.2
Late Midseason														
Glooscap	2.39	0.28	1.46	1.29	0.40	38	79	190	95	16	3	37	13.0	14.5
Kent	2.35	0.26	1.60	1.07	0.38	54	95	180	86	19	3	30	9.7	14.5
Jewell	2.21	0.31	1.56	1.28	0.40	55	91	180	98	22	4	33	4.1	14.4
Late Season														
Bounty	2.32	0.27	1.50	1.17	0.42	41	84	130	117	17	4	33	7.1	12.3
Statistics														
Significance	NS	NS	NS	**	**	NS	*	NS	*	*	NS	*		
BLSD (0.05)	-	-	-	0.16	0.04	-	17	-	33	6	-	6		

Table 3. Effect of cultivar on nutrient composition of strawberry leaves sampled during fruiting - Morris 1986.

Variety and Maturity	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Yield (1000 lb/A)	Berry Wt. (g/fruit)
	%					ppm								
Early Season														
Annapolis	2.51	0.33	1.41	1.15	0.45	28	60	15	86	13	3	31	4.9	6.4
Veestar	2.30	0.33	1.63	0.64	0.29	27	62	18	84	17	3	30	4.0	6.7
Veeglow	2.24	0.30	1.54	0.73	0.30	25	57	17	82	14	4	27	3.4	6.4
Crimson King	2.28	0.32	1.55	0.70	0.30	28	56	14	73	19	4	25	4.8	6.2
Early Midseason														
Honeoye	2.40	0.33	1.51	0.85	0.34	30	62	16	85	17	4	32	8.4	7.3
Redcoat	2.03	0.30	1.50	0.66	0.32	28	55	18	92	17	4	26	16.2	6.0
Late Midseason														
Glooscap	2.34	0.33	1.65	0.91	0.32	27	56	19	80	17	4	30	13.4	7.1
Kent	2.21	0.29	1.55	0.83	0.33	27	58	19	97	16	4	26	8.1	8.2
Jewell	2.19	0.34	1.63	0.92	0.33	31	62	21	81	18	4	33	8.5	9.4
Late Season														
Bounty	2.37	0.31	1.61	0.80	0.35	30	59	15	76	15	4	30	5.7	6.6
Statistics														
Significance	*	**	**	**	**	*	NS	NS	**	**	NS	**		
BLSD (0.50)	0.35	0.01	0.10	0.12	0.03	4	-	-	11	3	-	4		

SULFUR MANAGEMENT FOR CORN PRODUCTION ON IRRIGATED SANDY SOILS

G.W. Rehm, B. Anderson, G. Cremers

Background and Justification:

The value of S for crop production in Minnesota has been recognized for the past 20-25 years. Several studies have been conducted to evaluate rates and sources of S needed for economical crop production. In much of this research, however, the S fertilizers have been either broadcast or applied in a band near the seed as a starter fertilizer.

Like N, both soil and fertilizer S is mobile in soils. This is especially true for sandy soils. Considerable research with N has been carried out to define management practices such as frequency and time of application which would result in a reduction in the loss of N due to leaching on sandy soils. Parallel studies to define the best management practices for the use of S fertilizers on these sandy soils have not been initiated.

In Minnesota, as well as in other states, rainfall patterns during the early portion of the growing season are such that the potential for loss of both N and S to leaching is high. Research shows that split applications of N will reduce the amount of N lost from these soils. Logic also suggests that split applications of S might also be more beneficial for corn production on these sandy soils. Yet few, if any, studies have been initiated to evaluate the concept of split applications of S. The objective of this study was, therefore, to evaluate the effect of split applications of fertilizer S on the growth and production of irrigated corn on sandy soils.

Experimental Procedure:

This study was conducted in Wadena County in north-central Minnesota. The soil was classified as a Sverdrup loamy sand. Appropriate soil properties are listed in Table 1.

Table 1. Appropriate soil properties at Wadena County Experimental site.

	Property					
Depth	pH	P	K	S	Zn	Organic Matter
in.		--- lb/acre ---		----- ppm -----		%
0-6	5.6	78	245	1.5	.7	1.2
6-12	-	-	-	2.0	-	.4
12-24	-	-	-	1.7	-	.2

Preplant fertilizer use consisted of a broadcast application of 30 lb. N and 100 lb. K_2O per acre. Tillage consisted of 2 disk operations prior to planting. Pioneer 3978 corn was planted on May 5 and emerged on May 18. All treatments received a 9-23-30 starter fertilizer at a rate of 100 lb. per acre. In addition to preplant and starter N, all treatments received 90 lb. N per acre at the 8 leaf and again at the 12 leaf stage. The N source for these applications was 28-0-0. A total of 219 lb. N per acre was applied. The S source was 21-0-0-24 for all treatments.

Total season rainfall plus irrigation was 22.6 inches. The large majority was rainfall. Plots were irrigated 3 times with .75 inches applied each time. The results of analysis of the irrigation water are summarized in Table 2.

Table 2. Nutrient content of the irrigation water at the experimental site.

Nutrient	Value
P	<.27
K	1.5
Ca	38.2
Mg	20.2
B	.03
NO_3-N	15.8
SO_4-S	2.6

The leaf opposite and below the ear was collected at silking. These were dried, ground and analyzed for S. Grain yields were harvested in mid-October and corrected to 15.5% moisture.

Results and Discussions:

Grain yields and the S concentration values for the ear leaf tissue for the individual treatments are listed in Table 3. Statistical analysis of the data showed no significant rate x time of application interaction for either yield or S concentration in the ear leaf tissue.

Table 3. Effect of rate and timing of S application on corn yield and the S concentration in the ear leaf at silking.

Time of Application	Rate	Yield	S Concentration
	lb/acre	bu/acre	% S
-	0	130.7	.170
All starter	6	131.9	.188
1/2 starter, 1/2 pre-emerge	6	144.1	.196
1/2 starter, 1/2 8 leaf stage	6	144.5	.205
1/2 starter, 1/2 early tassel	6	141.6	.206
1/3 starter, 1/3 pre-emerge, 1/3 tassel	6	147.8	.184
All pre-emerge	6	138.4	.193
All starter	12	142.9	.187
1/2 starter, 1/2 pre-emerge	12	147.1	.206
1/2 starter, 1/2 8 leaf stage	12	150.2	.215
1/2 starter, 1/2 tassel	12	153.6	.191
1/3 starter, 1/3 pre-emerge, 1/3 tassel	12	144.8	.192
All pre-emerge	12	141.4	.200
All starter	24	151.8	.205
1/2 starter, 1/2 pre-emerge	24	144.0	.217
1/2 starter, 1/2 8 leaf stage	24	148.4	.229
1/2 starter, 1/2 tassel	24	147.7	.203
1/3 starter, 1/3 pre-emerge, 1/3 tassel	24	148.2	.210
All pre-emerge	24	150.6	.221

Yield increased curvilinearly with applied S with highest yield associated with the use of 12 lb. S per acre regardless of method of application. The equation for the yield curve is Y=130.8 + 12.1x -2.08x 2

where x is a coded value for rate of applied S. The coded values are 0, 1, 2, and 3 for 0, 6, 12, and 24 lb. S/acre respectively. The CV for the yield data was 5.4%

The S concentration in the ear leaf tissue also increased curvilinearly with rate of applied S. the regression equation is Y=.176 + .0156x - .0001x 2 where x is the same coded value as used in the yield equation. The S concentration associated with use of 12 lb. S/acre was .207 % indicating that this would be near the critical level of S in plant tissue. This value falls within the range of .180% - .210% reported as critical S values in other studies. The CV for S concentration in corn leaf tissue was 4.9%

The method or timing of the S application had no significant effect on grain yield (Table 4). Even though early season rainfall was sometimes excessive, delayed application of fertilizer S did not improve yield. The S applied early in the growing season was apparently not leached below the rooting depth in this soil.

Table 4. Effect of timing of S application on corn yield and the S concentration in the ear leaf at silking.

Time of Application	Grain Yield bu/acre **	S Concentration %
starter	142.2 a	.193 c
1/2 starter, 1/2 pre-emerge *	145.1 a	.206 b
1/2 starter, 1/2 8 leaf stage	146.7 a	.216 a
1/2 starter, 1/2 early tassel	147.6 a	.200 b c
1/3 starter, 1/3 pre-emerge, 1/3 tassel	146.9 a	.195 c
All pre-emerge	143.4 a	.205 b

** Treatment means followed by the same letter are not significantly different at the .05 confidence level.

* Pre-emergence application was broadcast on the soil surface immediately after planting. sulfur was broadcast followed by irrigation, at the 8 leaf and tassel growth stages.

The S concentration in the ear leaf tissue was affected by the time of application. Concentration was lowest when all of the S was applied in a starter. Differences in S concentration, however, were small and, as indicated by yield, there was an ample supply of S throughout the growing season from all timing sequences used for S application.

Summary

In this study, use of fertilizer S for corn production on an irrigated sandy soil with a low organic matter content produced a yield increase of about 16 bu/acre. This is a substantial return for an investment in 12 lb. of S/acre.

The timing of the application, however, had no significant effect on yield. Split and late applications did not improve yield when compared to starter or pre-emergence times of application. Although growing season rainfall was substantial, it apparently was not high enough to move early S applications out of the root zone.

The S concentration in the ear leaf tissue also responded to rate of applied S. The timing of the S application did influence S concentrations; but, differences were small.

Based on the data collected in this study, it would appear that there is no better system to supply fertilizer S to corn than to apply it in a starter fertilizer.

THE EFFECT OF SULFUR FERTILIZATION ON YIELD AND FORAGE QUALITY OF CORN AND ALFALFA

Michael O'Leary, George Rehm, and Neal Martin
Department of Soil Science
Department of Agronomy and Plant Genetics
University of Minnesota

Numerous studies have been conducted in the past to determine the importance of sulfur fertilizer for crop production programs in Minnesota. This research has demonstrated that the need for supplemental S is beneficial only on the sandy soils of Minnesota. These soils are often times characterized as low organic matter soils with a high leaching status, conditions which can lead to crop response from sulfur fertilization. Since the soil organic matter is the major reservoir of S for plant use and yield levels continue to increase, questions arise about the need for S in fertilizer programs for fine textured soils with a low organic matter content.

Substantial acreage of Minnesota cropland is utilized for the production of forage crops, mainly corn and alfalfa. Forage quality is an area that is becoming more important to livestock producers in their quest for profitable livestock production. It is well known that S is an important component of various amino acids in plants and thus the S status of soil has the potential to influence the formation of plant proteins. Protein level of forage is one indicator of the quality of that forage for use in animal nutrition. If the quality of forage can be improved the value of that forage is increased which would lead to increased profitability in livestock production.

Most research to date with sulfur has dealt with the effects of fertilizer S on crop yield. Very little attention has been focused on the effect of fertilizer S on the quality of forage crops (alfalfa and corn silage). This report summarizes data from 1986, the third year of a study designed to measure the effect of fertilizer S on both the yield and forage quality of corn and alfalfa. Research during the first two years of the study was conducted in fairly equal amounts on silt loam and sandy soils. 1986 research was centered primarily on the silt loam soils of Southeast Minnesota which are commonly low in organic matter. This was done in order to more closely assess the needs for S on these soils and to monitor forage quality as affected by S fertilization.

Experimental Procedures

This study was initiated in 1984 and continued through 1986. Overall objectives of the study were to evaluate the effect of S fertilization on the yield and forage quality of corn and alfalfa.

Alfalfa: Fertilizer S rates of 25, 50, 75, and 100 lb./acre were broadcast in early spring on established stands of alfalfa and compared to a control treatment. Gypsum was used as the S source. Field plots were laid out in a randomized complete design with 4 replications. Alfalfa trials were conducted at four sites in 1986 with one site on loamy sand and the remaining sites located on silt loam soils. Silt loam sites were located on farmer cooperator fields and the loamy sand site was on the Staples Irrigation Demonstration farm. All sites had levels of organic matter classified as low. Soil test results from all sites are summarized in Table 1. Sites were selected that did not have recent histories of manure application. In addition to S, adequate P,K, and B were broadcast at rates recommended for top yields. Three cuttings were harvested at all locations. Inclement weather for the second and third cuttings delayed the harvest schedule and made a four cut management scheme impossible on the silt loam sites.

Whole plant samples were collected from each plot at each harvest for moisture determinations and analysis. Samples were analyzed for total S and for quality characteristics. Acid detergent fiber (ADF), neutral detergent fiber (NDF) and crude protein (CP) were determined utilizing Near Infrared (NIR) technology.

Corn: Experiments on corn were conducted at four sites selected on the driftless soils of southeast Minnesota. Silt loam textures and low organic matter levels are characteristic of soils in this region. All sites were located in farmer cooperator fields. In this study various rates of S (0,10,20,40) and four rates of N (0,75,150,225) were examined in factorial combination utilizing a randomized complete block design. Nitrogen and sulfur treatments along with recommended amounts of P and K were broadcast in early spring and incorporated with primary tillage operations. Granulated gypsum was used as the S source and urea for the N source. Soil samples were taken before fertilizer application with results summarized in Table 1.

Ear leaf samples were collected from all plots at silking and analyzed for N and S. Total dry matter production was measured at physiological maturity and samples of whole plant material were collected for N, S and forage quality analysis. ADF, NDF and crude protein were determined with standard NIR procedures. Grain harvest was conducted after crop drydown to determine grain yield.

Results and Discussion:

Effects of S fertilization on yield of alfalfa in 1986 were similar to those found in the previous two years of the study (Table 2). Yield was significantly increased at the Staples site (loamy sand) by S fertilization, with 25 lb. S/acre sufficient to produce maximum yields. Yields nearly doubled with the addition of S. Yield response was similar for all cuttings at the Staples site. Yields on the silt loam soils in Goodhue and Wabasha counties were not significantly affected by addition of fertilizer S. The differential yield response can be attributed to the differences in textures at the sites. Because the Staples site has a loamy sand texture and the SO_4-S soil test was 5 ppm a response would be expected.

Whole plant samples at each cutting were collected and analyzed for S. Results are shown in Table 3. Application of fertilizer S increased the concentration of S in alfalfa tissue for nearly all cuttings at all sites. At Staples the S concentrations in the tissue increased with the addition of S at least through the 50 lb. S/acre rate. Values for the concentration of S in tissue from the control plots were all less than .20 percent. A response to the use of S fertilizer would be expected at these levels as .20 % is considered the critical level.

Except for the second cutting at the Goodhue Co. (J) site, use of fertilizer S increased the S concentration in the tissue for all cuttings on sites with silt loam soils. In general, the S concentration increased with S rate up to 50 lb. /acre. Sulfur concentrations of alfalfa tissue taken from control treatments were above the critical value for all cuttings. With these values no response to fertilizer S would be expected, however these data do indicate that S is being absorbed by the alfalfa plant.

Forage quality analysis was performed on whole plant samples taken at each cutting. Crude protein (CP), acid detergent fiber (ADF), and neutral detergent fiber (NDF) were determined with standard NIR techniques. These three measurements provide a good estimate of the quality of the forage produced. Data for forage quality are presented in Tables 4-6. In general, forage quality of alfalfa was affected very little by S fertilization. The use of fertilizer S did produce a significant increase in the protein content of the first cutting forage at Staples. Samples from later harvests did not exhibit this trend, even with the large increase in yield attributed to S fertilization at the Staples site. Protein contents were generally higher and fiber levels generally lower for the first cutting compared to the last two due most probably to a rain induced delay in harvest schedule for the last two cuttings.

Yield data for the four experiments on corn are presented in Table 7. As would be expected, yields increased with the addition of N. A nitrogen rate of 75 lb./acre was sufficient at all sites to produce optimum yield. Yield increases from N rates higher than this are not statistically significant.

Application of fertilizer S did produce a significant increase in yield at the Goodhue Co. (F) site in 1986. A rate of 10 lb. S/acre was sufficient to produce this yield increase. Response to fertilizer S was not evident at the other sites in 1986. This response to S is the second occurrence during the course of this study that corn yield has been shown to respond to S application on these soil types. A response to S application was observed during 1984 in Goodhue Co. The response to S at these sites is not consistent with previous research. Response of corn to S had previously been demonstrated only on sandy textured soils. The response to S at these sites can most probably be attributed to the low organic matter content of the soils (1984-1.6%, 1986-1.8%) and fairly high amounts of rainfall in the growing season. Statistical analysis indicated no N x S interaction in 1986, indicating the effects were independent of each other.

Total dry matter production was influenced by rate of N applied but not by S application. Slightly more response to N rate was observed for dry matter yields than for grain yields with some sites showing response to 150 lb. N/acre. As was the case with grain yield there was no significant N x S interaction.

Results from analysis of ear leaf samples for N and S are summarized in Table 8. Nitrogen concentration in ear leaf tissue was increased by the use of N fertilizer but not affected by S fertilizer. The S concentration in leaf tissue was affected by both N and S application. At the Goodhue Co. (JN) site leaf S was not affected by N rate, at the (JS) site leaf S was lowered with the use of N and at Goodhue (F) and Wabasha Co. the use of 75 lb. N/acre resulted in the highest S concentration in the tissue.

S concentration in leaf tissue was increased significantly as a result of fertilizer S application at 3 out of 4 sites. S concentration was increased with each rate of S at these sites. At the Goodhue Co. (F) site there was an increase in leaf S also, but not at the probability level to be considered highly significant. The Goodhue Co. (F) site exhibited a yield response to S so it is difficult to define "critical" values for S from this leaf tissue data.

N/S ratios were calculated with ear leaf values of N and S. This ratio was increased with N use at 3 of 4 locations. Use of fertilizer significantly reduced the ratio at 3 of 4 locations also. The ratios seem to vary over a wide range for any particular site and do not seem to have a relationship with yield.

Whole plant samples were collected when dry matter yields were taken at physiological maturity. These samples were dried, ground and analyzed for S, CP, ADF, and NDF. Sulfur concentrations for whole plant material are presented in table 9. Increasing nitrogen application did not produce consistent effects on whole plant S concentrations. Use of S fertilizer increased the concentration of whole plant sulfur at the Goodhue Co. (JN) and (JS) sites but had no significant effects at the other two sites. Use of S fertilizer did not significantly increase whole plant S concentration at the Goodhue Co. (F) site at which a grain yield response to S was observed. Protein content was increased by the use of fertilizer N but the addition of S had no significant effect (Table 9). Neither N or S application had major effects on ADF or NDF values for 1986 (Table 10). Consistent effects on the values of ADF or NDF from the use of N and S fertilizer have not been demonstrated in the previous years of the study.

Summary:

1. Use of fertilizer S improved yield of alfalfa grown on a sandy soil but had no significant effect on yield of alfalfa grown on silt loam soils.

2. The S concentration of alfalfa tissue increased with rate of applied S. Response to S occurs when S concentration in alfalfa tissue is less than .20%.

3. Forage quality, as determined by CP, ADF and NDF was affected very little by S fertilization.

4. Corn grain and total dry matter yield response to N application occurred at all sites.

5. Grain yield was significantly increased at the Goodhue Co. (F) site with 10 lb. S/acre.This site had an organic matter content of 1.8%.

6. The concentration of N in the ear leaf tissue was affected by applied N but not the rate of S used.

7. The S concentration in ear leaf tissue was affected by both N and S application.

8. The N/S ratio in the ear leaf tissue was not consistently influenced by applied S. There was no apparent relationship between N/S ratio and corn yield.

9. The percentage of crude protein in corn tissue at physiological maturity was increased with N but not S fertilization.

10. Neither applied N nor S consistently affected the percentages of ADF or NDF in tissue of corn at physiological maturity.

Table 1. Soil properties (0-6 in.) for experimental sites where fertilizer S was applied to corn and alfalfa, 1986.

	---------- Alfalfa Sites ---------				---------- Corn Sites ----------			
Soil Property	Staples	Wabasha Co.	Goodhue Co. (P)	Goodhue Co. (J)	Goodhue Co. (J-N)	Goodhue Co. (J-S)	Goodhue Co. (F)	Wabasha Co.
pH	7.2	6.0	6.4	6.7	5.9	5.5	6.3	6.5
P lb/acre (Bray & Kurtz #1)	81	25	32	70	27	56	31	115
K lb/acre (1N $NH_4C_2H_3O_2$)	145	117	190	255	231	264	160	348
Organic matter, %	2.3	3.0	2.4	2.2	1.9	2.2	1.8	2.7
SO_4-S, ppm	5.0	8.5	6.5	5.0	3.0	3.0	6.5	6.0
Texture	LS	SiL	SiL	SiL	L	SiL	SiL	SiL

Table 2. Effect of rate of applied S on alfalfa yield, 1986.

	Site, Cutting and Total															
Sulfur	----- Staples -----				---- Wabasha Co.----				-- Goodhue Co.(P) --				-- Goodhue Co.(J) --			
Applied	1	2	3	T	1	2	3	T	1	2	3	T	1	2	3	T
lb./acre	tons dry matter/acre															
0	.7	1.0	.9	2.6	1.6	1.6	1.3	4.5	1.7	1.5	1.4	4.6	1.5	1.5	1.1	4.1
25	1.6	1.5	1.4	4.5	1.5	1.5	1.3	4.3	1.7	1.6	1.5	4.8	1.6	1.5	1.1	4.2
50	1.7	1.5	1.4	4.6	1.8	1.6	1.3	4.7	1.7	1.7	1.5	4.9	1.6	1.6	1.1	4.3
75	1.8	1.6	1.4	4.8	1.5	1.7	1.3	4.5	1.7	1.6	1.6	4.9	1.6	1.6	1.1	4.3
100	1.7	1.5	1.5	4.7	1.6	1.6	1.4	4.6	1.6	1.6	1.5	4.7	1.5	1.5	1.0	4.0
PR>F	.01	.01	.01	.01	.15	.47	.71	.07	.15	.12	.13	.09	.63	.90	.70	.67
BLSD(.05)	.2	.2	.1	.3	-	-	-	-	-	-	-	-	-	-	-	-
C.V. %	7.7	8.3	6.3	4.7	10.1	7.5	8.6	3.1	6.1	4.1	7.5	3.8	8.4	11.1	13.8	6.8

Table 3. Effect of rate of applied S on the S concentration of alfalfa tissue, 1986.

	Site and Cutting											
Sulfur	Staples			Wabasha Co.			Goodhue Co.(P)			Goodhue Co.(J)		
Applied	1	2	3	1	2	3	1	2	3	1	2	3
lb./acre	% S											
0	.17	.16	.18	.28	.24	.26	.23	.21	.21	.24	.25	.25
25	.29	.25	.23	.36	.32	.30	.31	.31	.27	.34	.30	.27
50	.34	.32	.30	.35	.31	.32	.33	.32	.27	.35	.31	.32
75	.35	.34	.30	.36	.35	.33	.32	.33	.30	.34	.30	.33
100	.37	.35	.32	.33	.35	.33	.33	.32	.32	.34	.34	.35
PR>F	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.07	.01
BLSD(.05)	.02	.03	.02	.03	.03	.02	.03	.03	.02	.03	-	.03
C.V. %	5.9	6.8	5.4	6.3	6.1	4.7	7.1	7.9	5.7	7.0	12.1	7.1

Table 4. Effect of S fertilization on the crude protein content of alfalfa, 1986.

	Site and Cutting											
Sulfur	Staples			Wabasha Co.			Goodhue Co.(P)			Goodhue Co.(J)		
Applied	1	2	3	1	2	3	1	2	3	1	2	3
lb./acre	% crude protein											
0	21.2	20.2	20.3	25.5	21.8	21.8	23.7	21.7	21.1	21.8	20.1	21.1
25	22.4	20.8	20.2	25.1	21.0	22.4	22.6	23.6	21.4	21.9	19.6	20.2
50	23.1	21.4	21.0	25.0	21.7	22.4	22.8	21.8	21.2	22.5	20.5	20.8
75	23.4	21.5	21.4	25.1	21.5	22.5	23.2	22.9	21.5	22.0	19.7	20.7
100	23.1	20.8	20.7	24.6	21.1	22.3	22.6	23.3	21.8	21.6	19.6	21.2
PR>F	.01	.13	.12	.62	.70	.68	.11	.09	.29	.36	.69	.40
BLSD (.05)	.5	-	-	-	-	-	-	-	-	-	-	-
C.V. %	1.5	3.4	3.1	3.0	3.9	2.9	2.7	4.6	2.3	2.7	5.0	3.3

Table 5. Effect of S fertilization on the neutral detergent fiber of alfalfa, 1986.

	Site and Cutting											
Sulfur	Staples			Wabasha Co.			Goodhue Co.(P)			Goodhue Co.(J)		
Applied	1	2	3	1	2	3	1	2	3	1	2	3
lb./acre	% NDF											
0	38.8	44.4	42.3	35.6	48.1	47.2	38.4	46.6	45.9	40.2	44.5	39.9
25	40.1	46.9	45.4	36.4	49.2	46.6	40.7	45.8	46.5	40.0	46.5	40.0
50	38.8	45.8	44.2	36.6	47.2	45.6	40.8	47.8	46.8	38.9	45.2	41.3
75	38.5	45.3	44.0	35.7	48.0	46.6	41.2	47.5	47.2	39.2	46.8	40.9
100	39.0	47.2	45.5	36.4	47.7	46.4	40.6	45.9	45.6	39.5	47.5	39.6
PR>F	.32	.04	.12	.71	.65	.60	.12	.51	.21	.16	.40	.70
BLSD (.05)	-	2.0	-	-	-	-	-	-	-	-	-	-
C.V. %	2.7	2.6	3.9	3.5	3.8	3.0	3.7	4.1	2.2	1.9	5.0	4.8

Table 6. Effect of S fertilization on the acid detergent fiber of alfalfa, 1986.

	Site and Cutting											
Sulfur	Staples			Wabasha Co.			Goodhue Co.(P)			Goodhue Co.(J)		
Applied	1	2	3	1	2	3	1	2	3	1	2	3
lb./acre	% ADF											
0	29.8	33.3	31.1	28.1	36.3	35.5	28.7	35.0	33.3	31.0	33.8	28.8
25	30.9	34.4	32.5	28.6	37.1	35.2	30.5	33.3	33.9	30.5	35.4	29.4
50	29.6	33.1	31.4	28.8	35.8	34.3	31.0	35.6	33.8	30.2	34.0	29.9
75	29.6	33.1	31.1	28.0	36.1	35.1	30.9	34.4	34.2	30.3	35.0	29.8
100	30.4	34.4	32.8	28.6	36.4	34.9	30.4	33.5	32.9	30.1	35.8	28.6
PR>F	.24	.26	.18	.74	.83	.67	.20	.29	.31	.27	.59	.70
BLSD (.05)	-	-	-	-	-	-	-	-	-	-	-	-
C.V. %	3.1	3.2	3.8	3.6	4.4	3.5	4.7	4.5	2.7	1.9	6.1	5.4

Table 7. Effect of the rate of applied N and S on total dry matter production and the grain yield of corn, 1986.

	Site							
N Applied	Goodhue Co. (S-W)	Goodhue Co. (S-S)	Goodhue Co. (F)	Wabasha Co.	Goodhue Co. (J-N)	Goodhue Co. (J-S)	Goodhue Co. (F)	Wabasha Co.
lb/acre	Yield - bu/acre				Dry matter - ton/acre			
0	135.4	150.0	114.9	163.4	5.55	6.06	3.97	7.01
75	169.9	165.9	133.3	172.9	6.32	6.55	4.66	7.39
150	174.7	168.0	129.5	172.8	6.72	6.81	4.54	7.66
225	176.1	170.0	138.5	175.7	7.11	6.99	4.99	7.54
PR>F	.01	.01	.01	.01	.01	.01	.01	.01
BLSD (.05)	11.0	6.1	10.9	5.1	.40	.26	.60	.32
S Applied lb/acre								
0	169.5	162.0	117.5	168.6	6.52	6.54	4.54	7.43
10	166.6	160.0	136.4	169.7	6.43	6.57	4.57	7.31
20	157.8	167.7	129.2	173.7	6.21	6.54	4.19	7.34
40	162.3	164.3	133.2	172.9	6.53	6.78	4.87	7.52
PR>F	.25	.13	.01	.18	.42	.28	.15	.56
BLSD (.05)	-	-	11.5	-	-	-	-	-
NxS Interaction								
PR>F	.46	.39	.94	.44	.70	.64	.50	.09
C.V.%	10.4	5.7	10.3	4.4	9.6	6.1	15.3	6.2

Table 8. Concentration of N and S in the ear leaf of corn at silking and N:S ratio as affected by N and S application. 1986.

	Site											
	Goodhue Co. (J-N)			Goodhue Co. (J-S)			Goodhue Co. (F)			Wabasha Co.		
N Applied lb/acre	% N	% S	N:A	% N	% S	N:S	% N	% S	N:S	% N	% S	N:S
0	2.73	.26	10.5	2.94	.29	10.3	2.88	.20	14.0	2.88	.25	11.4
75	3.01	.27	11.0	3.09	.29	10.6	3.40	.23	14.6	3.06	.27	11.5
150	3.11	.27	11.8	3.16	.28	11.2	3.58	.24	14.7	3.21	.28	11.6
225	3.21	.27	12.1	3.24	.27	11.9	3.56	.24	15.2	3.20	.27	11.7
PR>F	.01	.17	.01	.01	.01	.01	.01	.01	.05	.01	.01	.24
BLSD (.05)	.06	-	.4	.06	.01	.4	.16	.01	.9	.10	.01	-
S Applied lb/acre												
0	3.02	.24	12.6	3.07	.26	11.8	3.33	.22	15.0	3.04	.25	12.0
10	3.05	.26	11.7	3.11	.26	11.1	3.37	.23	14.7	3.11	.27	11.5
20	2.98	.27	11.0	3.12	.28	11.0	3.32	.23	14.6	3.12	.27	11.5
40	3.00	.30	10.1	3.14	.31	10.1	3.40	.24	14.1	3.08	.28	11.2
PR>F	.32	.01	.01	.20	.01	.01	.76	.07	.14	.40	.01	.01
BLSD (.05)	-	.01	.4	-	.01	.4	-	-	-	-	.01	.3
NxS Interaction												
PR>F	.16	.14	.24	.92	.99	.99	.07	.48	.68	.01	.08	.04
C.V.%	3.3	5.6	5.2	2.9	5.0	5.3	6.1	7.7	6.5	4.9	5.1	3.9

Table 9. Effect of rate of applied N and S on the S concentration (WPS) and crude protein (CP) content of corn whole plant material at physiological maturity, 1986.

	Site							
N Applied lb/acre	Goodhue Co. (J-N)	Goodhue Co. (J-S)	Goodhue Co. (F)	Wabasha Co.	Goodhue Co. (J-N)	Goodhue Co. (J-S)	Goodhue Co. (F)	Wabasha Co.
	% WPS				% CP			
0	.102	.122	.084	.104	5.32	6.57	6.76	7.45
75	.104	.118	.086	.107	6.10	7.09	6.71	7.78
150	.109	.120	.089	.112	7.08	7.60	7.38	7.96
225	.109	.113	.087	.116	7.21	7.61	7.49	8.10
PR>F	.03	.01	.23	.01	.01	.01	.02	.01
BLSD (.05)	.006	.005	-	.004	.39	.21	.66	.29
S Applied lb/acre								
0	.102	.113	.083	.109	6.61	7.16	7.01	7.45
10	.106	.118	.087	.110	6.55	7.20	7.29	7.78
20	.105	.120	.087	.112	6.20	7.24	6.88	7.96
40	.111	.123	.088	.109	6.35	7.26	7.17	8.09
PR>F	.03	.01	.21	.29	.22	.85	.55	.84
BLSD (.05)	.006	.005	-	-	-	-	-	-
N&S Interaction								
PR>F	.69	.65	.71	.05	.58	.39	.97	.52
C.V.%	7.4	5.8	7.4	5.4	9.5	4.6	10.4	5.4

Table 10. Effect of the rate of applied N and S on the acid detergent fiber and neutral detergent fiber of corn at physiological maturity, 1986.

	Site							
N Applied	Goodhue Co. (J-N)	Goodhue Co. (J-S)	Goodhue Co. (F)	Wabasha Co.	Goodhue Co. (J-N)	Goodhue Co. (J-S)	Goodhue Co. (F)	Wabasha Co.
	% ADF				% NDF			
0	28.4	27.7	20.7	27.6	49.5	47.3	41.3	45.0
75	30.8	29.9	32.1	27.3	51.6	49.7	45.0	44.1
150	28.9	30.6	22.1	26.5	48.4	49.6	42.7	43.4
225	30.2	31.5	22.5	27.6	49.8	50.9	42.9	44.7
PR>F	.22	.02	.52	.59	.28	.11	.46	.51
BLSD (.05)	-	2.5	-	-	-	-	-	-
S Applied lb/acre								
0	30.4	30.2	21.3	27.6	50.2	49.7	42.4	44.6
10	29.1	30.4	22.4	26.3	49.1	49.9	43.2	43.3
20	30.1	30.1	24.5	27.0	51.0	49.6	45.8	43.8
40	28.8	29.0	20.2	28.1	49.0	48.3	40.4	45.4
PR>F	.55	.64	.07	.26	.58	.68	.15	.31
BLSD (.05)	-	-	-	-	-	-	-	-
N×S Interaction								
PR>F	.69	.39	.51	.29	.58	.33	.67	.26
C.V.%	12.1	11.1	17.9	9.5	9.5	8.2	13.0	7.5

THE EFFECT OF TILLAGE ON CORN AND SOYBEAN PRODUCTION IN SOUTHEASTERN MINNESOTA

J.F. Moncrief, T.L. Wagar, J.J Kuznia, D.D. Brietbach, B.R. Durgan, and R. Behrens

Were erosion is a concern some form of conservation tillage should be employed. Southeastern Minnesota has the highest potential for water erosion in the state. Farmers who adapt alternative tillage systems that provide erosion control and an opportunity to reduce production inputs need to know what changes in yield limiting factors may be associated with these systems. In an effort to evaluate these systems, plots have been established in several locations in southeastern Minnesota. At each location the following factors have been monitored: plant population, cover (in and between the row) by crop residue, weed density by species, and grain yields.

The soil at the Carver county site is a well drained mollisol. The crop sequence at this site is continuous corn. Cover by crop residue ranged from 9 to 26% in the row. Final stand was not affected by tillage although the trend was for slightly higher stand with the moldboard plow treatment. There was also a significantly higher population of foxtail associated with this treatment although weed control was good for all systems. Yield at this site was about 160 bu/ac and was not affected by tillage.

At the Fillmore county site the soil is also a well drained mollisol with a high intrinsic yield potential (table 6). This site is also in continuous corn. Cover after planting was about the same as the Carver county site (table 8). Plant population was significantly affected by tillage. The moldboard plow treatment had a slightly lower population (table 9).

The dominant weeds at this site are foxtail and velvetleaf (table 10). In contrast to the Carver county site the density of foxtail was significantly higher in the no till and chisel plow treatments. Velvetleaf was associated with the spring disc and chisel plow treatments. At this site the plots were split with a cultivation treatment. Late season weed densities of foxtail and velvetleaf were lower that earlier stands (table 10 and 11). All plots received an application of Buctril in early June (table 6). Foxtail without cultivation in the no till plots was the only late season treatment that had a probable affect on grain yields.

The soil at the Steele county site is a somewhat poorly to poorly drained mollisol. Tillage ranges in intensity from no till to moldboard plow. The resultant cover is shown in tables 16 and 17. The cover in the row ranged from 3 to 26% for the moldboard to chisel plow treatments respectively (table 17). This resulted in a slight delay in emergence (table 18).

There was good weed control at this site. Differences in weed densities due to tillage were significant in some cases but at levels which would not be expected to affect yield. Early season weed densities are shown in table 20. Foxtail was highest in the no till and chisel treatments, intermediate in the ridge till, and lowest in the moldboard and paraplow treatments. Ragweed was highest in the moldboard and lowest in the paraplow. Chisel and moldboard plowing resulted in the highest numbers of lambsquarter. The paraplow treatment had significantly higher levels of volunteer corn. Late season weeds and the effect of cultivation are shown in table 21. Paraplowing had volunteer corn. Chisel plowing resulted in higher levels of quackgrass and pigweed. Late season weed pressure is shown in table 23. Note that the densities were so low that plants per acre were used in this table vs thousands of plants per acre in table 21.

Cultivation and tillage did not affect soybean grain yields (tables 25 and 26).

The Wabasha county site is on a well drained silt loam soil (table 27). Soil cover by crop residue is shown in tables 28 and 29 for corn and soybeans respectively. Soil cover was similar without tillage following corn and soybeans. The corn row spacing was changed from 38" to 30" at this site. Ridges were disced in the ridge till treatment and will be reestablished this year. Crop stands are shown in table 30. The tillage treatment with disced ridges had the highest plant population of corn. This may have

been due to the lower level of residue. Soybean stand was reduced when tillage was reduced, although stands would not be expected to affect yields.

Weed densities by species are shown in tables 31 and 32 for corn and soybeans respectively. The no till corn had higher levels of nutsedge and pigweed. The establishment year ridge till had more volunteer soybeans. None of the weeds in the corn would be expected to affect yields. The no till and establishment year ridge till had higher levels of foxtail. In the soybeans there were higher levels of foxtail associated with the no till and spring disc treatments. Lambsquarter populations ranked : chisel>spring disc>no till>ridge till.

There was no difference in corn grain yields due to tillage (table 33). Soybeans grown with no till or spring disc tillage had significantly lower yields (table 34). It is not probable that the weed pressure differences due to tillage account for the 3 bu/acre yield difference, since this was before herbicide application. It is surprising that there was no disadvantage to the 30" soybeans in the ridge till treatment.

CARVER COUNTY

Table 1. Cultural practices at Carver County, MN, 1986.

Tillage

No Till-This is the establishment year for this location so in 1987 half of the no till plots will become ridge till.

Chisel Plow-November 13, 1985

Moldboard Plow-November 13, 1985

Crop	Preceding Crop
Corn - Pioneer 3906	Corn

Planting and Harvest Date

	Planting		
Crop	Date	Rate	Harvested
Corn	May 22, 1986	28,300 plants/ac	Oct. 8, 1986

Fertilizer

	Material Analysis	Actual			
		N	P_2O_5	K_2O	
Crop	(Rate)	----lbs/ac----			Date Applied
Corn:	82-0-0 (220 lbs/ac)	180	0	0	May 21, 1986
	9-23-30 (150 lbs/ac)	14	35	45	May 22, 1986 (with planter)

Soil

Lester (Mollic Hapludalfs, fine-loamy, mixed, mesic) loam 2 to 6 percent slopes. Soil is well-drained.

Weed Control

All plots were sprayed with 2.5 qts/ac Bladex + 2.5pts/ac Dual to on May 28, 1986.

Soil Test

Soil samples were taken in the spring of 1986. Results are:

Replication	pH	Bray 1 P	K
		----lbs/ac----	
Rep. 1	7.4	33	241
Rep. 2	6.3	29	216
Rep. 3	6.6	20	169

Table 2. The effect of tillage on soil cover by corn residue on June 6, 1986.[1]

	Tillage					
	No Till		Chisel		Moldboard	
	mean	std dev	mean	std dev	mean	std dev
Location	----------%----------					
In Row	25.8	15.9	14.3	6.5	9.3	6.0
Between	53.5	19.4	27.7	10.6	12.7	11.0

1. n=24 for no till, n=12 for the chisel and moldboard plow systems.

Table 3. The effect of tillage on corn stand.[1]

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	st dev	mean	st dev	mean	st dev
Date	Tillage	--------plants/ac x 10^{-3}----------					
6/9	(.129)	22.8	3.36	23.2	3.32	24.9	1.57
6/26	(.139)	23.2	3.03	23.3	2.55	24.9	1.90

1. n=24 for no till, n=12 for the chisel and moldboard plow systems.

Table 4. The effect of tillage on the presence and density of weed species[1] on June 19, 1986.[2]

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	st dev	mean	st dev	mean	st dev
Weed	Tillage	----------plants/ac x 10^{-3}----------					
Foxtail	(.004)	2.01	2.46	4.14	4.88	12.3	9.47
VolCorn	(.293)	2.31	3.34	3.31	4.50	3.41	7.68
Alfalfa		.35	.44	.20	.44	0.00	0.00
Dandeln		.64	.50	0.00	0.00	0.00	0.00
Thistle		.02	.05	0.00	0.00	0.00	0.00
NutSedg		.68	1.78	0.00	0.00	2.27	3.52
Quack		.09	.23	0.00	0.00	0.00	0.00
Ragweed		.07	.21	.02	.05	0.00	0.00
Lambqtr		0.00	0.00	0.00	0.00	2.04	1.71
Clover		.04	.10	.04	.09	0.00	0.00
Smartwd	(.397)	.30	.49	.11	.18	2.17	2.61
Velvetl	(.574)	.04	.08	.25	.51	.17	.41
Knotwee		.03	.11	0.00	0.00	0.00	0.00
Cockle		.006	.02	0.00	0.00	0.00	0.00
Goldrod		.02	.05	0.00	0.00	0.00	0.00

1. Weed species which were significantly affected by tillage are in bold type.
2. n=12 for no till, n=6 for the chisel and moldboard plow systems.

Table 5. The effect of tillage on corn yield and moisture.[1]

	Tillage					
	No Till		Chisel		Moldboard	
Sig. of	mean	st dev	mean	st dev	mean	st dev
Tillage	----------bu/ac----------					
(.667)	157	6.85	161	8.57	160	9.72
	----------% moisture----------					
(.841)	29.5	1.26	29.8	.48	29.8	.82

1. n=6 for no till, n=3 for the chisel and moldboard plow systems.

FILLMORE COUNTY

Table 6. Cultural practices at Fillmore County, MN, 1986.

Tillage

No Till
Disc - Disced twice on April 10th and once on May 6th.
Chisel-Chisel plowed with a Glencoe Soil Saver on May 3rd and again on May 6th.
Moldboard - Disced and Moldboard Plowed on April 10th, and disced again on May 6th.

Cultivation

Each plot is split with one half cultivated and the other half not.

Crop	Preceding Crop
Corn - Pioneer 3737	Corn

Planting and Harvest Date

Planter was a John Deere Maxemerge 4 row (38") planter equipped with John Deere row cleaners.

	Planting		
Crop	Date	Rate	Harvested
Corn	May 7, 1986	28,300 plants/ac	Oct. 28, 1986

Fertilization History

1983-injected 5-6000 gal/ac of liquid dairy manure.

	Material Analysis (Rate)	Actual N	P_2O_5	K_2O	Date Applied
		----lbs/ac----			
Corn:	16-41-8[1] (125 lbs/ac)	20	51	10	May 6, 1985
	82-0-0 (134 lbs/ac)	110	0	0	May 22, 1985

1. Planter applied 2" beside and 2" below row.

Fertilizer

	Material Analysis (Rate)	Actual N	P_2O_5	K_2O	Date Applied
		----lbs/ac----			
Corn:	82-0-0 (244 lbs/ac)	200	0	0	May 22, 1986
	9-23-30 (125 lbs/ac)	11	29	38	May 7, 1986 (with planter)

Soil

Tama (Typic Argiudolls, fine-silty, mixed, mesic) and Downs (Mollic Hapludalfs, fine-silty, mixed, mesic) silt loams, eroded, 2 to 6 percent slopes. Soil is well drained.

Weed Control

All plots were sprayed with 2 lbs./ac Bladex + 2 lbs/ac Dual preemergence and 1 pint/ac of Buctril on June 4, 1986. Corn was at 5 leaf stage.

Insect Control

6.9 lbs/ac Counter at time of planting.

Soil Test

Soil samples were taken on April 23rd to a depth of five feet in increments of 0-6" 6-12" 12-24" 24-36" 36-48" 48-60" for nitrate analysis. Two samples were taken per plot and then combined for a composite sample. Cores were taken in row middles for the ridge till treatment Results are:

Table 7. The effect of tillage on soil nutrients 0-6", n=3.

		Tillage							
	Sig. of	No Till		Disc		Chisel		Moldboard	
Nutrient	Tillage	mean	stdev	mean	stdev	mean	stdev	mean	stdev
		lb/ac							
Phosphorus	(.639)	81.3	13.1	80.3	34.2	65.7	30.1	58.7	14.2
Potassium	(.879)	425	165	381	121	372	95	351	19
pH	(.039)	6.9	.2	6.6	.2	6.7	.1	6.5	.2

Table 8. The effect of tillage on soil cover by corn residue on May 22, 1986, n=12.

	Tillage							
	No Till		Disc		Chisel		Moldboard	
	mean	st dev	mean	st dev	mean	st dev	mean	st dev
Location	%							
In Row	10.7	8.58	31.7	16.4	29.0	12.7	5.00	4.55
Between	53.3	12.3	37.0	17.1	44.0	16.8	3.00	3.86

Table 9. The effect of tillage on corn stand, n=12.

		Tillage							
		No Till		Disc		Chisel		Moldboard	
	Sig. of	mean	st dev	mean	st dev	mean	st dev	mean	st dev
Date	Tillage	plants/ac x 10^{-3}							
5/22	(.021)	26.8	2.17	26.0	2.67	26.6	2.38	23.8	2.58
6/16	(.001)	27.5	2.22	27.2	1.76	27.4	2.11	24.2	2.57

Table 10. The effect of tillage on the presence and density of weed species[1] on May 16, 1986, n=12.

		Tillage							
		No Till		Disc		Chisel		Moldboard	
	Sig. of	mean	st dev	mean	st dev	mean	st dev	mean	st dev
Weed	Tillage	plants/ac x 10^{-3}							
Foxtail	**(.000)**	**50.6**	**58.2**	**.25**	**.37**	**33.6**	**66.6**	**.14**	**.28**
Velvetl	**(.032)**	**13.1**	**15.3**	**22.7**	**21.0**	**19.5**	**12.2**	**9.35**	**2.49**
NutSedg		.28	.54	.15	.36	0.00	0.00	.07	.17
VolCorn		.34	.81	0.00	0.00	.76	2.26	0.00	0.00
Milkwed		0.00	0.00	.25	.65	0.00	0.00	.39	.14
Parsnip		.16	.39	0.00	0.00	0.00	0.00	0.00	0.00
Soybean		.10	.35	0.00	0.00	0.00	0.00	0.00	0.00
Dandeln		.39	.93	0.00	0.00	0.00	0.00	0.00	0.00

1. Weed species which were significantly affected by tillage are in bold type.

Table 11. The effect of tillage and cultivation on the presence and density of weed species[1] on Oct.15, 1986, n=6.

	Tillage							
	No Till		Disc		Chisel		Moldboard	
	no cult	cult	no cult	cult	no cult	cult	no cult	cult
Weed	plants/ac x 10^{-3}							
foxtail	**30.7**	**9.51**	**.472**	**.139**	**10.4**	**3.11**	**.320**	**.029**
Velvetl	2.83	.446	5.21	.849	5.00	1.67	3.01	.855
Nutsedg	.295	.015	0.00	0.00	0.00	.173	0.00	0.00
Volcorn	0.00	.022	.301	.126	.372	.293	.130	.454
Milkweed	0.00	0.00	0.00	0.00	0.00	0.00	.116	0.00
Pigweed	0.00	0.00	0.00	0.00	0.00	0.00	.055	.032
Buckwht	0.00	0.00	.524	.084	1.74	.217	1.39	.277
Dandeli	.693	1.52	.520	.104	.453	.399	.118	.167
Clover	0.00	0.00	0.00	.009	0.00	0.00	0.00	0.00
Quack	0.00	0.00	0.00	.211	.600	.160	.112	.094
Thistle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.028
Mallo	0.00	.043	0.00	0.00	0.00	0.00	0.00	0.00
Mustard	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1. Weed species which were significantly by tillage and cultivation are in bold type.

Table 12. The significance[1] of tillage, cultivation, and the interaction of tillage and cultivation on weeds on Oct. 15, 1986, n=6.

Weed	till	cult.	till x cult.
	--significance--		
Foxtail	.000	.013	.683
Velvetleaf	.002	.000	.013
Nutsedge			
Vol.Corn	.016		
Milkweed			
Pigweed			
Buckwheat			
Dandilion	.637	.034	.941
Clover			
Quack			
Thistle			
Mallow			
Mustard			

1. Due to the absence of weeds in some cells, analysis of variance cannot be performed on some variables.

Table 13. The effect of tillage and cultivation on corn yields, and corn grain moisture, n=3.

	Tillage							
	No Till		Disc		Chisel		Moldboard	
	mean	stdev	mean	stdev	mean	stdev	mean	stdev
Cultivation(.510)	bu/ac[1]							
cultivation	204	5.62	206	3.22	199	0.66	200	6.73
no cultivation	199	3.65	207	4.00	204	0.93	202	7.80
(.673)	% moisture[2]							
cultivation	20.6	.87	21.5	.48	21.6	.13	21.4	.60
no cultivation	21.4	.34	21.5	.34	21.2	.56	21.2	.52

1. The significance of tillage on yield was .015 and the tillage x cultivation interaction was .064.
2. The significance of tillage on moisture was .080 and the tillage x cultivation interaction was .039.

STEELE COUNTY

Table 14. Cultural practices at Steele County, MN, 1986.

Tillage

No Till-Chop stalks May 21, 1986.
Ridge Till-Chop stalks May 21, 1986.
Chisel Plow-Chisel plowed on Nov.1, 1985 with a John Deere 8650 then field cultivated twice with a Wilrich 42' field cultivator on May 21st.
Moldboard Plow-Moldboard plowed on Nov.1, 1985 with a John Deere 4240 then field cultivated twice with a Wilrich 42' field cultivator on May 21st.
Paraplow-Paraplowed on Oct. 30, 1985 with a John Deere 4420 and disced twice on May 21st.

Crop	Preceding Crop
Soybeans - Pioneer 1677	Corn

Planting and Harvest Date

Planter used on the no till and ridge till plots was a Hiniker Econotill two row (30") planter. The remaining plots were seeded with a John Deere Maxemerge 7000 eight row (30") planter.

	Planting		
Crop	Date	Rate	Harvested
Soybeans	May 21, 1986	200,000 plants/ac	Oct. 21, 1986

Fertilization History

Crop	Material Analysis (Rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		----lbs/ac----			
	0-0-60 (250 lbs/ac)	0	0	150	Fall 1984
Corn:	7-21-7[1] (10 gal/ac)	8	24	8	April 29, 1985
	82-0-0 (163 lbs/ac)	134	0	0	May 30, 1985

1. Applied with the seed.

Fertilizer

1986 - none

Soil

Le Sueur (Aquic Argiudolls, fine-loamy, mixed, mesic) clay loam, 2 to 4 percent slopes. Soil is moderately well drained to somewhat poorly drained.

Weed Control

All plots received $1^1/_2$ pints/ac Command + $^1/_2$ lb/ac Sencor pre-emergant.

Soil Test

Table 15. Nutrient levels sampled on November 6, 1985, n=3.

		Tillage									
		No Till		Ridge		Chisel		Moldboard		Paraplow	
	Sig of	mean	stdv	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Nutrient	Tillage	lb/ac									
Phosphor	(.855)	45	7	49	10	51	12	50	14	42	8
Potassium	(.288)	231	15	272	68	213	35	200	5	218	38
pH	(.775)	6.4	.20	6.4	.26	6.5	.29	6.4	.29	6.4	.31

Table 16. The effect of tillage on soil cover by corn residue measured perpendicular to the row on May 22, 1986, n=12.

Tillage									
No Till		Ridge		Chisel		Moldboard		Paraplow	
mean	stdv	mean	stdv	mean	stdv	mean	stdv	mean	stdv
%									
49.0	1.7	17.3	2.1	25.0	7.0	2.00	0.0	25.3	1.5

Table 17. The effect of tillage on soil cover by corn residue on June 17, 1986, n=12.

	Tillage									
	No Till		Ridge		Chisel		Moldboard		Paraplow	
	mean	stdv	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Location	%									
In Row	21.0	8.4	3.7	4.0	25.7	10.3	3.3	4.5	22.0	8.6
Between	53.7	15.4	20.0	8.2	27.3	10.4	3.7	3.2	24.7	9.6

Table 18. The effect of tillage on soybean stand in tillage system planted with the John Deere planter, n=6.

		Tillage					
		Chisel		Moldboard		Paraplow	
	Sig. of	mean	stv	mean	stv	mean	stv
Date	Tillage	plants/ac x 10^{-3}					
5/30	(.000)	114	22.1	173	6.27	124	15.5
7/8	(.386)	148	19.5	161	12.2	155	13.1

Table 19. The effect of tillage on soybean stand in tillage systems planted with the Hiniker planter, n=6.

		Tillage			
		No Till		Ridge Till	
	Sig. of	mean	st dev	mean	st dev
Date	Tillage	plants/ac x 10^{-3}			
5/30	(.334)	152	35.4	171	21.8
7/8	(.901)	198	17.2	197	16.9

Table 20. The effect of tillage on the presence and density of weed species[1] on June 17, 1986, n=12.

		Tillage									
		No Till		Ridge Till		Chisel		Moldboard		Paraplow	
	Sig of	mean	std	mean	std	mean	std	mean	std	mean	std
Weed	Tillage	plants/ac x 10^{-3}									
Foxtail	**.040**	**43.0**	**93.0**	**22.6**	**48.8**	**63.0**	**173**	**12.2**	**30.6**	**2.78**	**5.58**
Ragweed	**.019**	**.224**	**.312**	**.409**	**.689**	**.209**	**.312**	**.850**	**.660**	**.078**	**.098**
Lambsqu.	**.000**	**.043**	**.079**	**.125**	**.169**	**6.18**	**18.0**	**6.19**	**9.74**	**1.03**	**2.23**
Pigweed		.046	.095	0.00	0.00	.653	1.45	.608	.916	.080	.187
Dandeln		.343	.337	.374	.324	0.00	0.00	0.00	0.00	.119	.224
Smartwd.	.505	.116	.173	.087	.156	.055	.158	.169	.333	.037	.097
Quack	.253	.130	.303	.238	.692	2.28	7.05	.066	.194	.029	1.00
Corn	**.052**	**.388**	**.395**	**.465**	**.838**	**.371**	**.780**	**.168**	**.358**	**4.30**	**8.57**
Alfalfa		0.00	0.00	0.00	0.00	.031	.074	.047	.112	.008	.028
Buckwht		0.00	0.00	.011	.038	0.00	0.00	.065	.226	.026	.092
Clover		.006	.022	0.00	0.00	.013	.045	.045	.156	0.00	0.00
Milkwed		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.023	.079
Pencres		0.00	0.00	.006	.020	0.00	0.00	0.00	0.00	0.00	0.00
ShePurs		.013	.045	.009	.031	0.00	0.00	0.00	0.00	0.00	0.00
Plantai		.049	.067	.054	.080	0.00	0.00	0.00	0.00	0.00	0.00
GoldRod		0.00	0.00	.024	.082	0.00	0.00	0.00	0.00	0.00	0.00
Mustard		0.00	0.00	.017	.041	0.00	0.00	0.00	0.00	0.00	0.00
FoxBrly		.006	.022	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1. Weed species which were significantly affected by tillage are in bold type.

Table 21. The effect of tillage and cultivation on the presence and density of weed species on Oct. 15, 1986, n=6.

	Tillage					
	Chisel		Moldboard		Paraplow	
	no cult	cult	no cult	cult	no cult	cult
Weed	plants/ac x 10^{-3}					
Foxtail	.177	.025	.159	.133	.073	0.00
Vol. Corn	.077	.200	.238	.008	.726	.509
Lambsqtr	.040	0.00	0.00	0.00	0.00	0.00
Pigweed	.070	.200	.067	.042	.073	.009
Dandelion	0.00	0.00	0.00	0.00	.062	0.00
Smartweed	.029	0.00	.012	0.00	0.00	0.00
Quack	1.89	.092	.115	.040	.018	.070
Alfalfa	.031	.018	.058	.008	0.00	0.00
Niteshade	.059	.011	.162	.044	.036	.050
Nutsedge	.088	.015	.024	.029	.011	0.00
Plantain	0.00	0.00	0.00	0.00	.026	0.00
Barnyard	.010	0.00	0.00	0.00	0.00	0.00
Fox Barley	0.00	.097	0.00	0.00	0.00	0.00

Table 22. The significance[1] of tillage, cultivation, and the interaction of tillage x cultivation on weed presence and density on Oct. 15, 1986, n=6.

			till x
	tillage	cult.	cult.
Weed	significance		
Foxtail	.157		
Vol. Corn	.050	.348	.297
Lambsquarter			
Pigweed	.086	.858	.238
Dandelion			
Smartweed			
Quackgrass	.020	.254	.076
Alfalfa			
Ragweed	.609		
Niteshade	.223	.663	.515
Nutsedge	.703		
Plantain			
Barnyard Grass			
Fox Barley			

1. Due to the absence of weeds in some cells, analysis of variance cannot be performed on some variables.

Table 23. The effect of tillage on the presence and density of weed species[1] without cultivation on Oct. 15, 1986, (see table 24 for the significant values), n=6.

	Tillage									
	No Till		Ridge Till		Chisel		Moldboard		Paraplow	
	mean	stdv	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Weed	plants/ac									
Foxtail	151	213	139	317	177	345	159	252	73.0	79.9
Vol.Corn	**624**	**592**	**689**	**860**	**76.8**	**163**	**238**	**288**	**726**	**688**
Lambsqtr	5.49	13.4	0.00	0.00	39.5	71.2	0.00	0.00	0.00	0.00
Pigweed	11.0	26.9	16.9	41.5	70.1	111	67.4	86.3	73.4	132
Dandiln	0.00	0.00	36.2	42.5	0.00	0.00	0.00	0.00	61.5	74.2
Smartwd	0.00	0.00	0.00	0.00	29.3	71.9	12.1	29.6	0.00	0.00
Quack	0.00	0.00	0.00	0.00	1894	3870	115	281	18.2	44.5
Alfalfa	0.00	0.00	0.00	0.00	30.8	53.8	57.8	79.6	0.00	0.00
Milkweed	5.49	13.4	13.1	32.0	0.00	0.00	0.00	0.00	0.00	0.00
Ragweed	52.7	63.1	55.5	68.6	37.9	67.5	35.8	56.0	26.4	64.6
Niteshade	23.4	36.8	18.0	28.0	59.0	144	162	147	35.9	87.8
Nutsedge	27.4	67.2	0.00	0.00	88.0	216	24.2	59.3	11.1	27.2
Plantain	11.0	26.9	29.2	32.4	0.00	0.00	0.00	0.00	26.4	64.6
Medic	5.49	13.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Velvetlf	5.49	13.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barnyd Gr	0.00	0.00	0.00	0.00	10.2	25.0	0.00	0.00	0.00	0.00

Table 24. The significance of tillage on weed species and density measured Oct. 15, 1986. Weed species that were significantly affected by tillage are in bold, n=6.

Weed	Sig. of Tillage
Foxtail	.879
Vol. Corn	**.025**
Lambsquarter	
Pigweed	.201
Dandilion	
Smartweed	
Quack Grass	
Alfalfa	
Milkweed	
Ragweed	.933
Niteshade	.101
Nutsedge	
Plantain	
Medic	
Velvetleaf	
Barnyard Grass	

1. Weed species which were significantly affected by tillage are in bold type.

Table 25. The effect of tillage and cultivation on soybean yields and soybean grain moisture, n=3.

	Tillage					
	Chisel		Moldboard		Paraplow	
	mean	stdev	mean	stdev	mean	stdev
Cultivation(.378)	bu/ac[1]					
cultivation	47.2	1.89	47.1	4.15	46.9	2.19
no cultivation	45.9	1.06	46.6	3.95	45.2	1.92
(.759)	% moisture[2]					
cultivation	13.9	0.14	14.2	0.18	14.0	0.03
no cultivation	14.0	0.05	14.1	0.09	14.0	0.11

1. The significance of tillage on yield was .869 and the tillage x cultivation interaction was .907.
2. The significance of tillage on moisture was .038 and the tillage x cultivation interaction was .655.

Table 26. The effect of tillage on soybean yields and soybean grain moisture without cultivation, n=3.

	Tillage									
	No Till		Ridge Till		Chisel		Moldboard		Paraplow	
Sig of	mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev
Tillage	bu/ac									
(.920)	46.7	2.02	46.3	1.26	45.9	1.06	46.6	3.95	45.2	1.92
	% moisture									
(.559)	14.0	0.27	13.9	0.13	14.0	0.05	14.1	0.09	14.0	0.11

WABASHA COUNTY

Table 27. Cultural practices at Wabasha County, MN, 1986.

Row Width

In 1986, row crop width was changed from 38" to 30".

Tillage

No Till

Spring Disc Ridge - disc to break down 38" ridges, will be 30" ridge till in 1987, see spring disc below for tillage.

Ridge formed - corn June 26, 1986
- soybeans July 11&15, 1986

Spring Disc - area following corn disc twice on April 25, 1986
- area following soybeans disc once on April 25, 1986

Chisel Plow - April 25,1986 - field cultivator May 5, 1986

Crops	Preceding Crops
Corn - Pioneer 3737	1983 - Sweet Clover
Soybeans - Pioneer 1677	1984-85 - Corn-Soybean rotation.

Planting and Harvest Date

Planter used on all corn plots was a John Deere Maxemerge six row (30") planter equipped with 2" fluted coulters. Planter used on no till, spring disc and chisel plow soybean plots was a Kinze No Till Drill with 10" row spacing. Planter used on spring disc ridge was a John Deere Maxemerge six row (30") planter equipped with 2" fluted coulters.

	Planting		
Crop	Date	Rate	Harvested
Corn	May 5, 1986	30,800 plants/ac	Oct. 22, 1986
Soybeans	May 7, 1986	225,000 plants/ac	Oct. 22, 1986

Fertilization History

Crop	Material Analysis (Rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		----lbs/ac----			
All plots except chisel plow.	28-0-0 (7 gal/ac)	75	0	0	May 14, 1984
Corn:	7-21-7 (12.5 gal/ac)	10	29	10	May 16&18, 1984
Corn:	7-21-7[1] (25 gal/ac)	20	60	20	May 13, 1985
Corn:	82-0-0 (170 lbs/ac)	140	0	0	June 19, 1985

1. Placement 2" beside and 2" below seed.

Fertilizer

Crop	Material Analysis (Rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		----lbs/ac----			
Corn:	46-0-0 (337 lbs/ac)	155	0	0	April 24, 1986
Corn:	9-23-30 (170 lbs/ac)	15	39	51	May 5, 1986

Soil

Fayette (Typic Hapludalfs, fine-silty, mixed, mesic) silt loam.

Weed Control

Corn

Banded 1 $^3/_4$ pt Dual + 3 $^1/_2$ pt Bladex/ac with the planter on May 5, 1986.

Soybeans

Roundup was sprayed on the soybean plots at 4 qt/ac on April 23, 1986 (very windy - 30mph). Weeds present were smooth brome, quackgrass, and cockle.

1 pt Roundup + 1/2% surfactant on May 7, 1986.

1 $^1/_2$ pt (3/4 lb) Basagran + 1/2 pt (1/8 lb) Blazer + 1 qt oil concentrate on May 30, 1986.

1 pt (2/10 lb) Poast + 1 qt oil concentrate on June 12,1986.

1 pt (1/2 lb) Basagran + 1 qt oil concentrate on June 12, 1986.

Soil Test

The soil pH=6.6 P=70 lbs/ac K=275 lbs/ac, tested on April 9, 1984.

Soil samples were taken April 22, 1986 to a depth of 5' in increments of 0-6", 6-12", 12-24", 24-36", 36-48",and 48-60" for nitrate analysis (data shown in companion paper).

Table 28. The effect of tillage on soil cover by soybean residue on May 22, 1986, n=16.

	Corn following Soybeans							
	No Till		Spr Disc[1]		Spring Disc		Chisel	
Location	mean	st dev	mean	st dev	mean	st dev	mean	st dev
	%							
In Row	45.7	22.7	12.5	9.34	20.8	10.6	10.8	7.11
Between	72.3	17.1	20.8	13.4	21.8	6.69	12.5	6.83

1. This treatment was ridge till (38" rows) since 1984. Ridges were disced down and corn was planted on 30" rows in 1986 and will become ridge till in 1987.

Table 29. The effect of tillage on soil cover by corn residue on May 22, 1986, n=16.

	Soybeans following Corn							
	No Till		Spr Disc[1]		Spr Disc[2]		Chisel	
Location	mean	st dev	mean	st dev	mean	st dev	mean	st dev
	%							
In Row	50.5	19.4	17.8	9.79	28.0	10.4	23.5	8.99
Between	64.5	15.0	28.3	14.0	31.8	16.0	24.5	11.0

1. This treatment was ridge till (38" rows) since 1984. Ridges were disced down and soybeans were planted on 30" rows in 1986 and will become ridge till in 1987.
2. Row width 10 inches.

Table 30. The effect of tillage on emerged corn and soybeans on May 13,1986, n=16.

		Tillage							
		No Till		Spr Disc[1]		Spr Disc[2]		Chisel	
	Sig. of	mean	st dev	mean	st dev	mean	st dev	mean	st dev
Crop	Tillage	plants/ac x 10^{-3}							
Corn	.016	27.9	3.49	29.8	2.74	26.7	3.29	26.6	2.57
Soybeans	.032[3]	214	69.8	101	19.5	232	42.1	264	51.0

1. This treatment was ridge till (38" rows) since 1984. Ridges were disced down and corn or soybeans were planted on 30" rows in 1986 and will become ridge till in 1987.
2. Row width 10 inches for soybeans.
3. The spring disc[1] treatment was omitted from the analysis of variance since it was planted on 30" rows.

Table 31. The effect of tillage on the presence and density of weed species in corn following soybeans on May 25, 1986, n=8.

		Tillage							
		No Till		Spr Disc[2]		Spring Disc		Chisel	
	Sig. of	mean	st dev	mean	st dev	mean	st dev	mean	st dev
Weed	Tillage	plants/ac x 10^{-3}							
Foxtail	.397	4.17	8.11	.078	.156	.788	1.46	.159	.314
Velvetl	.209	6.16	10.1	1.69	1.95	3.27	3.23	4.28	5.89
Nutsedg	**.042**	**114**	**174**	**1.47**	**2.07**	**27.6**	**42.9**	**15.6**	**15.0**
Pigweed	**.085**	**5.17**	**6.11**	**.411**	**.603**	**.469**	**.771**	**.141**	**.261**
Wcockle	.649	.553	.926	.127	.240	.833	2.07	.306	.864
Milkwee		0.00	0.00	.025	.070	.932	2.64	0.00	0.00
Lambsqt	.445	.672	1.06	.396	.334	.237	.329	.157	.255
Smartwd		.221	.625	0.00	0.00	0.00	0.00	.149	.372
Dandeln	.804	.194	.362	.110	.312	.057	.115	.016	.046
Soybean	**.000**	**.173**	**2.16**	**3.50**	**2.29**	**.921**	**2.55**	**.646**	**1.09**
Thistle		0.00	0.00	0.00	0.00	0.00	0.00	2.82	7.75
Buckwht		.064	.182	0.00	0.00	0.00	0.00	0.00	0.00
YSorrel		0.00	0.00	.053	.150	0.00	0.00	0.00	0.00
Pennycr		.064	.182	0.00	0.00	0.00	0.00	0.00	0.00
Quack		0.00	0.00	0.00	0.00	0.00	0.00	1.41	3.08
Mustard		.436	1.23	0.00	0.00	0.00	0.00	0.00	0.00

1. Weed species which were significantly affected by tillage are in bold type.
2. This treatment was ridge till (38" rows) since 1984. Ridges were disced down and corn was planted on 30" rows in 1986 and will become ridge till in 1987.

Table 32. The effect of tillage on the presence and density of weed species[1] in soybeans following corn on May 26, 1986, n=8.

		Tillage							
		No Till		Spr Disc[2]		Spr disc[3]		Chisel	
	Sig. of	mean	st dev	mean	st dev	mean	st dev	mean	st dev
Weed	Tillage	plants/ac x 10^{-3}							
Foxtail	.024	9.78	26.9	4.32	11.9	12.4	12.3	2.32	2.90
Velvetl	.201	7.42	9.22	1.60	3.45	.414	.787	7.85	6.90
NutSedg	.801	7.46	19.5	5.19	10.0	7.63	18.2	2.31	4.29
Pigweed	.957	14.9	15.1	19.6	35.9	9.87	10.7	16.2	24.5
WCockle		0.00	0.00	2.54	2.68	1.00	2.82	3.49	5.01
Milkwee		0.00	0.00	.389	1.10	0.00	0.00	0.00	0.00
Laubqtr	**.006**	**37.1**	**35.5**	**14.9**	**13.1**	**54.8**	**56.9**	**74.4**	**59.0**
Smartwd		0.00	0.00	.389	1.10	0.00	0.00	1.21	2.28
Dandeln		24.9	30.2	8.39	6.65	1.30	4.62	0.00	0.00
Thistle		0.00	0.00	0.00	0.00	0.00	0.00	.353	1.00
YSorrel	.484	1.05	1.79	.767	1.66	6.62	12.9	2.27	3.25
Pennycr		3.77	10.6	0.00	0.00	0.00	0.00	0.00	0.00
Clover		0.00	0.00	1.75	3.27	2.09	4.08	2.91	2.89
AshTree		.308	.871	0.00	0.00	0.00	0.00	0.00	0.00
Quack		.083	.235	0.00	0.00	0.00	0.00	.889	2.51
VolCorn		0.00	0.00	0.00	0.00	.248	.702	0.00	0.00
Ragweed		0.00	0.00	.184	.528	1.87	5.28	.603	1.14

1. Weed species which were significantly affected by tillage are in bold type.
2. This treatment was ridge till (38" rows) since 1984. Ridges were disced down and soybeans were planted on 30" rows in 1986 and will become ridge till in 1987.
3. Row width 10 inches.

Table 33. The effect of tillage on corn yields and corn grain moisture, n=4.

	Tillage							
	No Till		Spr Disc[1]		Spr Disc		Chisel	
Sig. of	mean	stdev	mean	stdev	mean	stdev	mean	stdev
Tillage	bu/ac							
(.698)	183	3.37	185	1.59	186	2.36	185	6.03
	% moisture							
(.038)	27.4	.58	26.3	.31	26.8	.73	26.6	.50

1. This treatment was ridge till (38" rows) since 1984. Ridges were disced down and corn was planted on 30" rows in 1986 and will become ridge till in 1987.

Table 34. The effect of tillage on soybean yields and soybean grain moisture, n=4.

	Tillage							
	No Till		Spr Disc[1]		Spr disc[2]		Chisel	
Sig. of	mean	stdev	mean	stdev	mean	stdev	mean	stdev
Tillage	bu/ac							
(.011)	43.2	1.33	46.3	2.11	42.8	1.18	46.3	1.63
	% moisture							
(.218)	16.1	.36	15.6	.52	15.9	.40	16.0	.43

1. This treatment was ridge till (38" rows) since 1984. Ridges were disced down and soybeans were planted on 30" rows in 1986 and will become ridge till in 1987.
2. Row width 10 inches.

THE EFFECT OF TILLAGE SYSTEM ON STAND ESTABLISHMENT, PRESENCE OF WEEDS, GROWTH, GRAIN YIELD, AND PROTEIN CONTENT OF WINTER AND SPRING WHEAT, AND BARLEY

J.F. Moncrief, J.J. Kuznia, D.D. Breitbach, L.J. Zilliox, L.M. Behnken, B.R. Durgan, R. Behrens, D.E. Herzfeld, C.D. Holen, and M.O. Johnson

Many farmers see reduced tillage as an opportunity to make their operation more profitable. When adopting reduced tillage systems which eliminate primary tillage for small grain production reduced savings must be weighed against possible increased costs in weed and disease control. The following data was collected in an effort to evaluate tillage alternatives for small grain production.

Two sites are reported on: Becker and Douglas counties. Plots are large (150 by 50 ft.) to accommodate farmer cooperator's equipment. At the Becker county site main tillage plots were split with two varieties of winter and one of spring wheat. Research has shown that when planting winter wheat into standing small grain stubble winter survival is enhanced greatly due to snow catch.

At Becker County the wheat yields were affected by tillage and variety. The moldboard and chisel plow treatments were the same for a given variety of winter wheat. There was also a tillage by variety interaction (table 11). The Bighorn suffered more of a yield suppression with the no till treatment. This is due to three reasons which are ranked in the suspected decreasing order of importance. Nitrogen availability was responsible for yield differences due to tillage. Reasons for tillage induced differences in N availability are discussed in the next paragraph. The second factor affecting yields was disease. There was generally a lot of leaf disease pressure which was not related to tillage but variety. The Bighorn had more disease pressure which probably exerted more of an influence on yield (table 9). The last factor responsible for yield differences is better weed competition with the tall variety (Roughrider).

In addition to drill applied plus soil N (125 lbs/ac) supplemental N was applied as urea. Early season rainfall probably leached much of the initial soil N (about 9" in April+May). This was one of the few years when the soil nitrate test is not a good predictor of N needs in this part of the state. On May 29, 50 lbs N/ac as urea was broadcast applied. Following this application the first appreciable rainfall was on June 7 (1.15"). Soil test NO_3^- on June 24 (table 2) suggest there were either volatilization and/or immobilization losses or less mineralization associated with the no till treatment which could account for yield differences due to tillage. This is also supported by the protein yields (table 13).

The Douglas County results are fairly straight forward. There was no effect of tillage on barley yields (63 bu/ac, table 22). The stands were lower than optimum and was the only probable yield limiting factor at this site. Grain protein suggests that nitrogen was adequate for all tillage treatments. This is expected after a low residue crop such as soybeans.

Statistics Reported significance values are the smallest level of significance which would lead to the rejection of the hypothesis that a given treatment did not affect a particular variable. For most field experimentation a significance value that is .10 or smaller is usually accepted as proof that differences in treatment averages are due to treatments and not to random variability. If treatment variances were found to be unequal by an $F_{.10}$ test, a natural log transformation was used to meet this assumption of analysis of variance.

BECKER COUNTY

Table 1. Cultural practices at Becker County, MN. 1986.

Tillage	Crops	Preceding Crop
No Till	Winter wheat - Bighorn	Barley
Chisel-fall	- Roughrider	
Moldboard-fall	Spring wheat - Marshall	

Planting and Harvest Dates

Planter was a Haybuster 8000 hoe drill, which has a paired row system (3" spacing) with 10" shank spacing.

	Planting		
Crop	Date	Rate	Harvested
Winter wheat	Sept. 14, 1985	85-90 lbs/ac	Aug. 1, 1986
Spring wheat	May 20, 1986	85-90 lbs/ac	Sept. 15, 1986

Fertilizer

			Actual			
Crop	Material (Rate)		N	P_2O_5	K_2O	Date Applied
			---lbs/ac----			
Winter wheat:	18-46-0[1] (180 lbs/ac)	DAP	32	83	18	Sept. 14, 1985
	46-0-0[2] (109 lbs/ac)	Urea	50	0	0	May 29, 1986
Spring wheat:	23-23-12[1] (150 lbs/ac)		35	35	18	May 20, 1986
	46-0-0[2] (109 lbs/ac)	Urea	50	0	0	May 29, 1986

1. Drill applied 1.5" beside and 1" below twin rows.
2. Urea was broadcast.

Soil

Hamerly clay loam (Aeric Calciaquolls, fine-loamy, frigid)-Winger silty clay loam (Typic Calciaquolls, fine-silty, frigid) complex, 2 percent slope. Soil is somewhat poorly drained to moderately well drained soil.

Weed Control

1 pt. MCPA and 2 oz. Banvel on June 3, 1986. Roundup was applied on Sept. 16, 1985.

Soil Tests

Table 2. The effect of tillage on nutrient levels, n=3.

		Tillage					
	Sig. of	No Till		Chisel		Moldboard	
Sept. 1985[1]	Tillage	mean	stdev	mean	stdev	mean	stdev
Nutrient[2]		lb/ac					
Nitrate	(.348)	96	12	89	9	81	8
Phosphorus	(.564)	13	5	13	4	9	3
Potassium	(.178)	337	59	305	11	256	62
pH	(.284)	8.1	.1	8.1	.1	8.2	.1
June 24, 1986[3]							
Nitrate	(.169)	64	37	81	14	149	59

1. Samples were taken from both winter and spring wheat areas then mixed.
2. Nitrate sample depth was 0-24", while the other nutrient levels were determined on a 0-8" sample.
3. Samples were taken from spring wheat areas only.

Table 3. The effect of tillage on percent of the soil surface covered by barley residue in winter wheat in Sept., 1985, n=3.

	Tillage					
	No Till		Chisel		Moldboard	
	mean	stdev	mean	stdev	mean	stdev
Variety	%					
Bighorn	65.7	6.50	26.0	5.57	9.00	3.61
Roughrider	60.0	9.00	28.0	5.20	8.67	2.08

Table 4. The effect of tillage on percent of the soil covered by barley residue on May 27, 1986, n=6.

	Tillage					
	No Till		Chisel		Moldboard	
	mean	std dev	mean	std dev	mean	std dev
Crop	%					
Winter Wheat	69.7	6.38	47.0	9.78	17.8	2.79
Spring Wheat	50.5	3.33	20.7	4.41	5.83	2.56

Table 5. The effect of tillage on winter wheat stand on May 7, 1986 n=6 and spring wheat stand June 5, 1986, n=17.

		Tillage					
		No Till		Chisel		Moldboard	
Crop	Sig. of Tillage	mean	st dev	mean	st dev	mean	st dev
		plants/ac x 10^{-3}					
Winter Wheat[1]	(.001)						
Bighorn		562	136	601	33.1	423	104
Roughrider		623	98.4	479	75.1	431	93.1
Spring Wheat	(.918)	870	198	880	146	895	195

1. The effect of variety on stand of winter wheat was .599, and the interaction of variety x tillage was .104.

Table 6. The effect of tillage on the presence and density of weed species in spring wheat on June 5, 1986[1], n=6.

		Tillage					
		No Till		Chisel		Moldboard	
Weed	Sig. of Tillage	mean	std dev	mean	std dev	mean	std dev
		plants/ac x 10^{-3}					
Mustard	(.314)	10.5	10.6	58.2	56.1	32.4	32.0
Alfalfa	(.836)	45.1	69.8	10.9	13.1	16.2	24.0
Buckwheat	(.186)	5.89	14.4	4.82	7.75	1.55	1.79
Smartweed	(.903)	23.6	57.7	.448	.695	.485	1.19
Lambsquartr	(.836)	1.47	3.61	.992	1.84	1.21	2.33
Quack		47.9	114	0.00	0.00	0.00	0.00
Ragweed	(.653)	4.95	8.57	11.6	27.4	.078	.189
Wht.Cockle	(.262)	.316	.775	8.10	19.2	3.50	3.61
Dandelion		1.79	3.53	.219	.536	0.00	0.00
Pigweed		0.00	0.00	.871	2.13	0.00	0.00
Vol. Barley	(.141)	16.1	25.9	.230	.562	.106	.260
Vol.Sunflow		0.00	0.00	0.00	0.00	.121	.297
Can.Thistle		0.00	0.00	.230	.562	0.00	0.00

1. The variety by tillage interaction was not significant (<.10) for any weed species.

Table 7. The effect of tillage on the presence and density of weed species[1] in winter wheat on June 5, 1986, n=6.

		Tillage					
		No Till		Chisel		Moldboard	
Weed	Sig. of Tillage	mean	std dev	mean	std dev	mean	std dev
		plants/ac x 10^{-3}					
Mustard	(.426)	20.3	32.8	45.7	54.0	51.8	30.2
Alfalfa	(.267)	8.13	9.94	122	159	57.3	75.2
Buckwheat	(.399)	300	690	61.5	59.7	58.6	17.8
Smartweed	(.051)	433	775	79.0	156	2.25	5.51
Lambsqtr	(.847)	15.6	34.4	10.9	15.1	4.86	5.65
Ragweed	(.293)	1.76	4.30	1.22	29.9	7.91	10.1
WhtCockle		0.00	0.00	14.8	14.7	63.1	54.0
Dandelion		2.34	5.73	0.00	0.00	0.00	0.00
CanThistl		15.6	34.4	7.73	17.2	0.00	0.00
SowThistl		6.32	14.1	0.00	0.00	1.10	2.68
Wild Oat		.949	2.32	0.00	0.00	0.00	0.00
MarshEldr		0.00	0.00	9.05	14.5	0.00	0.00

1. Weed species which were significantly affected by tillage are in bold face type.

Table 8. The effect of tillage on the growth stages of winter wheat on May 7, 1986 and spring and winter wheat on June 5, 1986. Haun's growth staging was used, n=30.

		Tillage					
		No Till		Chisel		Moldboard	
Crop	Sig. of Tillage	mean	st dev	mean	st dev	mean	st dev
		Haun's growth stage					
May 7, 1986							
Winter Wheat[1]	(.336)						
Bighorn		4.19	.419	4.34	.411	4.26	.417
Roughrider		4.17	.426	4.23	.295	4.24	.385
June 5, 1986							
Winter Wheat	(.015)	8.53	.230	8.55	.291	8.36	.275
Spring Wheat	(.001)	2.29	.229	2.14	.168	2.10	.152

1. The significance of variety was .413, and the variety x tillage interaction was .818.

Table 9. The effect of tillage and variety on leaf disease measured in wheat on July 3, 1986, n=3.

Leaf Position	Roughrider No Till	Roughrider Chisel	Roughrider Moldboard	Bighorn No Till	Bighorn Chisel	Bighorn Moldboard	Marshall No Till	Marshall Chisel	Marshall Moldboard
	Modified Hosford Scale								
Upper	7.33	6.67	7.33	8.33	8.00	8.00	4.33	4.33	4.67
Middle	7.67	7.67	7.00	8.00	8.00	7.66	4.00	3.33	4.00
Lower	8.67	8.67	8.67	9.00	9.00	8.67	6.00	5.00	5.66

Table 10. The significance values of leaf disease ratings measured on July 3, 1986, n=3.

Leaf Position	Winter Wheat Tillage	Winter Wheat Variety	Winter Wheat Till. x Var.	Marshall Tillage
	significance			
Upper	.599	.060	.790	.444
Middle	.609	.374	.940	.309
Lower	.444	.116	.444	.284

Table 11. The effect of tillage and variety on wheat yields[1], n=3.

Variety	Sig. of Tillage	No Till mean	No Till st dev	Chisel mean	Chisel st dev	Moldboard mean	Moldboard st dev
		bu/ac					
Winter wheat	(.004)[2]						
Bighorn		12.9	2.18	23.2	4.09	23.5	4.02
Roughrider		29.6	1.11	38.4	7.60	34.9	4.25
Spring wheat							
Marshall	(.003)	24.0	1.81	24.5	3.17	29.7	2.04

1. The results are based on the grain after it was cleaned.
2. The significance of variety was .000, and the interaction of variety x tillage was .045.

Table 12. The effect of tillage on the test weight of wheat.[1]

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of Tillage	mean	st dev	mean	st dev	mean	st dev
		lb/bu					
Winter wheat	(.676)[2]	n=3					
Bighorn		50.5	.866	49.8	1.89	52.7	1.61
Roughrider		55.2	1.89	57.2	1.44	55.2	1.44
Spring wheat		n=6					
Marshall	(.001)	44.8	1.60	46.4	1.28	48.1	1.28

1. The results are based on the grain after it was cleaned.
2. The effect of variety on test weight was .001 and the variety x tillage interaction was .150.

Table 13. The effect of tillage on the protein content of Bighorn and Roughrider winter wheat and Marshall spring wheat.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of Tillage	mean	st dev	mean	st dev	mean	st dev
% Protein		%					
Winter wheat[1]	(.852)	n=3					
Bighorn		14.9	.807	15.1	.808	14.7	.211
Roughrider		13.5	.618	13.7	.386	14.1	.715
Spring wheat	(.082)	n=6					
Marshall		16.0	.090	16.3	.353	16.2	.262
Protein Yield		lbs/ac					
Winter wheat[2]	(.067)	n=3					
Bighorn		121	42.6	181	33.2	180	29.5
Roughrider		208	17.2	274	61.4	256	43.3
Spring wheat	(.002)	n=6					
Marshall		192	14.3	201	23.9	242	16.0

1. The significance of variety on protein content was .018, and the interaction of variety x tillage was .550.
2. The significance of variety on protein-yield was .006 and the variety x tillage interaction was .614. Protein yield refers to the protein fraction x yield (lbs/ac).

DOUGLAS COUNTY

Table 14. Cultural practices at Douglas County, MN 1986.

Tillage
No Till
Chisel Plow - fall
Moldboard Plow - fall
The chisel and moldboard plow treatments were followed by a spring field cultivation.

Preceding Crop
Soybeans

Crop
Barley - Robust

Planting and Harvest Date
Planter was a Haybuster 107 drill, with 7" row spacing that had double disk openers and twin angled packing wheels.

Crop	Planting Date	Harvested
Barley	April 25, 1986	August 2, 1986

Fertilizer

Crop	Material (Rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		---lbs/ac-----			
Barley:	18-46-0[1] DAP (100 lbs/ac)	18	46	0	April 25, 1986
	46-0-0[2] Urea (217 lbs/ac)	100	0	0	Spring 1986

1. Drill applied with seed.
2. Urea was broadcast.

Soil
Complex of: Barnes (Udic Haploborolls, fine-loamy,mixed)-Langhei (Typic Udorthents, fine-loamy, mixed (calcareous),frigid) loams, 2 to 6 percent slopes, well-drained eroded. The Langhei occurs on eroded knobs and Barnes on uniform slopes and valleys.

Weed Control
Bromoxynil(Buctril) + MCPA(ester) at 1.5pt./ac + .5pt\ac on May 28.

Soil Test
Soil samples were taken in the fall of 1985. Results were:

Crop	pH	Bray 1 P	Olsen P	K	NO_3-N 0-6"	NO_3-N 18-24"
		----------lbs/ac----------				
Barley	7.7	7	13	369	15	7

Table 15. The effect of tillage on the percent soil surface covered with soybean residue on April 25,1986 (after planting), n=18.

Tillage					
No Till		Chisel		Moldboard	
mean	std dev	mean	std dev	mean	std dev
%					
68.4	3.85	27.8	4.65	11.8	3.49

Table 16. The effect of tillage on barley population on May 21, 1986, n=36.

	Tillage					
	No Till		Chisel		Moldboard	
Sig. of	mean	std dev	mean	std dev	mean	std dev
Tillage	plants/ac x 10^{-3}					
(.027)	251	82.9	208	55.7	257	81.0

Table 17. The effect of tillage on barley growth stages 1986, n=60.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	std dev	mean	std dev	mean	std dev
Date	Tillage	Haun growth stage					
5/21	(.000)	2.84	.358	3.19	.365	3.14	.384
5/27	(.000)	3.81	.395	4.09	.361	4.09	.342
6/5	(.005)	5.70	.537	5.49	.444	5.78	.507
6/12	(.048)	7.26	.629	7.11	.446	7.32	.571
		Zadok's stage					
6/19	(.310)	46.9	2.95	46.5	2.51	47.3	2.73
6/27	(.139)	56.3	2.80	55.2	3.21	55.6	3.04
7/3	(.364)	83.0	1.25	83.1	1.10	83.3	1.13

Table 18. The effect of tillage on weed species[1] present and their density on May 21, 1986, n=12.

		Tillage					
		No Till		Chisel		Moldboard	
Weed	Sig. of Tillage	mean	std dev	mean	std dev	mean	std dev
		plants/ac x 10^{-3}					
Foxtail	**(.000)**	**3.65**	**2.69**	**8.73**	**16.4**	**21.2**	**18.5**
Mustard	**(.082)**	**1.34**	**2.94**	**.950**	**1.04**	**6.87**	**11.1**
Lambsqtr	(.109)	.072	.119	.140	.308	2.44	3.01
Buckwht	(.563)	.244	.267	.808	1.22	2.91	3.19
Ragweed	**(.089)**	**.230**	**.358**	**.118**	**.165**	**.032**	**.109**
SowThisl		0.00	0.00	.008	.027	0.00	0.00
Nt.Shade		.146	.387	.008	.027	0.00	0.00
M.Elder		.192	.359	.006	.021	0.00	0.00
CanThisl		.024	.056	.083	.128	0.00	0.00
Mallow		.009	.032	.017	.057	0.00	0.00
Smartwd		.027	.094	.741	2.57	0.00	0.00
Pigweed	(.529)	.025	.086	.146	.399	.126	.324
BlkMedic		.058	.121	.017	.057	0.00	0.00

1. Weed species which were significantly affected by tillage are in bold type.

Table 19. The effect of tillage on weed species[1] present and their density on June 9, 1986 (12 days after spraying with Bromoxynil plus MPCA), n=12.

		Tillage					
		No Till		Chisel		Moldboard	
Weed	Sig. of Tillage	mean	std dev	mean	std dev	mean	std dev
		plants/ac x 10^{-3}					
Foxtail	**(.022)**	**6.69**	**12.2**	**52.0**	**135**	**112**	**110**
Mustard		0.00	0.00	0.00	0.00	.685	2.37
Buckwht		0.00	0.00	.078	.214	.912	1.37
Ragweed		0.00	0.00	.018	.062	0.00	0.00
Smartwd		0.00	0.00	.582	1.70	.817	1.56
Pigweed		0.00	0.00	0.00	0.00	.041	.141

1. Weed species which were significantly affected by tillage are in bold type.

Table 20. The effect of tillage on area covered with quack grass on May 21 and June 9, 1986, n=12.

	Tillage					
	No Till		Chisel		Moldboard	
Date	mean	std dev	mean	std dev	mean	std dev
	ft2/ft2x100					
5/21	.343	.415	1.92	3.03	0.00	0.00
6/9	2.40	2.09	4.41	0.00	3.00	0.00

Table 21. The effect of tillage on weed species[1] present and density in the untreated check areas on June 9, 1986. The area was covered with plastic during herbicide application, n=3.

		Tillage					
		No Till		Chisel		Moldboard	
Weed	Sig. of Tillage	mean	std dev	mean	std dev	mean	std dev
		plants/ac x 10^{-3}					
Foxtail	(.048)	23.8	33.7	16.3	8.77	129	54.9
Mustard		1.16	2.01	0.00	0.00	.581	1.01
Lambsqtr		0.00	0.00	0.00	0.00	4.65	2.66
Buckwheat		.581	1.01	0.00	0.00	3.49	3.02
CanThistl		.581	1.01	0.00	0.00	0.00	0.00
Mallow		.581	1.01	0.00	0.00	0.00	0.00
Smartweed		0.00	0.00	.581	1.01	3.49	6.04
Quack		0.00	0.00	0.00	0.00	2.32	4.03
SowThistl		.581	1.01	0.00	0.00	.581	1.01
Kochia		.581	1.01	0.00	0.00	0.00	0.00

1. Weed species which were significantly affected by tillage are in bold type.

Table 22. The effect of tillage on barley yields, moisture, protein content, and test weight, n=3.

	yield[1]		% moisture		% protein		pro yield[2]		test wt	
Tillage	mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev
	--bu/ac---		----%-----		----%-----		--lbs/ac--		--lbs/bu--	
No Till	63.1	3.85	17.7	.276	11.2	.394	294	24.2	46.3	.289
Chisel	63.2	3.39	17.4	.488	11.4	.445	292	20.8	47.5	0.00
Moldboard	61.9	2.01	17.9	.484	11.2	.101	282	11.0	47.3	.577
Sig. of Tillage	(.460)		(.387)		(.642)		(.328)			

1. The results are based on the grain after it was cleaned.
2. Protein yield refers to the protein fraction x yield (lbs/ac).

THE EFFECT OF TILLAGE SYSTEM, VARIETY, AND FUNGICIDE APPLICATION ON WINTER AND SPRING WHEAT, BARLEY, AND SOYBEAN PRODUCTION

J.F. Moncrief, J.J. Kuznia, D.D. Breitbach, K.J. Pazdernik, H.L. Bissornette, B.R. Durgan, R. Behrens, C.D. Holen, and M.O. Johnson

Many farmers see reduced tillage as an opportunity to make their operation more profitable. When adopting reduced tillage systems which eliminate primary tillage for small grain production reduced savings must be weighed against possible increased costs in weed and disease control. The following data was collected in an effort to evaluate tillage alternatives for small grain production.

The site is located in Norman county Minnesota. Plots are large (150 by 50 ft.) to accomodate farmer cooperators equippment. Main tillage plots were split with two varieties of winter and spring wheat. Research has shown that when planting winter wheat into standing small grain stubble winter survival is enhanced greatly due to snow catch. Two varieties of winter wheat were chosen two contrast a winter hardy variety (Roughrider) and a less winter hardy variety (Bighorn) which is shorter but has higher intrinsic yield potential.

Four crops were grown at this site. The spring was extremely wet near Ada, Minnesota this year which resulted in a June 2 planting date for the spring wheat. This site is on a Fargo-Hegne silty clay soil with poor to somewhat poor internal drainage which delayed spring wheat planting. This accounts for most of the yield difference between winter and spring wheat. Both winter and spring wheat had more leaf disease due to increased residue levels (see leaf disease ratings). There was statistically the same response to fungicide application for all tillage systems, however. The winter wheat response averaged 12.5 bu/ac and the spring wheat 4.0 bu/ac. There tended to be a larger response with the Bighorn variety. Tillage did not affect winter wheat yields although the tendency was for higher yields with less tillage with the Bighorn. Spring wheat yields were not statistically affected by tillage although the trend was for reduced yields with less tillage. Although the density of foxtail in the spring wheat was less than in the winter wheat it exerted more competitive pressure and probably explains the yield decline.

Barley and soybean yields were not affected by tillage. The barley yields were generally low due the late planting date and inadequate surface drainage. Soybean yields were 33 bu/ac regardless of tillage (table 27). The lack of soybean response to tillage is consistent with data from other locations in the state.

Statistics Reported significance values are the smallest level of significance which would lead to the rejection of the hypothesis that a given treatment did not affect a particular variable. For most field experimentation a significance value that is .10 or smaller is usually accepted as proof that differences in treatment averages are due to treatments and not to random variabilIty. If treatment variances were found to be unequal by an F.10 test, a natural log transformation was used to meet this assumption of analysis of variance.

NORMAN COUNTY

Table 1. Cultural practices at Norman County, MN, 1986.

Tillage

No Till-the soybean and barley plots were dragged in spring.
Chisel Plow - fall
Moldboard Plow - fall

Roughrider

The chisel and moldboard plow treatments on the plots were field cultivated twice with a drag behind it.

Preceding Crop Spring Wheat

Crops

Winter wheat - Bighorn
Spring wheat - Marshall
- Stoa
Barley - Robust
Soybeans - McCalls

Planting and Harvest Dates

A Haybuster No Till Disc Drill was used to plant all plots.

	Planting		
Crop	Date	Rate	Harvested
Winter wheat	Sept. 25, 1985	80 lbs/ac	July 31, 1986
Spring wheat	June 2, 1986	120 lbs/ac	Sept. 15, 1986
Soybeans	June 2, 1986	94 lbs/ac	Oct. 13, 1986
Barley	June 2, 1986	96 lbs/ac	Sept. 15, 1986

Soil

Fargo silty clay, 0 to 1 percent slopes (Vertic Haplaquolls, fine, montmorillonitic, frigid) on 50 percent of the plot and Hegne (Typic Calciaquolls, fine, frigid)-Fargo (Vertic Haplaquolls, fine, montmorillonitic, frigid) silty clays on the rest of the plot. Both soils are poorly drained.

Soil Test

Soil samples were taken in the fall of 1985.
Results were:

Crop	pH	Olsen P	K	NO_3-N
		-------lbs/ac------		
Wheat	7.9	30	467	35
Barley	8.1	14	491	23
Soybean	8.0	27	481	22

Fertilizer

Crop	Material (Rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		---lbs/ac----			
		No Till			
Winter wheat:	18-46-0[1] DAP (140 lbs/ac)	25	64	0	Sept. 25, 1986
	28-0-0[2] UAN (35 gal/ac)	104	0	0	April 23, 1986
		Tilled			
	18-46-0[1] DAP (140 lbs/ac)	25	64	0	Sept. 25, 1985
	28-0-0[2] UAN (30 gal/ac)	89	0	0	April 23, 1986
		No Till			
Spring wheat:	28-0-0[2] UAN (36 gal/ac)	107	0	0	April 23, 1986
	18-46-0[1] DAP (110 lbs/ac)	20	51	0	June 2, 1986
		Tilled			
	28-0-0[2] UAN (30 gal/ac)	89	0	0	April 23, 1986
	18-46-0[1] DAP (110 lbs/ac)	20	51	0	June 2, 1986
		No Till			
Barley:	28-0-0[2] UAN (30 gal/ac)	89	0	0	April 23, 1986
	18-46-0[1] DAP (60 lbs/ac)	11	28	0	June 2, 1986
		Tilled			
	28-0-0[2] UAN (27 gal/ac)	80	0	0	April 23,1986
	18-46-0[1] DAP (60 lbs/ac)	11	28	0	June 2, 1986
		No Till			
Soybeans:	18-46-0[1] DAP (53 lbs/ac)	10	24	0	June 2, 1986
		Tilled			
	18-46-0[1] DAP (53 lbs/ac)	10	24	0	June 2, 1986

1. Drill applied.
2. 28% broadcast spraying.

Fungicides

Manzate 200 flowable at 1.5 qts/ac was applied on :

Winter wheat: 1st application - June 11
2nd application - June 23

Crookston Expt. Station sprayer was used at 175 psi with 50 gallons of water.

Spring wheat: 1st application - July 18
2nd application - July 25

Ada Co-op Sprayer was used at 70 psi with 26 gallons of water.

Growth Regulator

Cerone growth regulator was applied to Roughrider winter wheat on June 11 at a rate of 3/4 pt/ac with the first fungicide application.

Weed Control

Wheat	Chemical	Amount	Carrier Volume	Applied
winter	Brominal 3+3	.7 pts/ac	8 gal/ac	June 6
spring	Brominal 3+3(no till)	.7 pts/ac	8 gal/ac	June 6
	Hoelon (no till)	3 pts/ac	11 gal/ac	June 7
Soybeans	Roundup(no till)	1.2 pts/ac	6 gal/ac	June 6
	Basagran(tankmix)	1 pts/ac	12 gal/ac	June 28
	Blazer "	.8 pts/ac	"	"
	Poast "	1.5 pts/ac	"	"
	Oil "	1 qt/ac	"	"
Barley	Roundup(no till)	1.2 pts/ac	6 gal/ac	June 6
	MCPA	1 pt/ac	6 gal/ac	June 27

Table 2. The effect of tillage on soil cover by wheat residue on June 3, 1986.

	Tillage					
	No Till		Chisel		Moldboard	
	mean	st dev	mean	st dev	mean	st dev
Crop-Variety	%					
Winter Wheat n=6						
Bighorn	80.0	13.6	22.7	8.92	7.00	3.46
Roughrider	84.7	11.4	21.0	8.38	7.00	4.22
Spring Wheat n=6						
Marshall	71.0	9.67	12.7	7.40	5.33	3.55
Stoa	75.3	15.0	10.7	5.48	3.67	3.17
Barley n=24						
Robust	73.2	16.9	16.0	6.78	6.67	4.52
Soybeans n=24						
McCalls	77.3	15.6	18.5	7.16	8.33	3.90

Table 3. The effect of tillage on plant population.[1]

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	st dev	mean	st dev	mean	st dev
Crop-Variety	Tillage	----------plants/ac x 10^{-3}----------					
Winter Wheat[2]	(.041)	n=14					
Bighorn		718	170	682	166	678	169
Roughrider		825	203	724	95.0	726	150
Spring Wheat[3]	(.090)	n=12					
Marshall		1096	242	873	175	995	170
Stoa		1024	105	1036	159	1007	202
Barley	(.247)	n=12					
Robust		840	122	780	110	766	118
Soybeans	(.034)	n=12					
McCalls		176	29.0	171	30.1	201	25.8

1. Spring wheat, soybeans, and barley stand counts were taken on June 24, 1986. Winter wheat stand count was taken onApril 22, 1986.
2. The significance of variety was .298, and the variety x tillage interaction was .950.
3. The significance of variety was .280, and the variety x tillage interaction was .056.

Table 4. The effect of tillage on crop growth.

		Tillage					
		No Till		Chisel		Moldboard	
		mean	st dev	mean	st dev	mean	st dev
Crop-Variety	Sig.	----------Haun growth stage----------					
Winter Wheat	(.000)[1]	n=15					
Bighorn	6/3	8.13	.215	7.72	.208	7.99	.185
Roughrider	6/3	7.77	.308	7.56	.168	7.61	.220
Spring Wheat	(.493)[2]	n=3					
Marshall	6/24	3.93	.058	3.87	.058	3.77	.116
Stoa	6/24	4.07	.208	3.97	.058	4.27	.116
		n=30					
Marshall	7/14	8.98	.048	8.98	.038	8.88	.187
Stoa	7/14	9.00	0.00	9.00	0.00	9.00	0.00
Barley	(.552)	n=3					
Robust	6/24	3.90	.100	3.83	.058	3.90	.173
	(.112)	n=15					
Robust	7/14	4.54	.356	4.39	.285	4.39	.320
		----------Vegetative Stage[3]----------					
Soybeans	(.041)	n=30					
McCalls	7/14	5.10	.712	4.67	.758	5.07	.785

1. The significance of variety was .000, and the variety x tillage interaction was .033.
2. The significance of variety was .019, and the variety x tillage interaction was .110.
3. Method used Stages of Soybean Development Special Report 80, an Iowa State University Cooperative Extension Service bulletin.

Table 5. The effect of tillage on soil temperature in winter wheat on April 22, 1986, n=3.

		Tillage					
	Sig. of	No Till		Chisel		Moldboard	
	Tillage	mean	st dev	mean	st dev	mean	st dev
Variety[1]	(.051)	degrees Fahrenheit					
Bighorn		40.7	1.15	45.3	0.58	44.0	4.58
Roughrider		41.3	1.15	44.0	2.00	46.0	1.73

1. The significance of variety was .673, and the variety x tillage interaction was .439.

Table 6. The effect of tillage on the presence and density of weed species[1] in Bighorn winter wheat on June 3, 1986, n=6.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	st dev	mean	st dev	mean	st dev
Weed	Tillage	plants/ac x 10^{-3}					
Foxtail	(.315)	967	1214	464	270	219	210
Mustard		0.00	0.00	.990	2.42	0.00	0.00
Pigweed		0.00	0.00	39.0	54.9	6.22	6.54
Buckwheat	**(.000)**	**6.35**	**14.7**	**53.0**	**42.9**	**105**	**87.4**
Clover		0.00	0.00	3.03	7.41	4.84	7.84
CanThistl		1.82	4.45	0.00	0.00	0.00	0.00
PennyCres		0.00	0.00	0.00	0.00	3.63	8.89
Boxelder		0.00	0.00	8.47	9.92	12.9	21.3

1. Weed species which were significantly affected by tillage are in bold type.

Table 7. The effect of tillage on the presence and density of weed species[1] in Roughrider winter wheat on June 3, 1986, n=6.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	st dev	mean	st dev	mean	st dev
Weed	Tillage	plants/ac x 10^{-3}					
Foxtail	(.256)	622	538	526	265	271	238
Pigweed		3.63	8.89	0.00	0.00	0.00	0.00
Buckwheat	(.217)	60.1	49.1	57.5	52.7	163	106
Clover		0.00	0.00	6.05	9.65	25.9	34.1
CanThistl		2.14	5.23	0.00	0.00	0.00	0.00
Smartweed		1.82	4.45	0.00	0.00	0.00	0.00
PennyCres		0.00	0.00	3.63	8.89	0.00	0.00
Boxelder		0.00	0.00	4.54	11.1	19.1	33.3
Ragweed		0.00	0.00	0.00	0.00	1.82	4.45
SowThistl		0.00	0.00	0.00	0.00	1.82	4.45
Lambsqtr		0.00	0.00	0.00	0.00	1.91	4.68

1. Weed species which were significantly affected by tillage are in bold type.

Table 8. The effect of tillage on the presence and density of weed species[1] in Marshall spring wheat on June 24, 1986, n=6.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	st dev	mean	st dev	mean	st dev
Weed	Tillage	plants/ac x 10^{-3}					
Foxtail	**(.064)**	**684**	**603**	**226**	**173**	**213**	**219**
Mustard		0.00	0.00	.712	1.74	.648	1.59
Pigweed	**(.017)**	**5.19**	**12.7**	**16.6**	**36.5**	**10.1**	**4.43**
Buckwheat		0.00	0.00	7.56	12.1	1.51	2.50
SprngWht		185	89.2	0.00	0.00	0.00	0.00
Lambsqtr		0.00	0.00	0.00	0.00	.637	1.56

1. Weed species which were significantly affected by tillage are in bold type.

Table 9. The effect of tillage on the presence and density of weed species[1] in Stoa spring wheat on June 24, 1986, n=6.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	st dev	mean	st dev	mean	st dev
Weed	Tillage	plants/ac x 10^{-3}					
Foxtail	**(.023)**	**507**	**246**	**394**	**151**	**230**	**158**
Mustard		0.00	0.00	4.03	6.25	0.00	0.00
Pigweed		0.00	0.00	0.00	0.00	3.25	4.15
Buckwheat	(.183)	15.7	18.8	1.73	4.23	5.14	8.70
SprngWht		96.8	96.7	0.00	0.00	0.00	0.00
Boxelder		0.00	0.00	0.00	0.00	3.46	8.47

1. Weed species which were significantly affected by tillage are in bold type.

Table 10. The effect of tillage on the presence and density of weed species[1] in soybeans on June 24, 1986, n=12.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	st dev	mean	st dev	mean	st dev
Weed	Tillage	plants/ac x 10^{-3}					
Foxtail	**(.024)**	**153**	**153**	**232**	**98.0**	**133**	**82.7**
Mustard		0.00	0.00	2.30	4.50	9.73	12.1
Pigweed		0.00	0.00	1.82	6.29	4.04	6.69
Buckwheat	(.230)	1.76	2.86	.403	1.40	2.24	3.87
SprngWht	**(.100)**	**45.5**	**30.1**	**32.1**	**21.2**	**12.9**	**8.95**
Dandelion		.395	1.37	0.00	0.00	0.00	0.00
Lambsqtr		0.00	0.00	0.00	0.00	.889	2.11
Quack		3.47	8.23	0.00	0.00	0.00	0.00

1. Weed species which were significantly affected by tillage are in bold type.

Table 11. The effect of tillage on the presence and density of weed species[1] in barley on June 24, 1986, n=12.

		Tillage					
		No Till		Chisel		Moldboard	
Weed	Sig. of Tillage	mean	st dev	mean	st dev	mean	st dev
		plants/ac x 10^{-3}					
Foxtail	(.253)	208	116	303	300	160	141
Mustard	**(.019)**	**.413**	**1.43**	**3.73**	**5.81**	**8.06**	**10.9**
Pigweed		0.00	0.00	1.06	2.74	4.21	6.73
Buckwheat	(.818)	4.13	5.50	4.88	8.71	3.45	4.66
Clover		.303	1.05	0.00	0.00	0.00	0.00
SprngWht	(.260)	42.5	63.8	38.4	29.3	16.6	15.3
Dandelion		.825	2.86	0.00	0.00	0.00	0.00
Lambsqtr		0.00	0.00	0.00	0.00	.356	1.23
Quack		0.00	0.00	.308	1.07	0.00	0.00
VolSunflr		.303	1.05	0.00	0.00	0.00	0.00

1. Weed species which were significantly affected by tillage are in bold type.

Table 12. The significance of interactions between type of wheat (winter or spring), height of variety (tall or short), and tillage on the density of weeds.

	Interactions		
Weed	Wheat to Height	Wheat to Tillage	Height to Tillage
	significance		
Foxtail	.433	.383	.527
Mustard	.570	.497	.790
Pigweed	.992	.051	.022
Buckwheat	.545	.125	.001
Clover	.183	.011	.522
Canada Thistle	.990	.135	1.000
Sow Thistle	.321	.374	.374
Smartweed	.321	.374	.374
Spring Wheat	.206	.000	.203
Penny Cress	1.000	.614	.236
Boxelder	.299	.167	.402
Ragweed	.321	.374	.374
Lambsquarter	.170	.993	.993

1. Type of wheat considers whether it is a spring or winter wheat. Stoa-spring wheat and Roughrider-winter wheat are tall varieties. Marshall-spring wheat and Bighorn-winter wheat are shorter varieties. Tillage considers no till, chisel plow, and moldboard plow.

Table 13. The effect of tillage, fungicide, variety, and time on leaf disease of winter wheat at Norman County, 1986.

Date	Location	Tillage: No Till	Tillage: Chisel	Tillage: Moldboard	Fungicide[2]: Yes	Fungicide[2]: No	Variety: Bighorn	Variety: Roughrider
6/11[1]		----------Modified Hosford Tan Spot Scale----------						
	Top Leaf (6 to 8)	4.25	3.83	2.67			2.39	4.78*
6/23								
	Leaf 9	5.53	5.29	5.32	5.28	5.48	5.44	5.31
	Leaf 8	5.75	5.08	5.33	5.03	5.75*	5.94	4.83*
	Leaf 7	6.75	5.92	5.50	5.39	6.72*	6.11	6.00
7/14								
	Leaf 9	8.46	8.44	8.25	7.82	8.94*	8.47	8.29
	Leaf 8	8.83	8.79	8.50	8.42	9.00*	8.69	8.72
	Leaf 7	9.00	9.00	8.92	8.94	9.00	9.00	8.94

1. A modified Hosford (1982) scale was used to rate the incidence of leaf disease (see table 15). The June 11 values are a visual estimate of the percent of the leaf infected.
2. Manzate 200 flowable at 1.5 qts/ac was applied on winter wheat: 1st application - June 11, 1986
2nd application - June 23, 1986
Cerone growth regulator at 3/4 pt/ac was applied on: Roughrider: with fungicide on - June 11, 1986
* Means within a row under a given heading followed by an asterisk are significantly different at .100.

Table 14. The effect of tillage and variety on the incidence of leaf disease on spring wheat at Norman County, 7/14/86.[1]

Location	Tillage: No Till	Tillage: Chisel	Tillage: Moldboard	Variety: Marshall	Variety: Stoa
	----------Modified Hosford Score--------				
Leaf 9	4.42	3.25	3.92*	3.67	4.06
Leaf 8	5.42	5.08	4.83	5.67	4.56*
Leaf 7	5.67	5.38	5.00	6.50	4.19*

1. A modified Hosford (1982) scale was used to rate the incidence of leaf disease (see table 15).
* Means within a row under a given heading followed by an asterisk are significantly different at .100.

Table 15. A modified Hosford (1982) tan spot scale used to rate leaf disease.[1]

Location	Hosford Score: 0	1	2	3	4	5	6	7	8	9
	----------Percent of leaf infected----------									
Leaf 9	0	0	1	2	3	4	5-10	10-25	25-50	55-100
Leaf 8	0	1-3	3-5	5-7	7-10	10-25	25-50	50-75	75-95	95-100
Leaf 7	0	1	5	10	25-50	50-60	60-75	75-85	85-95	95-100

1. Hosford's (1982) tan spot rating system was modified by assigning a different range in percent leaf infected for each leaf level rated. This provides a more precise estimate of relative differences due to treatment.

Hosford,R. 1982. Tan Spot. In: Tan Spot of Wheat and Related Diseases Workshop Proceedings. North Dakota State University, Fargo, N.D. pp.1-24.

Table 16. The effect of fungicide on the yields in wheat. The effects of tillage are averaged over fungicide, n=9.[1]

		Fungicide			
		treated[2]		not treated	
	Sig. of	mean	std dev	mean	std dev
Variety	Fungicide	bu/ac			
Winter wheat	(.008)				
Bighorn		52.7	12.8	38.1	8.6
Roughrider		50.3	4.47	39.9	4.0
Spring wheat	(.094)				
Marshall		31.0	4.73	27.0	6.28
Stoa		18.0	4.09	14.6	2.78

1. The yields are based on the grain after it was cleaned.
2. Treated refers to fungicide on Bighorn, Marshall and Stoa, and fungicide plus cerone on Roughrider.

Table 17. The effect of tillage and fungicide on the yields of wheat, n=3.[1]

	Tillage					
	No Till		Chisel		Moldboard	
	treated[2]	not treated	treated	not treated	treated	not treated
Variety	bu/ac					
Winter wheat						
Bighorn	65.0	44.3	49.9	38.2	43.3	31.7
Roughrider	50.9	39.4	46.7	42.5	53.4	37.8
Spring wheat						
Marshall	27.1	23.4	31.2	27.0	34.7	30.7
Stoa	16.3	12.9	17.9	12.8	19.7	18.0

1. Results are based on the grain after it was cleaned.
2. Treated refers to fungicide on Bighorn, Marshall, and Stoa, and fungicide + cerone on the Roughrider.

Table 18. The significance of tillage, fungicide, variety and the interactions on wheat yield.

Wheat	Till	Fung	Var.	Til x Fun	Til x Var	Var x Fun	TilxFunxVar
	significance						
Winter	.132	.008	.733	.469	.132	.470	.801
Spring	.133	.094	.002	.834	.786	.755	.843

Table 19. The effect of tillage on barley yields, protein content, and test weight, n=6.

	yield[1]		% protein		pro yield[2]		test wt	
	mean	st dev	mean	st dev	mean	st dev	mean	st dev
Tillage	---bu/ac----		-----%------		---lbs/ac---		---lbs/bu---	
No Till	20.0	4.27	12.9	.448	105	24.1	37.2	1.47
Chisel	20.2	4.87	12.9	.500	107	27.2	39.1	.736
Moldboard	18.3	2.48	13.5	.623	101	13.3	38.6	1.43
Sig. of Tillage	(.790)		(.126)		(.968)		(.017)	

1. The results are based on the grain after it was cleaned.
2. Protein yield refers to the protein fraction x yield (lbs/ac).

Table 20. The effect of tillage on the moisture of wheat and barley at harvest, n=6.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	std dev	mean	std dev	mean	std dev
Variety	Tillage	----------% moisture----------					
Winter wheat							
Bighorn	(.025)	12.6	.437	13.2	.534	13.5	.556
Roughrider	(.308)	13.0	.696	13.3	.474	13.6	.690
Spring wheat							
Marshall	(.001)	10.1	.352	11.5	.555	10.8	.482
Stoa	(.018)	11.1	.711	10.4	.250	10.2	.485
Barley							
Robust	(.821)	8.87	.700	8.68	.356	8.74	.230

Table 21. The effect of tillage and fungicide on the protein content and the protein-yield of Bighorn and Roughrider winter wheat harvested on July 31, 1986, n=3.

	Tillage					
	No Till		Chisel		Moldboard	
	mean	std dev	mean	std dev	mean	std dev
% protein	%					
fungicide						
Bighorn	11.5	1.13	11.9	1.34	12.0	1.69
Roughrider	13.1	.913	12.6	.665	13.6	1.76
no fungicide						
Bighorn	12.4	1.44	12.5	.576	12.4	.969
Roughrider	12.9	1.06	13.3	1.26	12.5	.732
protein-yield[1]	lbs/ac					
fungicide						
Bighorn	392	90.3	314	119	271	58.7
Roughrider	346	31.2	305	1.92	376	51.5
no fungicide						
Bighorn	282	57.7	249	18.5	202	35.8
Roughrider	264	22.5	294	37.8	244	23.9

1. Protein-yield refers to the protein fraction x yield (lbs/ac).

Table 22. The significance of tillage and fungicide effects on the protein content and protein-yield of Bighorn and Roughrider winter wheat.

	Tillage	Fungicide	Till x Fung
protein content	significance		
Bighorn	.953	.389	.978
Roughrider	.984	.551	.130
protein-yield	significance		
Bighorn	.150	.049	.834
Roughrider	.995	.028	.209

Table 23. The effect of tillage and fungicide on the protein content and the protein-yield of Marshall and Stoa spring wheat, n=3.

	Tillage					
	No Till		Chisel		Moldboard	
	mean	std dev	mean	std dev	mean	std dev
% protein	----------	----------	%	----------	----------	----------
fungicide						
Marshall	15.4	.362	14.7	.862	15.0	.690
Stoa	16.8	.829	17.9	1.06	18.1	1.06
no fungicide						
Marshall	15.5	.886	15.8	.219	15.2	.609
Stoa	17.3	.705	19.2	.201	18.5	.038
protein-yield[1]	----------	----------	lbs/ac	----------	----------	----------
fungicide						
Marshall	209	33.2	231	33.8	261	31.7
Stoa	139	22.6	159	40.6	178	33.1
no fungicide						
Marshall	183	46.2	213	31.9	233	58.4
Stoa	112	.864	124	15.0	167	10.4

1. Protein-yield refers to the protein fraction x yield (lbs/ac).

Table 24. The significance of tillage and fungicide effects on the protein content and protein-yield of Marshall and Stoa spring wheat.

	Tillage	Fungicide	Till x Fung
protein content	----------	significance	----------
Marshall	.410	.083	.180
Stoa	.012	.035	.320
protein-yield	----------	significance	----------
Marshall	.382	.402	.977
Stoa	.009	.023	.317

Table 25. The effect of tillage and fungicide on the test weights of spring and winter wheat, n=3.

	Tillage					
	No Till		Chisel		Moldboard	
	treated[2]	not treated	treated	not treated	treated	not treated
Variety	----------	----------	lb/bu	----------	----------	----------
Spring wheat						
Marshall	53.0	49.0	54.6	51.7	53.5	53.2
Stoa	48.2	47.2	48.5	46.0	49.0	47.8
Winter wheat						
Bighorn	58.1	56.8	58.2	56.0	57.0	55.7
Roughrider	59.2	58.3	59.8	58.2	59.3	58.7

1. Results are based on the grain after it was cleaned.
2. Treated refers to fungicide application.

Table 26. The significance of tillage and fungicide effects on the wheat test weights.

	Tillage	Fungicide	Till x Fung
Spring wheat	----------significance----------		
Marshall	.315	.112	.490
Stoa	.420	.080	.636
Winter wheat	----------significance----------		
Bighorn	.092	.007	.498
Roughrider	.371	.002	.097

Table 27. The effect of tillage on soybean yield, moisture, dockage, and test weight, n=3.

	yield		moisture		dockage		test wt	
	mean	st dev	mean	st dev	mean	st dev	mean	st dev
Tillage	---bu/ac----		-----%------		-----%-----		---lb/bu---	
No Till	32.4	.940	12.5	.172	2.00	.866	58.0	.500
Chisel	33.2	1.03	12.7	.226	2.33	1.53	58.2	.289
Moldboard	32.8	1.44	12.7	.434	2.33	1.15	58.2	.289
Sig. of Tillage	(.780)		(.614)		(.913)		(.790)	

CORN - TILLAGE RESIDUE MANAGEMENT, LANCASTER, 1986

J.B. Swan, A.E. Peterson, W.H. Paulson
R. Higgs, D. Linden, G. Randall, C. Sheaffer

The driftless soils area has the greatest county average estimated soil losses from cropland in Minnesota, ranging from 4.0 to 6.6 t/ac/yr in the six counties involved. Typical soils of the regional such as Fayett-Dubuque, Seaton, and associated soils, are highly erodible, form dense crusts if unprotected from raindrop impact, and consequently, have low final infiltration rates and high runoff from the intense storm events common to the region. New and improved tillage practices are increasingly being relied upon to meet environmental goals under more intense cropping systems. These systems modify the soil and water losses as well as the kind and concentration of materials in the runoff. A more complete understanding of these tillage systems will allow a more accurate prediction of their effect on the environment and will permit them to be more effectively incorporated into the overall farming systems of the region.

Experimental Procedures

The experimental site is located on the Lancaster Experimental Farm. Four tillage treatments are replicated four times (Table 1), the first replicate is located on Palsgrove silt loam; the other three replicates are located on Rozetta silt loam. Each treatment is split into normal and mulched subtreatments. On the no-till (slot plant) plots an additional subtreatment (bare) is established by removing all residue prior to planting; the residue is then placed on the adjacent no-till mulched plot. Corn residue additions are made after tillage but before planting to obtain approximately 60 to 80 percent surface cover. Plots are approximately 90 to 100 feet in width and 80 feet in length. Row width was 36 inches in 1986. Pioneer 3747 was planted April 29, 1986 at 31,600 plants/acre. The conventional (moldboard) treatment was plowed about April 25 and secondary tillage with a disk was done April 28 on the conventional and chisel treatments. The paraplow treatment was carried out in both fall 1983 and 1984; any effect observed in 1986 was due to residual effects of these earlier treatments. All plots were planted with a 4-row John Deere 7000 Max-Emerge planter equipped with fluted coulters on one side and "trash whip" units on the other side which removed residue from an 8 to 9 inch area over the row.

Nitrogen (250 lb N/acre as ammonium nitrate) was applied in April prior to planting. Starter fertilizer at planting was 200 lb/acre of 6-24-24. The insecticide was Furadan at 10 lb/acre. Pre-emergence herbicide was applied on April 30 (1.5 lb/A of Aatrex 4L and 1 qt/A of Dual 8E). Banvel was applied postemergence at 1 pint/A on May 21.

Percent cover was determined from slides taken May 28. Planting depth, rate of emergence, and silking date measurements were made on designated portions of each plot. Hourly spring soil temperatures, leaf number, soil moisture, bulk density, and percent cover were measured on chisel, paraplow and no-till treatments in Rep 3 for mulch added and bare or normal treatments. Soil temperature was measured at depths of 1, 5, 10, 15 and 50 cm. Yields for individual plots were determined by hand harvesting 60 foot of row (two subsamples each consisting of paired 15 ft. lengths of row) in late October.

Ten plot frames (45 3/4 x 45 3/4 inches) were emplaced soon after planting before the surface was weathered by rainfall. Infiltration measurements were made on paraplow mulch, no-till bare and mulch, and conventional normal and mulch treatments during the period May 27 to 30. Tensiometer measurements were made at three depths within the plot frame during the infiltration event.

Results - Corn yields

Except for July rainfall, precipitation amounts and distribution were favorable at Lancaster in 1986 and corn yields on most treatments ranged from 160 to 170 bu/A (tables 1 and 2). Corn yields of individual tillage, residue, and in-row residue management treatments were statistically different at the 10 percent level of significance. Average corn yields of the four replicates were significantly different, ranging

from 159.6 bu/A in rep. one to 168.6 bu/A in rep. three (table 3). Soil depth was again related to corn yield; however, the relationship was less strong than in each of the three previous years. In 1981 and 1982 no effect of depth on yield was observed. Thus the effect of rooting depth and available water holding capacity in the root zone on yields depends greatly on climatic conditions in the individual year as well as on the crop grown.

Seedbed Conditions and Corn Growth

The average planting depth and average standard deviation of planting depth were both statistically different at the 0.01 level of significance. The Trash Whip treatment had a significantly (0.01 level of significance) greater average planting depth (35 mm) and lower standard deviation (5.8 mm) than the fluted coulter (29 and 7.3 mm respectively). The greatest differences in planting depth between coulter and trash whip units was measured on the chisel mulch and conventional mulch treatments.

On the chisel mulch and conventional mulch treatments the heavy mulch and loose seedbed frequently prevented the coulter from cutting through the residue. In some cases, the residue was pushed into the loose soil by the coulter making it difficult for the disc opener on the planter unit to penetrate the residue. For no-till, average planting depth for coulter and trash whip units differed by less than 2 mm for individual residue treatments. However, for the paraplow, average planting depth for the trash whip units was approximately 8 and 3 mm deeper than the coulter for normal and mulch treatments respectively. The trash whip units were adjusted for no till and paraplow conditions and consequently ran excessively deep in the looser soil conditions on the moldboard and chisel treatments.

In-row residue cover was reduced about 20 to 25 percent by the trash whip attachment (TW) compared to the in-row cover resulting from the coulter unit (C) (table 1). The regression equation

Eq 1: % cover TW = -7.5 + 0.83 (% cover C)

explained 95% of the variation in % cover of the TW treatments for 1986. In 1986 the trash whip treatment significantly increased yields by 5 bu/A compared to the coulter unit on paraplow and no-till treatments. The effect of increasing in-row residue cover (by mulch additions) was to increase the number of days required to reach 75% emergence (table 4) and to delay the date of silking (table 1).

Percent in-row cover was less closely related to grain moisture in 1986 than in 1985:

For 1985 Eq 2: % Grain Moisture = 20.5 + 1.97 x 10^{-2} (% in-row cover); R^2 = 0.87
For 1986 Eq 3: % Grain Moisture + 19.1 + 0.69 x 10^{-2} (% in-row cover); R^2 = 0.47

Percent in-row cover was closely related to air growing degree days to 6-leaf (measured on rep 3):

Eq 4: Air GDD (planting to 6 leaf) = 296 - 0.54 (% in row cover); R^2 = 0.84

The effect of in-row residue cover and tillage on soil temperature and corn growth was evaluated at Lancaster in 1983, 1984, 1985 and 1986. Hourly soil temperatures were recorded for 1, 5, 10, 15, 50, and 100 cm depths under the row on chisel normal and mulch, no-till bare and mulch, and paraplow normal and mulch treatments in 1984, 1985, and 1986. Soil temperatures were measured using 4-couples in parallel for 15 cm and shallower depths. Leaf stage measurements were taken periodically. Eq 4 was developed using station air temperatures and leaf stage observations; the results in 1986 agree with previous observations.

Increasing the absorption of solar radiation by painting the soil surface black increased soil temperature and early corn growth. Adjacent strips 15 feet long and 1 foot wide (centered over the row) were painted on May 9 or 62.3 air GDD (°C) after planting. Black paint reduced the air GDD to 6-leaf by 15 GDD (equivalent to about 1/2 a leaf number) on the no-till bare treatment and by 5 GDD on the no-till mulch

and chisel mulch treatments. Similar comparisons were made at the Southwest Experiment Station, Lamberton.

Large differences in "final" (50 to 60 minute average) infiltration rates were measured between treatments (tables 5 and 6). Final infiltration rates from mulch treatments equalled or exceeded comparable normal or bare treatment. Large differences in infiltration and matric potential were measured on the no-till treatments with mulch cover. These differences are thought to be due to macropore flow. On the conventional mulch treatments, positive matric potential measured at the 8 and 18 cm depths indicate the presence of a flow restricting layer below the plow layer (table 7). Paraplow treatments with mulch continued to have final infiltrations rates equal to or greater than other treatments.

Final infiltration rates for 1981-1986 are given in table 6. The ratio of (bare/mulch) infiltration rates for conventional tillage was 0.81 which was slightly above the 6 year average of 0.57. The relationship of no till mulch to conventional bare was 1.15 which is close to the long term average of 1.18.

The results again illustrate the requirement for rapid infiltration of 1) a porous surface layer with high saturated conductivity, 2) a protective mulch cover, 3) absence of flow restricting layers within the depth of infiltration. Residue cover by itself is not sufficient to produce a high infiltration rate when significant restriction to flow occurs within the infiltrating profile.

Summary

Five and eight year yield results with continuous corn at Lancaster show nearly equal yields from conventional tillage, ridge till, and chisel treatments (table 8). In 1986 no-till (slot plant) was the highest yielding treatment. Thus farmers in the driftless soil area can choose between a variety of tillage options which have yields comparable to conventional tillage, but which are superior in soil and water conservation and offer savings in time, labor, and fuel compared to the conventional moldboard plow tillage method.

Table 1. Effect of tillage and mulch treatments on percent cover, planting depth, emergence silking date, population, grain yield and moisture - 1986 Lancaster

Tillage	Residue	In-row Residue Mgt.	Percent Cover In-row	Percent Cover Entire Area	Planting Depth Avg. mm	Planting Depth S.D. mm	Days planting to 75% emergence	Date 50% plants silked July	Population at Harvest Plants/A	Grain Yield bu/A	Grain Moisture %
			------ % ------								
Paraplow											
	Normal (N)	C	33	51	29	8.0	14.5	16.5	28375	162.0	19.7
		TW	15	40	37	6.4	15.5		27650	166.3	19.0
	Mulch (1x+N)	C	77	89	25	10.1	20.	18.0	26800	169.7	19.5
		TW	66	78	28	7.4	19.		26560	170.4	19.5
No-Till											
	Bare (0)	C	8	13	34	7.0	<14	16.3	28190	154.7	19.4
		TW	4	11	35	3.8	<14		28740	164.7	19.2
	Normal (1x)	C	28	49	31	7.7	15	16.5	29650	165.3	19.4
		TW	14	32	32	6.4	14.5		30130	166.9	19.0
	Mulch (2x)	C	80	84	33	5.4	16.5	18.0	28980	161.0	19.6
		TW	54	74	32	6.1	15		28550	170.9	18.9
Fall Chisel											
	Normal N	C	9	14	37	3.2	<14	15.5	28860	159.2	19.1
		TW	-	-	36	4.6	14				
	Mulch (1x+N)	C	81	91	20	8.7	20	18.3	27410	163.4	19.8
		TW	-	-	39	6.3	17.5				
Conv. (Spring plow)											
	Normal (0)	C	2	4	39	4.0	<14	15.8	28800	163.8	18.8
		TW	-	-	41	4.6	14.5				
	Mulch (1x)	C	82	92	13	11.0	17	18.3	26440	155.5	19.7
		TW	-	-	38	6.8	15.5				
Significance level					0.01	0.01			0.01	0.10	0.05

S.D. = Standard deviation, C = Fluted coulter, TW = Trash whip unit

Table 2. 1986 Weather Summary, Lancaster Experiment Station

Month	Precipitation Total	Precipitation Departure	Growing Degree Days 1985	Growing Degree Days Depart.	AIR TEMPERATURE Avg. Max	AIR TEMPERATURE Avg. Min.	AIR TEMPERATURE Avg.	AIR TEMPERATURE Departure
	inches	inches	----------	----------	---------- of	----------	----------	----------
April	2.37	-0.96	-	-	59.1	39.6	49.4	2.0
May	3.90	0.19	319.3	20	68.4	48.5	58.5	-0.5
June	5.47	1.24	497.0	-16	77.6	55.0	66.3	-1.8
July	1.85	-2.26	680.6	25	82.2	62.6	72.4	0.1
August	3.65	-0.49	483.1	-111	76.4	54.0	65.2	-5.3
September	4.67	1.06	397.1	43	71.3	53.5	62.4	0.1

1.85 inches of precipitation was well spaced throughout July, 0.5 inches occurring on July 8-9 and again on July 11-12 and 0.65 on July 25.

Table 3. Average yields and depth to clay residuum by replicate and monthly precipation for 1981 through 1986, Lancaster, WI.

	Replicate Number				Monthly Precipitation			
Year	1	2	3	4	May	June	July	August
	bu/A				inches			
1981	146.8	146.7	142.1	147.1	0.85	4.28	2.91	11.35
1982	150.0	143.4	142.8	147.3	5.46	3.45	5.29	4.06
1983	72.8	85.2	96.4	111.2	5.18	3.28	3.34*	3.12*
1984	107.3	110.4	118.0	120.1	3.92	7.77	2.57**	1.37**
1985	118.5	121.1	129.6	130.6	4.95	1.32***	2.11***	3.34
1986	159.5	162.4	168.6	164.8	3.90	5.47	1.85	3.65
Avg. depth to clay residuum inches	29	41	46	62				

1981 - Subplots with population < 17,000 omitted.
1982 - Missing values estimated for 8 plots out of a total of 48 plots.
1983 - Subplots with population < 18,000 omitted Rep. II, III, IV.
* 1983 - 1.3 inches precipitation from July 3 to Aug. 25 (53 days).
** 1984 - 1.52 inches precipitation from July 18 to Aug. 31 (45 days).
*** 1985 - 1.59 inches precipitation from May 28 to July 25 (57 days)
Largest rain was 0.36 inches.

Table 4. Influence of tillage method and residue management on rate of emergence - 1986 Lancaster, WI.

Treatment			PERCENT EMERGENCE				
		Coulter or Trash Whip Unit	Days post plant				
Tillage	Residue		14	16	20	22	28
Paraplow	Normal	C	68	89	100	100	
		TW	47	81	100	100	
	Mulch	C	8	35	77	81	100
		TW	13	41	81	84	100
No-Till	Bare	C	92	97	100	100	
		TW	80	94	100	100	
	Normal	C	60	86	94	100	
		TW	72	86	100	100	
	Mulch	C	28	69	94	100	
		TW	46	91	100	100	
Chisel	Normal	C	86	92	100	100	
		TW	74	89	100	100	
	Mulch	C	13	38	75	84	100
		TW	27	59	100		
Conventional-Moldboard	Normal	C	89	95	100	100	
		TW	65	89	100	100	
	Mulch	C	11	44	89	89	100
		TW	27	81	97	97	100

Table 5. 1986 Lancaster Infiltration Rate Measurements

Treatment			appl. rate	water applied to	INFILTRATION RATE X MINUTES AFTER RUNOFF COMMENCES IN/HOUR										
Tillage	Residue	Rep.	in/hr	runoff	2.5	7.5	12.5	17.5	22.5	27.5	32.5	37.5	42.5	47.5	52.5	57.5
No-Till	Bare	E	4.48	0.26	3.48	3.00	1.80	1.56	1.08	1.20	1.68	1.80	1.32	1.32	1.32	1.08
		W	4.40	0.37	3.20	1.76	1.28	1.28	0.80	1.16	1.28	1.16	1.28	1.04	1.28	1.28
	Mulch	E	4.56	0.48	4.08	2.64	1.80	1.80	0.72	0.96	1.44	0.96	0.96	0.96	0.96	1.44
		W	4.32	0.56	3.96	3.48	3.24	2.52	2.64	2.88	2.52	2.52	2.40	2.64	3.00	3.00
Conventional (moldboard plow)																
	Normal	E	3.76	1.19	2.52	2.04	1.68	1.56	2.28	2.28	2.28	1.56	1.56	1.32	1.56	2.04
		W	4.32	1.44	3.12	2.28	2.28	2.40	1.92	2.04	1.80	2.04	1.80	2.04	1.80	1.92
	Mulch	E	4.00	1.20	1.68	1.80	1.80	1.80	1.80	1.80	1.68	1.56	1.80	1.80	2.04	2.28
		W	4.24	1.06	3.00	2.28	2.16	2.16	2.28	2.28	2.40	2.40	2.28	2.40	2.28	2.40
Paraplow																
	Mulch	E	4.56	0.70	4.32	3.48	3.48	3.36	3.00	3.00	-	-	-	-	-	-
		W	4.24	0.39	3.84	3.24	3.24	2.64	2.88	3.00	3.48	3.12	3.00	3.12	2.88	2.76

Table 6. Infiltration rate 55 minutes after runoff begins (paired observations).

Tillage	Residue	1981	1982	1983	1984	1985	1986	Avg.
		in/hr						
No-Till	Bare	-	-	-	1.68	1.00	1.24	
	Mulch	1.46	1.10	3.53*	0.60	3.02	2.10	1.66+
Conventional	Bare	0.97	1.52	0.54	1.70	1.40	1.83	1.33
	Mulch	2.72	2.34	1.49	2.90	2.14**	2.25	2.31
					RATIO			
Conv Bare/Conv Mulch		0.36	0.65	0.36	0.58	0.65	0.81	0.57
No Till Mulch/Conv Bare		1.51	0.72	6.53	0.35	2.16	1.15	1.18+

* Soil disturbed prior to planting by anhydrous ammonia injection.
** 1 observation only
\+ Omit 1983

Table 7. Relationship of infiltration rates (average 40 - 60 minutes after runoff starts) to matric potential.

				Matric Potential Depth in Soil		
Tillage	Residue	Rep	in/hr	7.5	17.5	32.5
					cm H_2O	
No-till	Bare	E	1.26	-16	-111	- 22
		W	1.22	-24	---	+ 7
	Mulch	E	1.08	+ 4	- 89	-133
		W	2.76	+ 2	- 3	+ 12
Conventional	Normal	E	1.62	- 7	- 52	- 66
		W	1.89	---	---	---
	Mulch	E	1.98	+ 6	+ 10	+ 19
		W	2.34	+ 7	+ 22	+ 4
Paraplow	Mulch	E	3.00*	- 6	- 3	- 20
		W	2.94	- 4	- 4	- 52

* 20-30 minutes

Table 8. Continuous corn tillage yield results, Lancaster, WI. 1979-1986

Tillage Treatment with Normal Residue	1979	1980	1981	1982	1983	1984	1985	1986	79-83	79-86	84-86
	bu/A										
Ridge plant	162	157	157	147	100	-	-	-	145	-	-
Slot plant	163	146	151	141	85	108	120	165	137	135	131
Chisel	160	150	167	154	95	115	125	159	145	141	133
Conventional	169	159	168	151	89	121	133	164	147	144	139
Paraplow*	-	-	-	-	-	106	125	162	-	-	131

* Fall 1983 and Fall 1984

TILLAGE AND DIFFUSE SOURCE PHOSPHORUS POLLUTION IN THE CLEARWATER RIVER WATERSHED, MINNESOTA, 1986 (STEARNS, WRIGHT, AND MEEKER COUNTIES)

J.F. Moncrief, J.J. Kuznia, M. Kells, W. Anderson,
D.D. Breitbach, J.L. Anderson, B.R. Durgan, and R. Behrens

The Clearwater River chain of lakes (which are phosphorus limiting) have in recent years suffered a degredation in water quality due to increased P loading. There has been several point sources that have been identified and corrective action taken to reduce their influence. Recently the focus has turned to diffuse sources of P loading. Many of the soils in this area are natively high in soil P. Since most of the P that enters the lakes is associated with the sediment it is logical that control of erosion coupled with proper fertilizer P management would abate this source of P. It is generally accepted that the most cost effective method of controlling erosion is with crop residue management through tillage. In an effort to evaluate tillage alternatives which are specific for the conditions in the watershed plots were established in three areas. These plots are large to accommodate farmer cooperator's equipment and in some cases have been split to evaluate fertilizer management.

It is desirable to characterize the indigenous soil phosphorus levels in the watershed since the focus of this project is abatement of diffuse sources. The native levels of P for the soils in the watershed are shown in figure 1 (after Soil Atlas data). These values are weighted soil horizon averages for the 12 to 60 inch depth. Relative level categories are with respect to crop production. In other words, "high" means a grower will not likely get a response to an application of P. Soils in the watershed are very heterogeneous when it comes to P levels. This is due to the genesis of the soils in this area. Most are recently alluviated (formed by rivers) or formed from glacial till which is by definition heterogeneous. About half of the watershed soils are medium to high in subsoil P.

There are several implications that can be made from this data. If erosion was allowed to occur (most P entering lakes is associated with sediment) on the soils with high native levels eutrophication could be accelerated. If growers in the watershed have a history of over application of fertilizer P or mismanagement of manure and allowed erosion to occur eutrophication could also have been accelerated. Or if a river such as Fairhaven or Three Mile Creek which pass through high soil P areas erode stream banks eutrophication could be accelerated.

All the above mentioned scenarios for P limited lake eutrophication have the common denominator of erosion. Most will argue that conservation tillage is the most cost effective method of controlling erosion. Following is the establishment year summary of data collected from tillage demonstration plots in the Clearwater River Watershed to be used in an educational effort to enhance adoption of conservation tillage techniques.

The results of the Stearns county site are shown in tables 1-7. The farmer cooperator at this site is a ridge till farmer. Because the soil at this site is compatible with spring tillage and the site was in a ridge till system, establishment of four tillage systems was possible during the first year. At this site there are four tillage systems to be used in a corn-soybean rotation. A summary of tillage treatments and cultural practices at this site are shown in table 1. Ridge till plots were planted on 38" rows and all other treatments on 8" rows. The plot area is on rented land which has had very little fertilizer applied in the last six years.

It is interesting to note the fertility levels at this site. All of the plots have soil test P levels in the high range. The soil test K levels are in the medium range. For this reason plots were split with row applied K on the narrow row soybeans and an N-P-K solution on the wide row soybeans (table 1). There was no difference in yield due to the fertilizer applications. There was a four bushel per acre advantage with the narrow row soybeans. This may be offset with equipment, labor, and fuel cost however. An economic analysis will shed light on this aspect.

Soil covered by corn residue is shown in table 3. Until next year there won't be a no till treatment. With this years tillage systems cover ranged from 3 to 27%. Soybeans emerged at the fastest rate with the ridge till system. On May 29th (13 days after planting) 95% of the soybeans were emerged with the ridge till system compared to the most residue free system (moldboard plow) at 78%. This would be more important for corn than soybeans, but it does illustrate the advantage of this system in early emergence. Cover in the row (controls soil temperature and rate of emergence) is about the same between these two treatments but soybeans were probably at a more shallow depth (and warmer).

The major weeds at this site were: buckwheat, foxtail, and lambsquarter (table 4). It is interesting to note that the chisel and moldboard treatments had the highest populations of these weeds just prior to herbicide application. Good control was obtained and weeds did not affect yields.

Wright county results are shown in tables 8 to 13. The soil at this site is not compatible with spring tillage. For this reason there is only two tillage treatments during the establishment year (ridge till and spring disc). In 1987 the no till, chisel and moldboard plow treatments will be evaluated.

On the east side (soybeans grown in 1986) there is evidence of over application of fertilizer or more likely manure. The cooperator at this site doesn't recall any manure being applied here for about 20 years. At that time there was a swine operation in this field. The extremely high levels of soil P and K have persisted in this field. On the west half of the site (corn in 1986) soil test P and K values are in the medium range and surprisingly uniform. This illustrates the importance of a good soil testing program. The field on the east doesn't need P or K for probably more than 30 years.

The percent soil covered with crop residue is higher at this site than the Stearns county site (table 10). Weed pressure at this site was minimal. Major weeds in the corn (table 11) were volunteer soybeans and buckwheat. It is interesting to note that there were more volunteer soybeans in the ridge till system on this date (May 29). The cultivation associated with this system would eliminate any differences later however. The major weed in the soybeans was lambsquarter (table 12). There were significantly less in the ridge till treatment.

Soybean yields are shown in table 13. There was no difference in yield due to the tillage systems at this site. It is unusual that there was no advantage to narrow rows (8" vs 30"). It is possible that the increased lambsquarter pressure masked out this response. Corn yield are shown in table 14. The spring disc option resulted in a 13 bu/ac yield increase. This is likely not due to tillage. The planter at this site had home made fertilizer openers mounted on an add on 3" tool bar ahead of the planter. When planting in the ridge till plots the fertilizer boot was pinched shut by this tool bar which prevented the application of starter fertilizer. The authors are convinced that the yield differences are due to the fertilizer response by the disc system.

The soil at the Meeker county site does not allow spring tillage. It also has a history of moldboard plowing. For these reasons tillage treatments were not able to be initiated at this site until the fall of 1986. The soil at this site is a complex of soils ranging in texture from clay loam to sandy loam (table 15). This is characteristic of this part of the county. The plot diagram is shown in figure 4. The plots are not symmetric to accommodate a water way to allow runoff of excess moisture.

Statistics Reported significance values are the smallest level of significance which would lead to the rejection of the hypothesis that a given treatment did not affect a particular variable. For most field experimentation a significance value that is .10 or smaller is usually accepted as proof that differences in treatment averages are due to treatments and not to random variability. If treatment variances were found to be unequal by an $F_{.10}$ test, a natural log transformation was used to meet this assumption of analysis of variance.

STEARNS COUNTY

Table 1. Cultural practices at Stearns County, MN. 1986.

Tillage - The site has been ridge till for 3 years.

Spring Disc-This is the establishment year so these plots were disced to eliminate ridges on May 6th. This treatment will become "no till" in 1987.

Ridge Till

Chisel Plow-Plots were spring disced, then chisel plowed, and disced again on May 6th.

Moldboard Plow-Plots were also spring disced, then moldboard plowed, and disced again on May 6th.

Preceding Crops

The cropping history at this site is as follows: 1981-red clover and oats, 1982-corn, 1983-soybeans, 1984-corn, 1985-corn.

1986 Crop

Soybeans - Pioneer 1677

Planting and Harvest Dates

Ridge till plots were planted with a four row Buffalo Till planter equipped with 12" sweeps at a 38"row spacing. All other plots were planted with a Tye No Till drill with 8" row spacing equipped with 2" fluted coulters.

	Planting		
Crop	Date	Rate	Harvested
		(Ridge Till)	
Soybeans	May 16, 1986	190,000 plants/ac	Oct. 16, 1986
		(All Others)	
		225,000 plants/ac	

Fertilization History

The fertilization history at this site is as follows: 1981-none, 1982-low rate of dry starter, 1983-low rate of starter and 0-0-60, 1984-4 gal./ac of 9-18-9 only, 1985-60 lbs/ac of N and 4 gal./ac of 9-18-9.

Fertilizer

All plots were split with and without a row fertilizer treatment at planting.

Crop	Material Analysis (Rate)	Tillage	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
			---lbs/ac---			
Soybeans:	9-18-9[1] (4 gal/ac)	Ridge Till	4	8	4	May 16, 1986
	0-0-60[2] (90 lbs/ac)	All Others	0	0	54	May 16, 1986

1. Planter applied 1" below the seed.
2. Potash was surface banded ahead of and incorporated by the fluted coulters.

Soil

Estherville (Typic Hapludolls, sandy, mixed, mesic) sandy loam, 2 to 6 percent slopes. Soil is somewhat excessively drained.

Weed Control

$1^1/_2$ pt (3/4 lb)Basagran + 1/2 pt(1/8 lb) Blazer on June 17.
1 pt (2/10 lb) Poast + $2^1/_2$ lb ammonium sulfate on June 24.
1 qt (1 lb) Basagran on June 24.
All post emergence applications were applied with 1 qt./ac of crop oil.

Soil Test

Table 2. Nutrient levels sampled on April 21, 1986, n=4.

		Tillage							
	Sig. of	Spr. Disc		Ridge Till		Chisel		Moldboard	
Nutrient	Tillage	mean	stdev	mean	stdev	mean	stdev	mean	stdev
		lb/ac							
Phosphorus	(.897)	51	16	56	12	53	2	52	20
Potassium	(.510)	237	82	209	33	192	20	253	51
pH	(.478)	6.4	.2	6.6	.2	6.4	.2	6.4	.2

Table 3. The effect of tillage on percent of the soil surface covered by corn residue on May 29, 1986, n=16.

	Tillage							
	Spring Disc		Ridge Till		Chisel		Moldboard	
	mean	std dev	mean	std dev	mean	std dev	mean	std dev
Location	%							
In Row	26.8	15.8	6.5	5.6	16.5	9.1	3.0	4.7
Between	20.3	12.3	25.5	15.2	17.5	11.5	4.0	7.0

Table 4. The effect of tillage on soybean stand, n=16.

		Tillage							
		Spring Disc		Ridge Till		Chisel		Moldboard	
	Sig. of	mean	std dev	mean	std dev	mean	std dev	mean	std dev
Date	Tillage	plants/ac x 10^{-3}							
5/29	(.036)	155	46.0	157	9.3	134	48.8	186	47.0
6/11	(.000)	213	45.4	165	11.1	207	39.6	240	35.1

Table 5. The effect of tillage on the presence and density of weed species[1] on June 11, 1986, n=16.

		Tillage							
		Spr. Disc		Ridge Till		Chisel		Moldboard	
	Sig. of	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Weed	Tillage	----------plants/ac x 10^{-3}----------							
Corn	(.688)	88.3	231	2.9	4.7	16.7	24.3	13.2	39.5
Buckwheat	**(.001)**	**2.04**	**3.52**	**1.61**	**2.09**	**4.98**	**9.45**	**40.4**	**39.3**
Smartweed	(.359)	4.76	7.89	.84	1.36	23.8	41.5	15.6	24.6
Clover	(.812)	1.88	4.01	3.65	4.33	7.50	27.9	6.21	14.1
Ragweed	(.405)	4.96	7.48	2.62	4.96	31.1	57.6	23.1	35.7
Quackgrass		0.00	0.00	1.08	2.56	3.16	10.1	.57	2.26
Foxtail	**(.000)**	**119**	**191**	**83.0**	**92.0**	**708**	**976**	**521**	**239**
Pigweed		1.77	2.69	.83	1.42	2.36	5.58	0.00	0.00
Pennycress		0.00	0.00	.64	1.28	0.00	0.00	0.00	0.00
Dandelion		0.00	0.00	.44	.72	.48	1.90	0.00	0.00
Lambsquart	**(.000)**	**25.4**	**15.7**	**4.43**	**3.44**	**87.3**	**72.4**	**111**	**66.1**
Mallow		.20	.78	0.00	0.00	0.00	0.00	3.22	12.9
Ash Tree		0.00	0.00	.24	.73	.52	2.06	0.00	0.00
Canada Th		0.00	0.00	.30	.83	0.00	0.00	0.00	0.00
Knotweed		0.00	0.00	1.33	3.48	0.00	0.00	0.00	0.00

1. Weed species which were significantly affected by tillage are in bold type.

Table 6. The effect of tillage and fertilizer[1] on the yields of soybeans yields, n=4.

		Tillage (.000)							
		Spr. Disc		Ridge		Chisel		Moldboard	
	Sig. of	mean	stdev	mean	stdev	mean	stdev	mean	stdev
Fertilizer	Fert.	----------yield bu/ac----------							
	(.613)								
fertilizer		40.6	1.80	36.4	1.34	39.8	.540	40.9	2.50
no fertilizer		39.7	1.99	35.6	.389	39.6	1.89	41.7	1.28

1. The fertilizer refers to 4 gal/ac 9-18-9 on ridge till plots and 90 lbs/ac 0-0-60 on the rest.
2. The significace of the interaction of tillage x fertilizer was .619.

Table 7. The effect of tillage and fertilizer[1] on the moisture of soybeans at harvest, n=4.

		Tillage (.003)							
	Sig. of	Spr. Disc		Ridge Till		Chisel		Moldboard	
Fertilizer	Fert.	mean	stdev	mean	stdev	mean	stdev	mean	stdev
	(.549)	----------% moisture----------							
fertilizer		14.4	.76	13.3	.71	13.7	1.26	13.8	.97
no fertilizer		14.4	.66	13.5	.60	14.3	1.29	13.4	.57

1. The fertilizer refers to 4 gal/ac 9-18-9 on ridge till plots and 90 lbs/ac 0-0-60 on the rest.
2. The significace of the interaction of tillage x fertilizer was .241.

WRIGHT COUNTY

Table 8. Cultural practices at Wright County, Mn. 1986.

Tillage

Spring Disc-This is the establishment year so these plots were disced to eliminate ridges. Tillage dates are:

Soybeans following corn:May 2, 1986.
Corn following soybeans:May 2, 1986.

Ridge Till-

Because this is an establishment year and this soil type is not compatible with spring tillage there are only two tillage treatments in 1986 (ridge till and spring disc). The no till, chisel and moldboard plow treatments will be established in the fall of 1986.

1986 Crops

Corn - Pioneer 3737
Soybeans - Pioneer 1677

Preceding Crop

Corn-soybean rotation since 1982.

Planting and Harvest Dates

Soybeans- Ridge till plots were planted with a John Deere Maxemerge planter equipped with Buffalo Till ridge cleaners with 10" sweeps. All other plots were planted with a Tye No Till drill with 8" row spacing equipped with 2" fluted coulters.

Corn- Ridge till plots were planted with a John Deere Maxemerge planter equiped with Buffalo Till ridge cleaners with 10" sweeps. All other plots were planted with the John Deere Maxemerge planter but the sweeps were raised.

	Planting		
Crop	Date	Rate	Harvested
Corn	May 2, 1986	30,000 plants/ac	Nov. 5, 1986
Soybeans	May 7, 1986	225,000 plants/ac	Oct. 10, 1986

Fertilization History

Since 1983 both corn and soybeans received 100 to 150 lbs/ac of a 5-12-36 fertilizer applied with the planter. Prior to that only the corn received fertilizer with the planter. No soil test information prior to 1986 is available.

Fertilizer

	Material Analysis (Rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		----lbs/ac----			
Corn:	8-23-30[1] (140 lbs/ac)	11	32	42	May 2, 1986
	28-0-0[2] UAN (37 gal/ac)	110	0	0	June 13, 1986

1. Planter placement 2" beside and 2" below row.
2. Surface banded between rows.

Soil

Fairhaven (Typic Hapludolls, fine-loamy over sandy or sandy-skeletal, mixed, mesic) silt loam, 2 to 6 percent slopes, moderately eroded. Soil is well-drained.

Weed Control

Corn

2 qt Lasso + 2 qt Bladex on May 2, with planter.

Soybeans[1]

1 qt (1 lb) Basagran + 1/2 pt (1/8 lb) Blazer on June 4.

1 pt (2/10 lb) Poast on June 12

1/2 pt (1/4 lb) Basagran + 1/4 pt (1/16 lb) Blazer on June 12

1. All post emergence applications were applied with 1 qt./ac of crop oil.

Soil Test

Table 9. Nutrient levels in the corn and soybean plots sampled on April 21, 1986, n=12 for spring disc and n=4 for ridge till.

			Tillage			
		Sig. of	Spring Disc		Ridge Till	
Crop	Nutrient	Tillage	mean	stdev	mean	stdev
			----------lb/ac----------			
Corn	Phosphorus	(.642)	31	8	31	15
	Potassium	(.138)	198	11	189	6
	pH	(.154)	6.3	.1	6.3	.1
Soybean	Phosphorus	(.129)	298	215	192	183
	Potassium	(.412)	613	362	487	236
	pH	(.298)	6.4	.3	6.6	.8

Table 10. The effect of tillage on percent of soil cover by residue on May 28, 1986, n=48 for spring disc and n=16 for ridge till.

	Crop							
	Corn following Soybeans				Soybeans following Corn			
	Spring Disc		Ridge Till		Spring Disc		Ridge Till	
Location	mean	stdv	mean	stdv	mean	stdv	mean	stdv
	----------%							
In Row	5.5	5.1	4.8	5.3	32.6	18.3	21.0	19.3
Between	12.0	9.1	19.8	7.9	30.0	18.5	50.8	14.5

Table 11. The effect of tillage on the presence and density of weed species[1] in Pioneer 3737 corn following soybeans on May 29, 1986, n=48 for spring disc and n=16 for ridge till.

		Tillage			
		Spr Disc		Ridge Till	
		mean	stdv	mean	stdv
	Sig. of	-----plants/ac x 10^{-3}------			
Weed	Tillage				
Soybeans	**(.086)**	**21.9**	**18.2**	**30.5**	**19.9**
Buckwheat	(.217)	8.48	7.24	30.3	41.1
Smartweed	(.222)	.17	.54	.98	1.68
Clover		0.00	0.00	3.08	6.24
Alfalfa		0.00	0.00	.301	.878
Common Ragweed	**(.000)**	**.17**	**.83**	**3.31**	**5.04**
Quackgrass	(.683)	4.96	12.2	3.55	11.1
Shephard's Purse		0.00	0.00	.61	1.37
Foxtail	**(.000)**	**.29**	**1.60**	**6.54**	**9.42**
Pigweed		.022	.158	0.00	0.00
Pennycress	(.746)	.135	.408	.301	.878
Lambsquarter	(.914)	.163	.503	.278	.835
Ash Tree	(.156)	.311	.603	1.11	1.97
Knotweed	(.204)	.099	.560	.346	.961

1. Weed species which were significantly affected by tillage are in bold type.

Table 12. The effect of tillage on the presence and density of weed species[1] in Pioneer 1677 soybeans following corn on May 28, 1986, n=48 for spring disc and n=16 for ridge till.

		Tillage			
		Spr Disc		Ridge Till	
		mean	stdv	mean	stdv
	Sig. of	-----plants/ac x 10^{-3}------			
Weed	Tillage				
corn	**(.056)**	**7.92**	**28.9**	**6.02**	**10.4**
Clover		0.00	0.00	.840	3.36
Alfalfa		1.10	4.52	0.00	0.00
Common Ragweed		.325	1.70	0.00	0.00
Quackgrass		1.97	13.6	0.00	0.00
Foxtail	(.308)	135	224	249	316
Pigweed	(.853)	3.99	13.6	1.14	3.02
Pennycress	(.989)	6.20	14.4	1.40	2.92
Giant Ragweed	(.467)	.597	4.14	1.42	3.07
Lambsquarter	**(.000)**	**623**	**540**	**239**	**137**
Dandelion		0.00	0.00	.609	1.79
Mallow	(.130)	14.7	44.0	.573	2.29

1. Weed species which were significantly affected by tillage are in bold type.

Table 13. The effect of tillage on soybean yields, moisture[1].

	Tillage			
	Spr Disc		Ridge Till	
Sig. of Tillage	mean	stdv	mean	stdv
	----------bu/ac----------			
(.583)	46.6	3.55	47.6	2.06
	--------% moisture--------			
(.245)	12.2	.48	11.9	.13
	-------plants/ac x 10^{-3}----			
(.000)	207	29.0	142	22.0

1. n=12 for spring disc, n=4 for ridge till and population on June 28, 1986, n=48 for spring disc and n=16 for ridge till.

Table 14. The effect of tillage on corn yields, moisture[1]

	Tillage			
	Spr Disc		Ridge Till	
Sig. of Tillage	mean	stdv	mean	stdv
	----------bu/ac----------			
(.042)	163	12	150	12
	--------% moisture--------			
(.329)	18.8	.40	18.6	.42
	-----plants/ac x 10^{-3}------			
(.144)	20.2	1.5	21.3	3.7

1. n=12 for spring disc, n=4 for ridge till and population on June 28, 1986, n=48 for spring disc and n=16 for ridge till.

MEEKER COUNTY

Table 15. Cultural practices at Meeker County, Mn. 1986

Tillage

Moldboard Plow-October 28, 1986
Chisel Plow-October 29, 1986
No Till-
Ridge Till-ridges formed July 18, 1986

Since this was the establishment year there was only one tillage treatment this year (moldboard plow). Ridges were established in the summer and the others in the fall.

Crops

Corn-Pioneer 3737
Soybeans-Pioneer 1677 and Corsoy

Preceding Crop

Corn-soybean rotation since 1978.

Fertilizer

Crop	Material Analysis (Rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		----lbs/ac----			
Corn:	82-0-0 (183 lbs/ac)	150	0	0	Spring
	4-15-40[1] (250 lbs/ac)	10	38	100	Planting

1. Planter placement 2" beside and 2" below row.

Soil

The soils present at this site are as follows: 29% of plot area is Delft (Cumulic Haplaquolls, fine-loamy,mixed, mesic) clay loam, 43% is Koronis (Mollic Haplaudalfs, fine-loamy, mixed, mesic) fine sandy loam, and the remaining 28% is Marcellon (Aquic Argiudolls, fine-loamy, mixed, mesic) loam.

THE EFFECT OF TILLAGE ON SOIL NITROGEN WITH CORN AND SOYBEAN PRODUCTION IN SOUTHEASTERN MINNESOTA

J.F. Moncrief, T.L. Wagar, L.J. Svien, J.J Kuznia, R.W. Hoff, and D.D. Brietbach

There has much debate as to the effects of tillage on water movement through soils. One argument is that some tillage strategies that reduce runoff and subsequently increase infiltration may increase the amount of nitrate nitrogen that is percolated into groundwaters. Another argument is that there is more runoff with some tillage strategies and this results in more surface water pollution. In an effort to investigate under what tillage systems nitrogen leaching is probable, mineral soil nitrogen has been monitored in the spring in six depth increments to five feet in tillage studies at Fillmore and Wabasha counties. For a more detailed description of production data comparing tillage strategies see the companion article.

The values for mineral nitrogen at Fillmore county are shown in tables 1 to 5. Statistics are summarized in table 4. This site has been in corn for two years. In 1984 this site was cropped to soybeans. Two soil samples were taken in each plot and composited. Statistics were run on the two 6" increments at the surface and then combining these two samples and running for five one foot increments to five feet. When run as one foot increments there was no effect of tillage (table 1) but a significant depth effect (table 2). The nitrate was highest in the top bottom increment. It was lowest in the second foot and increased with depth to five feet. The ammonium was higher in the top three feet. When looking at total mineral nitrogen the surface foot was the highest. The distribution of the nitrate and ammonium with depth was somewhat offsetting. The no till treatment had higher nitrate and lower ammonium in the top 12" (table 3). These trends again were offsetting resulting in similar total mineral nitrogen for all tillage treatments. When the total profile mineral nitrogen is considered there is no difference due to tillage. There was quite a lot of variability in the nitrogen values at this site.

Mineral nitrogen data at Wabasha county are shown in tables 6 to 10. This site has been in a corn-soybean rotation since 1984. There was generally more nitrogen following corn than soybeans. Two tillage treatments were changed in 1986. The paraplow treatment was changed to a spring disc and due to a change in row spacing the ridge till treatment was lightly disced. The soil samples were taken before tillage so nitrogen reflects previous tillage history. The ridge till treatment following soybeans had higher levels of nitrate and lower levels of ammonium (table 6). Samples were taken between the rows. Following corn there were higher levels of nitrate and total mineral nitrogen associated with the paraplow treatment (table 6) Ammonium concentrations were lower with the no till treatment (table 6). The highest concentrations of nitrogen following soybeans were found in the upper and third foot increments (table 7). Nitrate concentrations following corn were highest in the fourth foot and then decreased to the surface. This was similar to the Fillmore site. When considering the top two 6" increments several things are significant (tables 8 and 9). The ammonium increased with depth after soybeans. There was an interaction between tillage and depth after corn. The ridge till treatment had more ammonium and total mineral nitrogen in the top 6". The paraplow treatment had higher ammonium and total mineral nitrogen in the 6-12" increment. When considering total profiles mineral nitrogen (table 10) it appears that the ridge till system had lower levels of ammonium.

These data must be interpreted with caution since it characterizes the profile nitrogen at one point in time (spring before tillage) but it does illustrate that tillage can affect nitrogen transformations and movement through the soil.

FILLMORE COUNTY

Tillage

No Till
Disc - Disced twice on April 10th and once on May 6th.
Chisel-Chisel plowed with a Glencoe Soil Saver on May 3rd and again on May 6th.
Moldboard - Disced and Moldboard Plowed on April 10th, and disced again on May 6th.

Cultivation

Each plot is split with one half cultivated and the other half not.

Crop Corn-Pioneer 3737 **Preceding Crop** Corn

Planting and Harvest Date

Planter was a John Deere Maxemerge 4 row (38") planter equipped with John Deere row cleaners.

	Planting		
Crop	Date	Rate	Harvested
Corn	May 7, 1986	28,300 plants/ac	Oct. 28, 1986

Fertilization History

1983-injected 5-6000 gal/ac of liquid dairy manure.

	Material Analysis (Rate)	Actual N	P_2O_5	K_2O	
Crop		----lbs/ac----			Date Applied
Corn:	16-41-8[1] (125 lbs/ac)	20	51	10	May 6, 1985
	82-0-0 (134 lbs/ac)	110	0	0	May 22, 1985

1. Planter applied 2" beside and 2" below row.

Fertilizer

	Material Analysis (Rate)	Actual N	P_2O_5	K_2O	
Crop		----lbs/ac----			Date Applied
Corn:	82-0-0 (244 lbs/ac)	200	0	0	May 22, 1986
	9-23-30 (125 lbs/ac)	11	29	38	May 7, 1986 (with planter)

Soil

Tama (Typic Argiudolls, fine-silty, mixed, mesic) and Downs (Mollic Hapludalfs, fine-silty, mixed, mesic) silt loams, eroded, 2 to 6 percent slopes. Soil is well drained.

Weed Control

All plots were sprayed with 1 pint/ac of Buctril on June 4, 1986. Corn was at 5 leaf stage.

Insect Control

6.9 lbs/ac Counter at time of planting.

Soil Test

Soil samples were taken on April 23rd to a depth of five feet in increments of 0-6" 6-12" 12-24" 24-36" 36-48" 48-60" for nitrate analysis. Two samples were taken per plot and then combined for a composite sample.

Table 1. The effect of tillage and preceding crop on the average NO_3^--N, NH_4^+-N and total mineral nitrogen (lbs/ac) for five one foot increments on April 23, 1986 at Fillmore county, MN., n=15.

Source of N	Tillage: No Till mean	No Till st dev	Disc mean	Disc st dev	Chisel mean	Chisel st dev	Moldboard mean	Moldboard st dev
	Corn the preceding year							
NO_3^--N	31.6	20.7	30.6	16.3	27.8	11.2	25.4	10.8
NH_4^+-N	15.9	9.08	19.5	8.38	16.5	7.70	19.9	9.33
Tol-N	47.5	26.3	50.1	18.6	44.3	17.3	45.3	15.2

Table 2. The effect of depth and preceding crop on the NO_3^--N, NH_4^+-N and total mineral nitrogen (lbs/ac) on April 23, 1986 at Fillmore county, MN. , n=12.

Source of N	Depth (inches): 0-6 mean	6-12 mean	0-12 mean	12-24 mean	24-36 mean	36-48 mean	48-60 mean
	Corn the preceding year						
NO_3^--N	17.4	15.1	32.5	20.7	28.0	29.5	33.6
NH_4^+-N	10.5	12.3	22.8	18.4	20.7	14.6	13.2
Tol-N	28.0	27.4	55.3	39.1	48.7	44.1	46.8

Table 3. The interaction of tillage x depth (0-6" an 6-12") and preceding crop on the average NO_3^--N, NH_4^+-N and total mineral nitrogen (lbs/ac) on April 23, 1986, at Fillmore county, MN., n=3.

Source of N	Depth	Tillage: No Till mean	No Till st dev	Disc mean	Disc st dev	Chisel mean	Chisel st dev	Moldboard mean	Moldboard st dev
		Corn the preceding year							
NO_3^--N	0-6"	29.2	25.3	14.2	7.31	14.7	2.76	11.6	4.69
	6-12"	17.1	6.97	13.4	5.24	15.8	4.28	14.0	3.85
NH_4^+-N	0-6"	9.06	4.14	11.4	6.03	10.8	2.33	10.8	5.18
	6-12"	8.57	4.68	12.4	3.09	11.4	4.97	16.7	0.72
Tol-N	0-6"	38.2	24.0	25.6	13.0	25.6	4.08	22.4	3.94
	6-12	25.6	9.75	25.8	8.08	27.2	8.50	30.7	4.26

Table 4. The significance of tillage, depth, the interaction of tillage x depth and preceding crop on the NO_3^--N, NH_4^+-N and total mineral nitrogen on April 23, 1986, at Fillmore county, MN..

Source of N	Analysis of 0-6" and 6-12": Till.	Depth	Till. x Depth	Analysis of 1 ft. increments to five feet: Till.	Depth	Till. x Depth
	Corn the preceding year					
NO_3^--N	.097	.900	.386	.659	.044	.255
NH_4^+-N	.093	.167	.271	.291	.010	.364
Tol-N	.660	.781	.186	.414	.070	.194

Table 5. The effect of tillage on NO_3^--N, NH_4^+-N and total mineral nitrogen from 0 to 5 feet (lbs/ac) on April 23, 1986, at Fillmore county, MN., n=4.

Total lbs/A of	Sig. of Tillage	No Till mean	No Till st dev	Disc mean	Disc st dev	Chisel mean	Chisel st dev	Moldboard mean	Moldboard st dev
		----------Corn the preceding year----------							
NO_3^--N	(.960)	158	96.4	153	46.5	139	27.0	127	45.2
NH_4^+-N	(.498)	79.7	42.6	97.3	27.7	82.4	14.3	99.4	20.5
Tol-N	(.950)	238	131	250	65.2	221	37.8	227	50.4

WABASHA COUNTY

Row Width

In 1986, row crop width was changed from 38" to 30".

Tillage

No Till

Spring Disc Ridge - disc to break down 38" ridges, will be 30" ridge till in 1987, see spring disc below for tillage.

Ridge formed - corn June 26, 1986
- soybeans July 11&15, 1986

Spring Disc - area following corn disc twice on April 25, 1986
- area following soybeans disc once on April 25, 1986

Chisel Plow - April 25,1986 - field cultivator May 5, 1986

Crops	Preceding Crops
Corn - Pioneer 3737	1983 - Sweet Clover
Soybeans - Pioneer 1677	1984-85 - Corn-Soybean rotation.

Planting and Harvest Date

Planter used on all corn plots was a John Deere Maxemerge six row (30") planter equipped with 2" fluted coulters. Planter used on no till, spring disc and chisel plow soybean plots was a Kinze No Till Drill with 10" row spacing. Planter used on spring disc ridge was a John Deere Maxemerge six row (30") planter equipped with 2" fluted coulters.

Crop	Planting Date	Planting Rate	Harvested
Corn	May 5, 1986	30,800 plants/ac	Oct. 22, 1986
Soybeans	May 7, 1986	225,000 plants/ac	Oct. 22, 1986

Fertilization History

Crop	Material Analysis (Rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied	
		----lbs/ac----				
All plots except chisel plow.	28-0-0 (7 gal/ac)	75	0	0	May 14, 1984	
Corn:	7-21-7 (12.5 gal/ac)	10	29	10	May 16&18, 1984	
Corn:	7-21-7 (25 gal/ac)	20	60	20	May 13, 1985	Placement 2" beside and 2" below seed.
Corn:	82-0-0 (170 lbs/ac)	140	0	0	June 19, 1985	

Fertilizer

Crop	Material Analysis (Rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		----lbs/ac----			
Corn:	46-0-0 (337 lbs/ac)	155	0	0	April 24, 1986
Corn:	9-23-30 (170 lbs/ac)	15	39	51	May 5, 1986

Soil

Fayette (Typic Hapludalfs, fine-silty, mixed, mesic) silt loam.

Weed Control

Corn

Banded 1 3/4 pt Dual + 3 1/2 pt Bladex/ac with the planter on May 5, 1986.

Soybeans

Roundup was sprayed on the soybean plots at 4 qt/ac on April 23, 1986 (very windy - 30mph). Weeds present were smooth brome, quackgrass, and cockle.

1 pt Roundup + 1/2% surfactant on May 7, 1986.

1 1/2 pt (3/4 lb) Basagran + 1/2 pt (1/8 lb) Blazer + 1 qt oil concentrate on May 30, 1986.

1 pt (2/10 lb) Poast + 1 qt oil concentrate on June 12,1986.

1 pt (1/2 lb) Basagran + 1 qt oil concentrate on June 12, 1986.

Soil Test

The soil pH=6.6 P=70 lbs/ac K=275 lbs/ac, tested on April 9, 1984.

Soil samples were taken April 22, 1986 to a depth of 5' in increments of 0-6", 6-12", 12-24", 24-36", 36-48",and 48-60" for nitrate analysis.

Table 6. The effect of tillage and preceding crop on the average NO_3^--N, NH_4^+-N and total mineral nitrogen (lbs/ac) for five one foot increments on April 22, 1986, at Wabasha county, MN., n=20.

Source of N	No Till mean	No Till st dev	Ridge till mean	Ridge till st dev	Paraplow mean	Paraplow st dev	Chisel mean	Chisel st dev
	----------Soybeans the preceding year----------							
NO_3^--N	20.2	5.90	23.0	6.61	19.2	5.82	20.7	7.10
NH_4^+-N	10.0	4.81	9.05	4.28	11.4	5.94	11.1	4.85
Tol-N	30.2	8.85	32.1	8.58	30.6	8.72	31.8	11.0
	----------Corn the preceding year----------							
NO_3^--N	28.4	9.26	31.9	10.5	39.4	17.1	28.9	9.42
NH_4^+-N	9.90	4.78	11.8	7.79	11.2	6.63	11.7	4.92
Tol-N	38.3	8.50	43.7	12.0	50.6	16.8	40.6	9.20

Table 7. The effect of depth and preceding crop on the average NO_3^--N, NH_4^+-N and total mineral nitrogen (lbs/ac) for five on foot increments on April 22, 1986, at Wabasha county, MN., n=16.

Source of N	0-6	6-12	0-12	12-24	24-36	36-48	48-60
	----------Soybeans the preceding year----------						
NO_3^--N	12.4	12.0	24.4	19.6	22.3	20.4	17.1
NH_4^+-N	9.11	7.61	16.8	8.58	13.5	7.37	5.80
Tol-N	21.5	19.6	41.2	28.2	35.7	27.8	22.9
	----------Corn the preceding year----------						
NO_3^--N	11.8	12.3	24.1	32.4	35.9	41.8	26.6
NH_4^+-N	10.7	8.86	19.6	8.22	14.5	7.31	5.71
Tol-N	22.5	21.1	43.7	40.6	50.4	49.1	32.3

Table 8. The interaction of tillage x depth (0-6" an 6-12") and preceding crop on the average NO_3^--N, NH_4^+-N and total mineral nitrogen (lbs/ac) on April 22, 1986, at Wabasha county, MN., n=4.

Source of N	Depth	Tillage: No Till mean	No Till st dev	Ridge till mean	Ridge till st dev	Paraplow mean	Paraplow st dev	Chisel mean	Chisel st dev
		Soybeans the preceding year							
NO_3^--N	0-6"	12.3	2.98	11.7	2.70	10.3	1.35	15.3	7.89
	6-12"	11.6	3.61	12.1	2.57	11.4	3.14	12.7	3.68
NH_4^+-N	0-6"	8.54	1.30	8.99	2.19	9.40	1.80	9.49	0.43
	6-12"	7.16	1.61	6.18	0.78	8.65	0.36	8.44	2.46
Tol-N	0-6"	20.9	3.66	20.7	1.04	19.7	2.26	24.8	7.85
	6-12	18.7	4.17	18.3	3.23	20.1	3.47	21.2	5.69
		Corn the preceding year							
NO_3^--N	0-6"	9.86	7.65	12.2	5.51	13.5	6.26	11.7	2.87
	6-12"	11.7	3.76	14.1	4.28	14.0	3.41	9.26	2.54
NH_4^+-N	0-6"	8.41	0.41	15.8	6.23	9.36	2.69	9.15	2.67
	6-12"	8.18	1.45	7.80	0.46	11.5	3.59	7.99	1.41
Tol-N	0-6"	18.3	7.40	28.0	2.88	22.9	8.41	20.9	0.26
	6-12"	19.9	3.19	21.9	4.40	25.4	5.14	17.3	3.92

Table 9. The significance of tillage, depth, the interaction of tillage x depth and preceding crop on the NO_3^--N, NH_4^+-N and total mineral nitrogen on April 22, 1986, Wabasha county, MN.

Source of N	Analysis of 0-6" and 6-12": Till.	Depth	Till. x Depth	Analysis of 1 ft. increments to five feet: Till.	Depth	Till. x Depth
	Soybeans the preceding year					
NO_3^--N	.285	.771	.698	.042	.000	.310
NH_4^+-N	.145	.017	.468	.071	.000	.747
Tol-N	.279	.187	.715	.618	.000	.832
	Corn the preceding year					
NO_3^--N	.707	.986	.700	.010	.000	.803
NH_4^+-N	.147	.123	.040	.075	.000	.388
Tol-N	.013	.172	.050	.003	.000	.698

Table 10. The effect of tillage on NO_3^--N, NH_4^+-N and total mineral nitrogen from 0 to 5 feet on April 22, 1986, at Wabasha county, MN., n=4.

Total lbs/A of	Sig. of Tillage	Tillage: No Till mean	No Till st dev	Ridge till mean	Ridge till st dev	Paraplow mean	Paraplow st dev	Chisel mean	Chisel st dev
		Soybeans the preceding year							
NO_3^--N	(.306)	101	23.4	115	25.1	95.9	27.8	103	22.5
NH_4^+-N	(.109)	50.1	4.80	45.1	1.94	56.9	7.57	55.6	11.8
Tol-N	(.818)	151	26.3	160	25.6	153	21.4	159	29.8
		Corn the preceding year							
NO_3^--N	(.370)	151	11.1	159	34.2	197	55.7	145	19.4
NH_4^+-N	(.240)	46.6	4.02	58.6	9.87	55.9	13.1	58.3	5.39
Tol-N	(.342)	197	10.2	218	37.2	253	52.4	203	21.2