SOIL SERIES 115

A REPORT ON FIELD RESEARCH IN SOIL SCIENCE

The 1985 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.

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The investigators also greatly appreciate the cooperation of many county agents, farmers, technical assitants, 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 1984 experiments only and should be regarded on this basis. Since most data are from only 1984 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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LONG-TERM PRECIPITATION RECORDS

D.G. Baker and D.L. Fusch

Two precipitation records, among many others, can be cited to show that we are currently in a "wet" regime. The records we have chosen to show are those of Minneapolis-St. Paul (1837-1983) and Fairmont (1887-1983), Fig. 1 and 2, respectively. In each illustration the asterisks represent the total precipitation each year and the long straight line is the average for the total record. The next longest straight line, (it is at the right hand side) represents the average or normal for the 1951-1980 period. For Minneapolis-St. Paul this 30-year average is slightly less than the long-term average, while for Fairmont it is slightly higher. The next straight line above is the average for the most recent 10 years, 1974-1983. And above this 10 year line at each station is another and shorter line that represents the average for the last 5 years, 1979-1983. Table 1 summarizes what these two records show about the recent annual precipitation averages.

Table 1. Precipitation averages at Minneapolis-St. Paul and at Fairmont.

Period	Minneapolis-St. Paul	Fairmont
1837-1983	26.83 in.	--
1887-1983	--	28.80 in.
1951-1980	26.42 in.	29.14 in.
1974-1983	28.60 in.	31.59 in.
1979-1983	30.02 in.	36.37 in.

These results, which show a marked recent increase in the annual total precipitation at the two stations, are not unique to either of these two stations, or even to the state of Minnesota. The rise in Devil's Lake (North Dakota) and Salt Lake (Utah) and the resulting problems have been in the news for some time. It is quite apparent that much if not all of the problems encountered by property owners on some local lakes are due to the recent precipitation increase.

The two records shown in Fig. 1 and 2 make it obvious that the current high precipitation is not the first time such an event has occurred. Indeed the two records show that wetter periods of even greater duration have occurred at least three or four times previously within the record period.

A second point of value to learn from the two records is that each wet period has been followed by a dry one. A third point to be gleaned is that while at first glance the rise and fall appear to have some regularity while the wet and dry periods are variable enough that a prediction as to their future occurrence cannot be made with any degree of confidence.

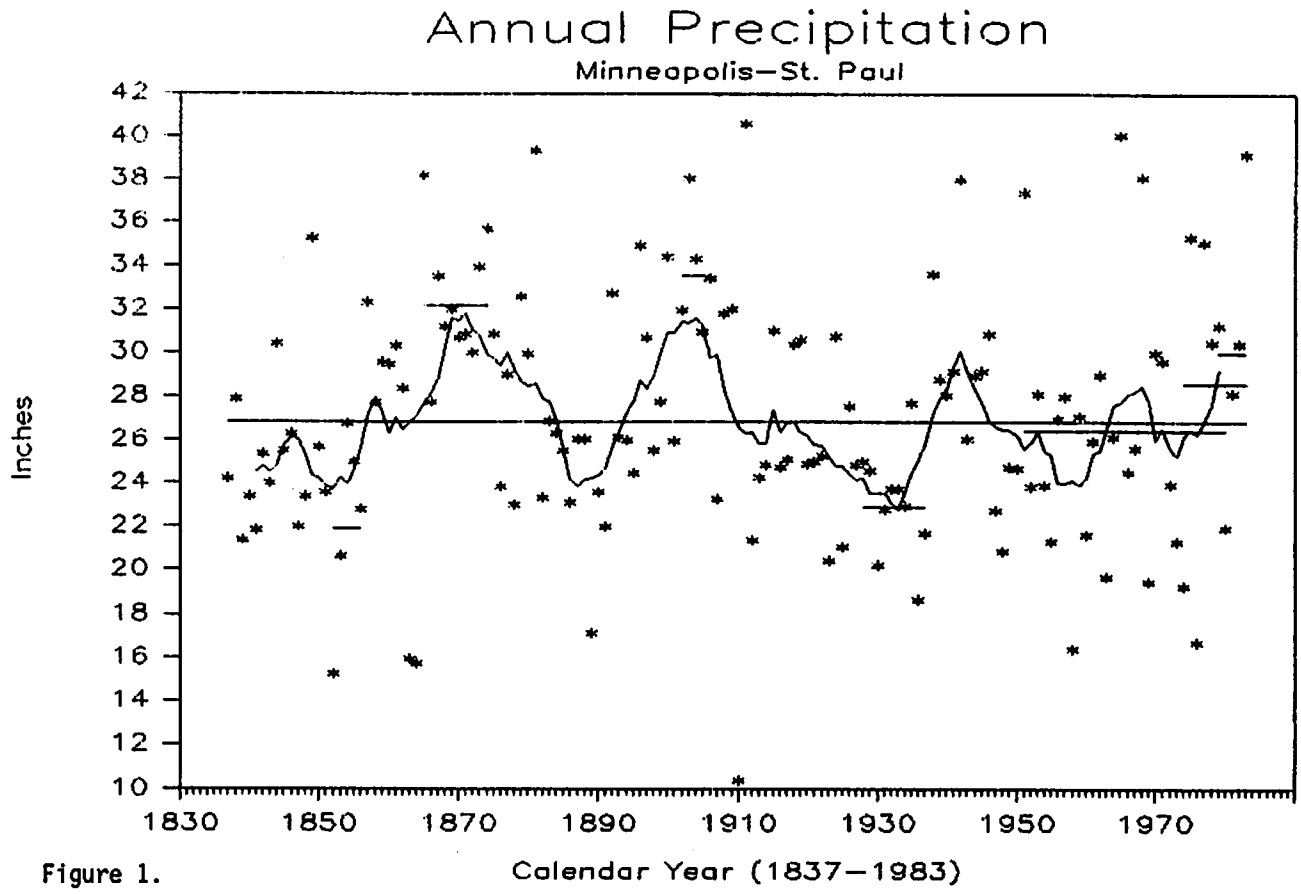


Figure 1.

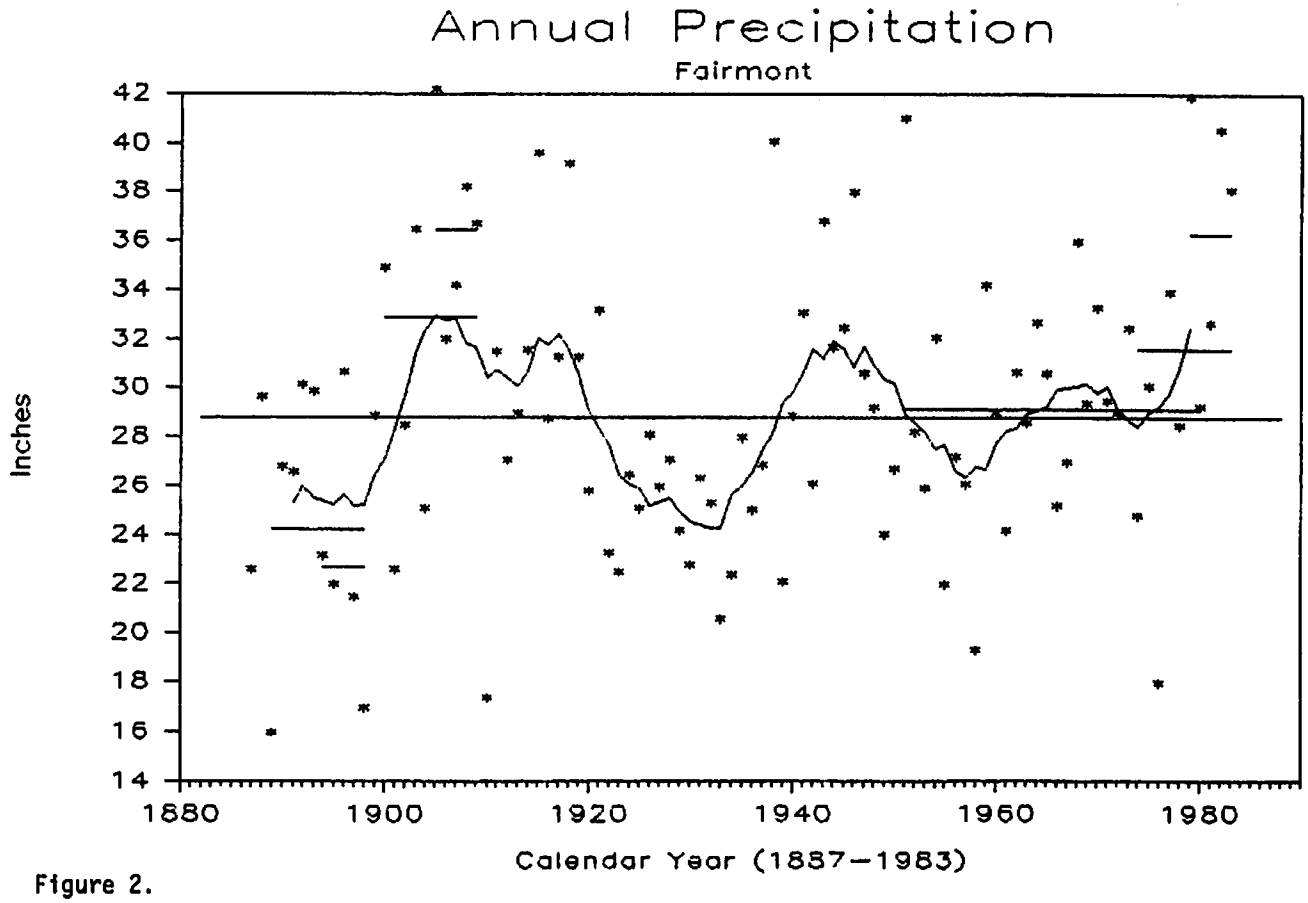


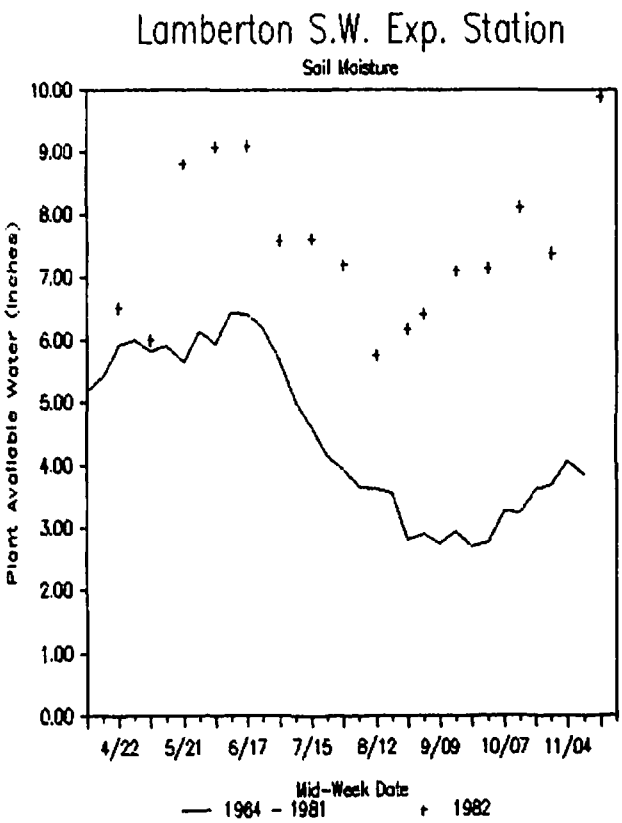
Figure 2.

SOIL MOISTURE

D.C. Baker, W.W. Nelson, G. Bardell and D.L. Ruschy

The recent precipitation increase is also evident in the soil moisture record at Lamberton, Southwest Agricultural Experiment Station. In the last three seasons, 1982-1984, Fig. 3, 4, and 5, respectively, the soil moisture has greatly exceeded the long-term average that began in 1964. The effect that these three years have had upon the long-term average is considerable: compare the 1964-1981 average with that of 1964-1984 shown in Fig. 6.

At Waseca the 1984 season did not show up as an especially wet season in terms of the soil moisture measurements as shown in Fig. 7. However, in comparing an average season at Waseca to one at Lamberton it is evident that Waseca has a wetter growing season. Not only is the total water content greater at Waseca but the Waseca soil water profile does not show the large midseason decrease in moisture supplies typical of Lamberton and western Minnesota. This very important difference between the two stations must be reflected in crop yields, since Waseca's water supplies generally remain much higher during the critical silking-tasseling and grain filling periods.



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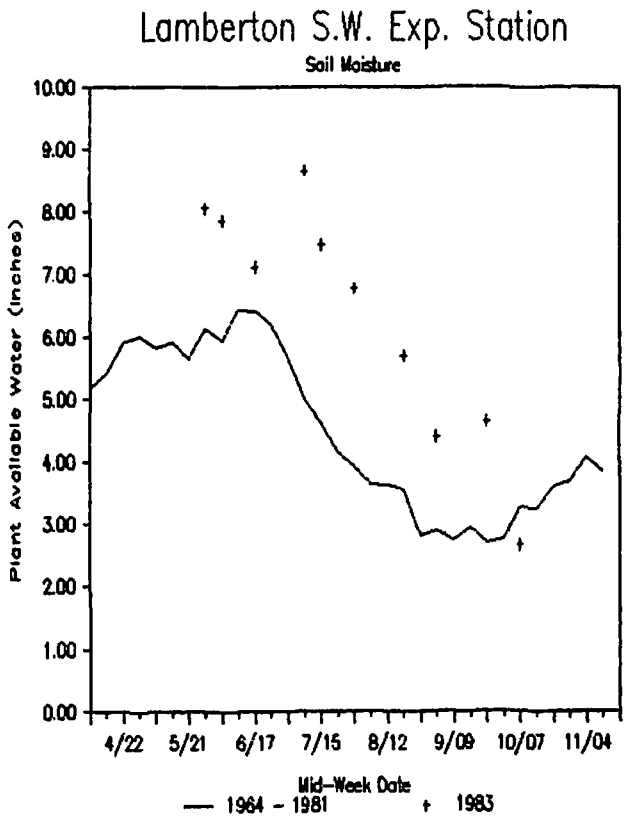

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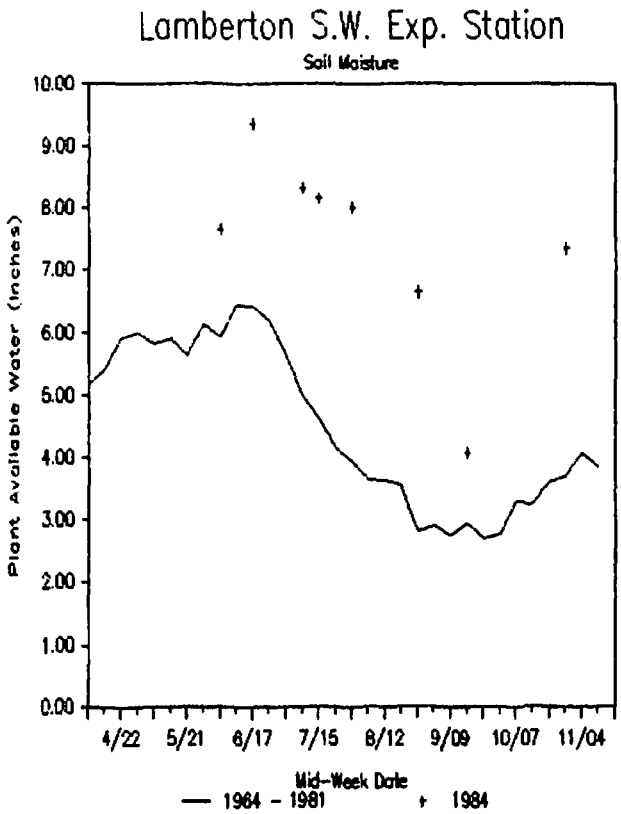

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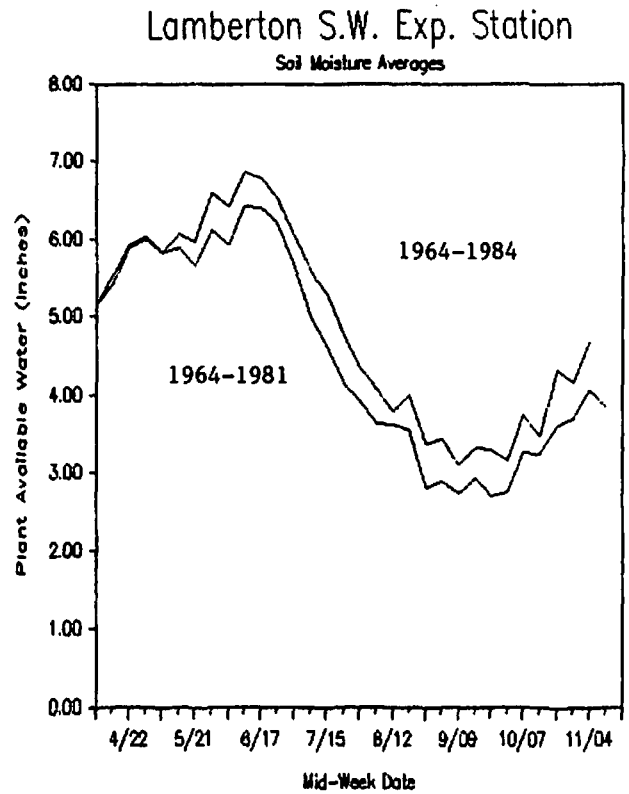

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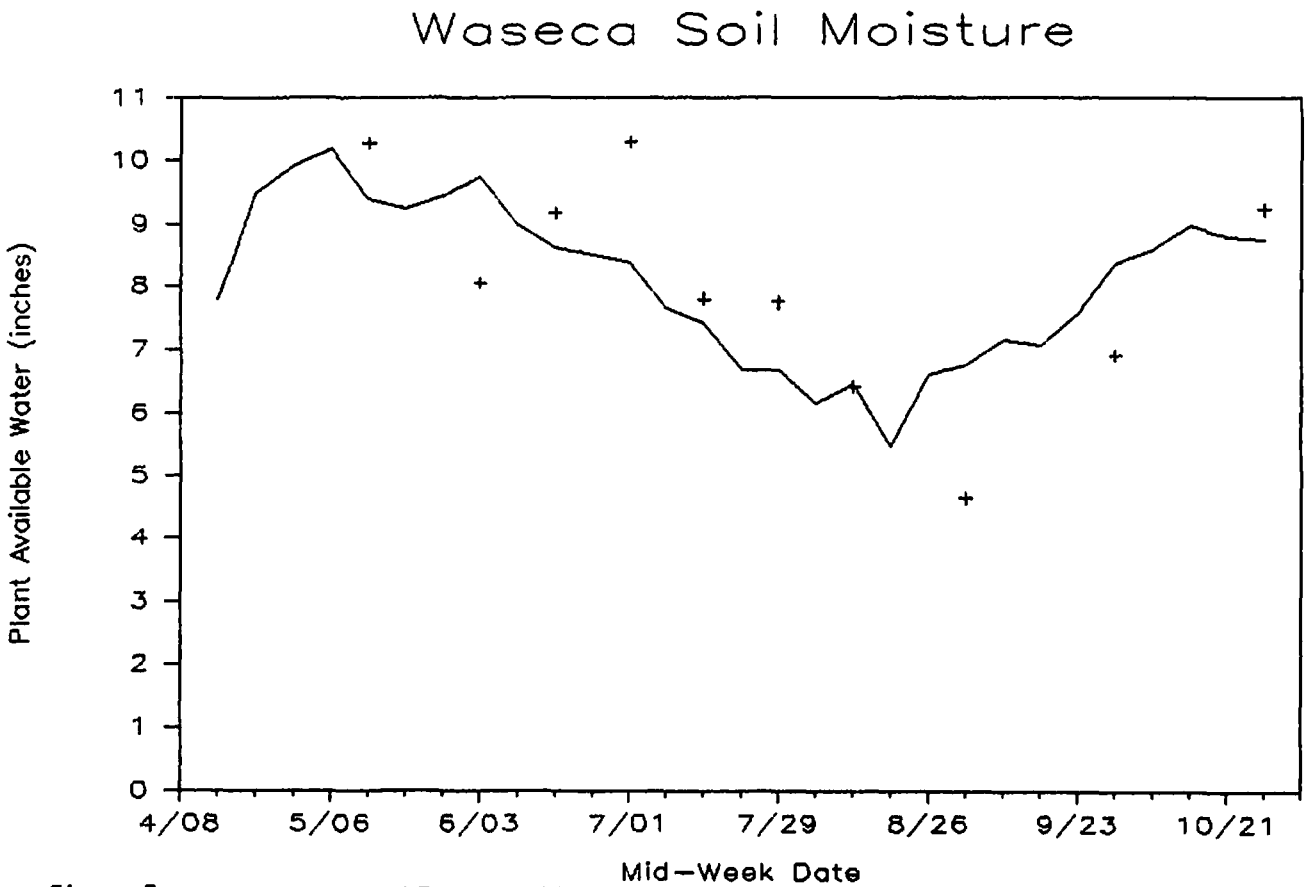


Figure 7.

The average total plant available soil water in 5 feet of soil under corn at Lamberton for the 1964-1984 period is to be seen in Fig. 8. This is similar to the generalized picture of the soil moisture profile that has been shown in previous years. It shows that on the average in the week of June 10 the maximum amount is reached and the minimum occurs on or about Sept. 9. The drawdown in soil water between these two dates (what we have termed the "grand consumption" period) amounts to about 3.90 inches. Fig. 8 also illustrates the two soil moisture recharge periods: (1) late summer and fall recharge from about Sept. 9 to soil freeze-up, which usually occurs in the first week of December, and (2) the spring recharge from soil thaw (about the first week in April) until about June 10. The fall recharge period is ordinarily greater than that of spring on agricultural soils.

Fig. 9-15 permit a more detailed examination of the soil moisture seasonal changes to be made. The seven depths represented by Fig. 9-15 are the intervals in which the 60-inch column of soil is sampled.

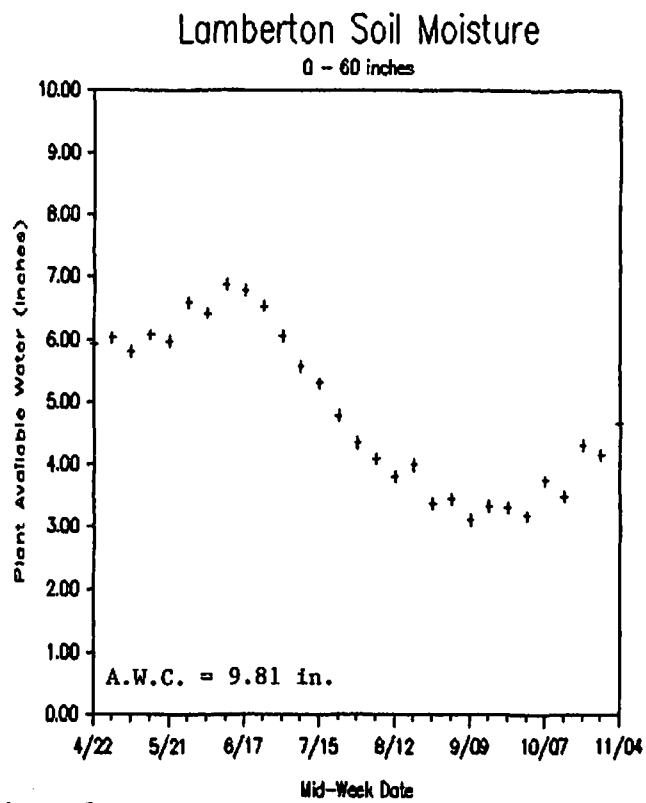
There is some indication of a lag with depth of the spring recharge. More evident, however, is the lag with depth of the time when the minimum soil moisture content is reached. The approximate dates when the maximum and minimum amount of water is reached on the average at each depth are shown in Table 2.

Table 2. Approximate dates of the maximum and minimum water content at different depths under corn at Lamberton, 1964-1984.

Depth	Date of Maximum	Date of Minimum	Interval, Days
0-6 in.	June 10	July 22	42
6-12	June 10	Aug. 26	77
12-18	June 10	Sept. 9	91
18-24	June 10	Sept. 9	91
24-36	June 17	Sept. 23	98
36-48	June 17	Oct. 7	112
48-60	June 24	Oct. 14	112

The maximum water content at each depth interval shows little variation because it is simply a matter of the rate at which the water can percolate through the soil. On the other hand, the time at which the minimum is reached is essentially a function of when the roots are able to reach a given depth as well as the movement of water (both upward and downward) to regions of lower soil water content.

A.W.C. in Figures 8 - 15 represents the plant Available Water holding Capacity.



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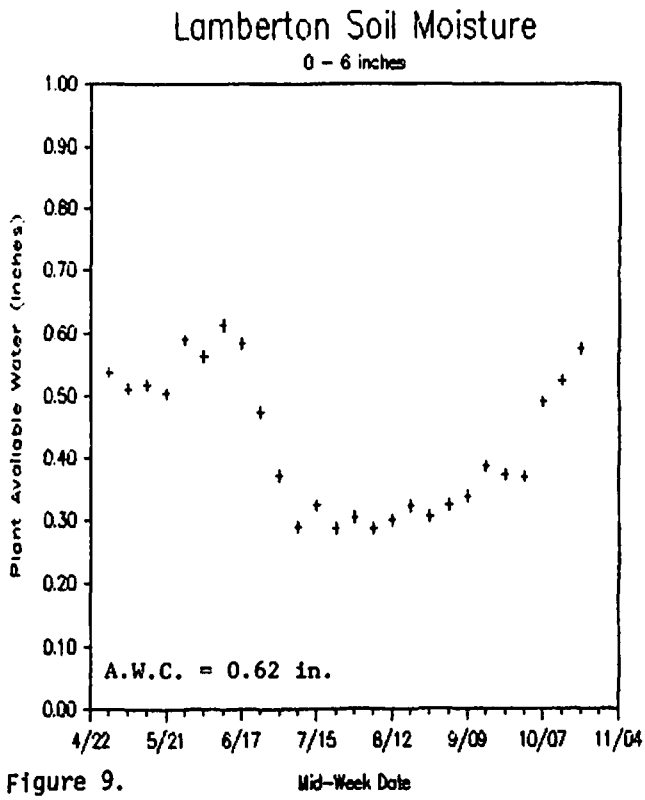

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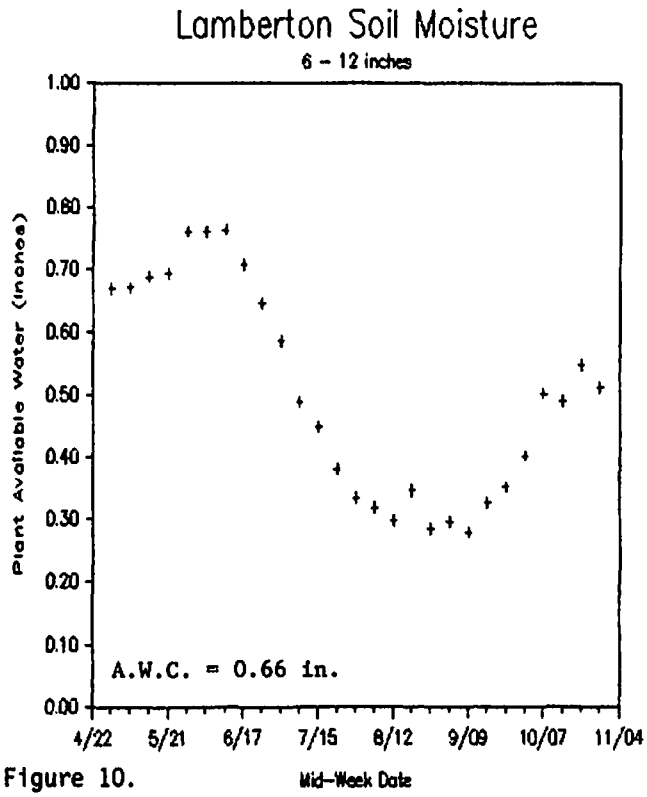

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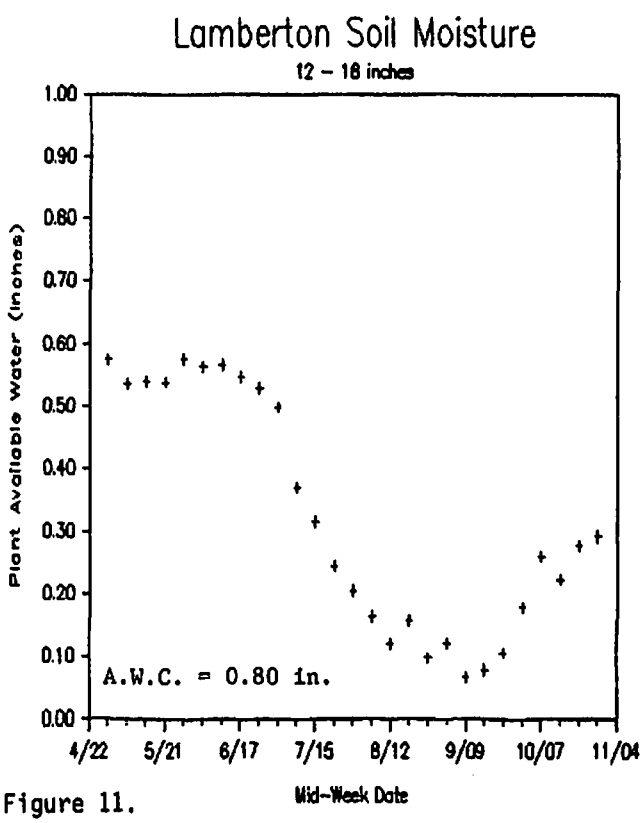

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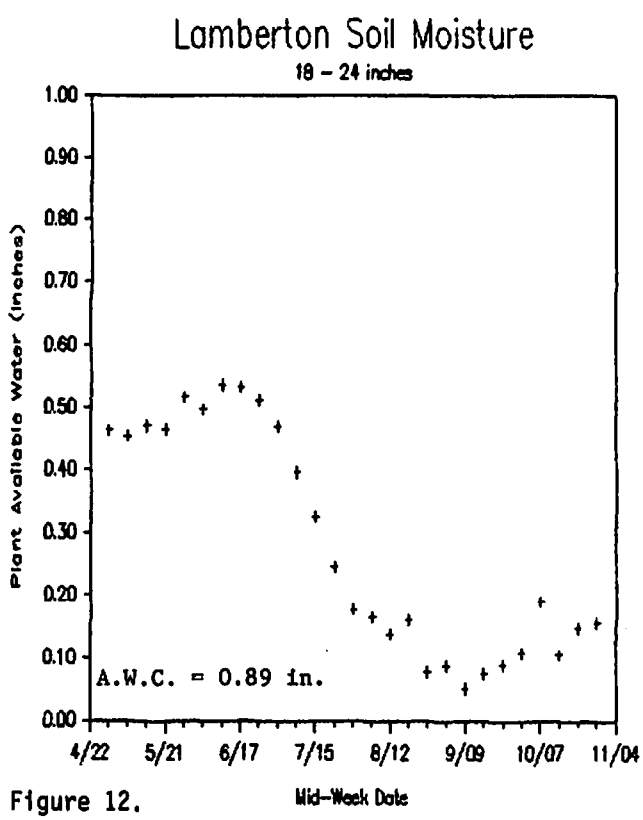

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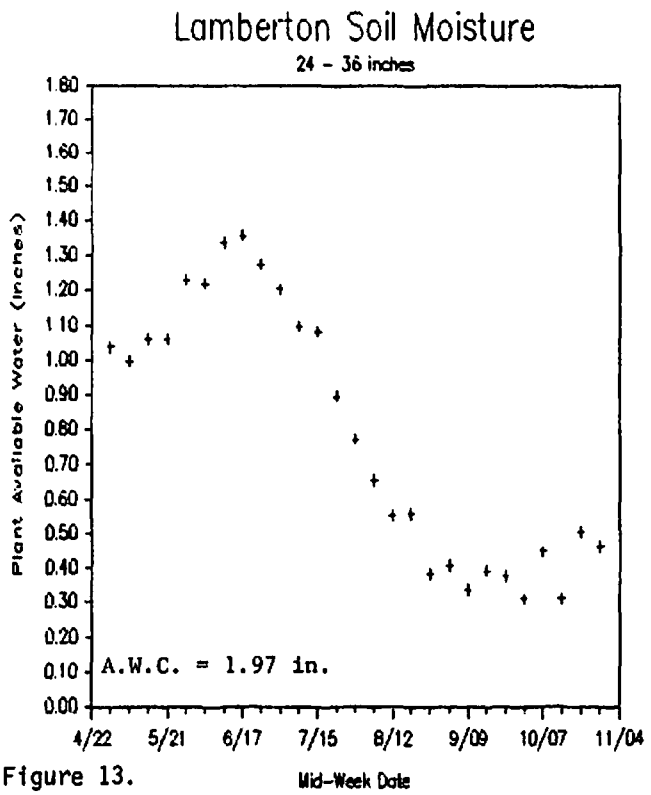

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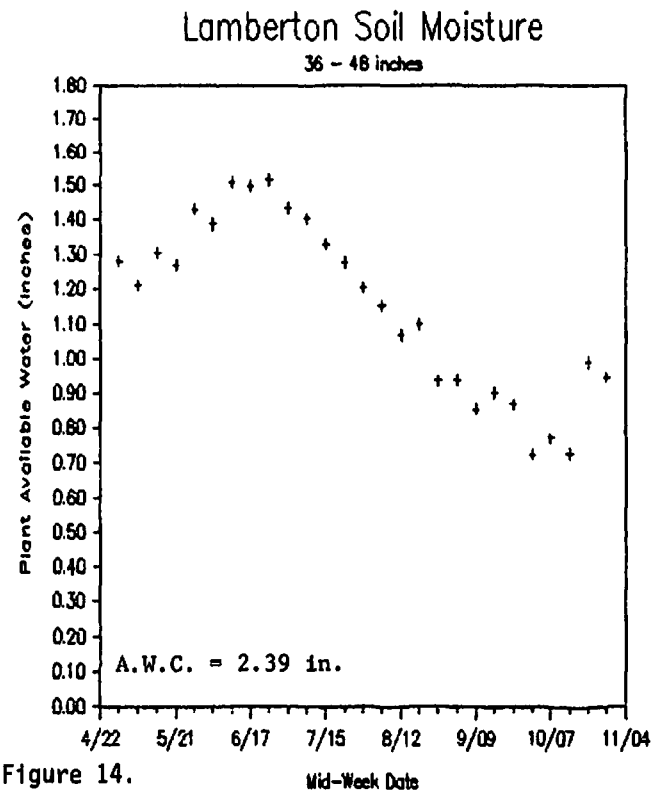

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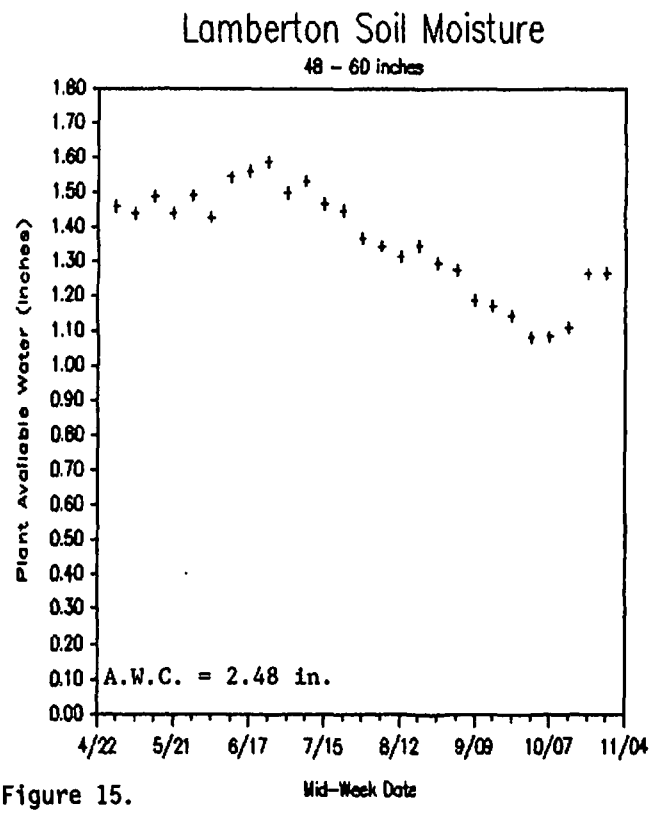

Figure 15.

SOIL MOISTURE MODELING

J.A. Zandlo, F.L. Kuehnast, D.I. Rusby, and D.G. Baker

Soil moisture is measured at only a few sites across the state. One reason for the lack of more measurements is that it is a difficult and time consuming task. As a result, there has been an attempt to develop mathematical models based on variables important to soil moisture such as precipitation and temperature. A model was developed here which permits an estimate to be made of the long-term variation in soil moisture. The results based on the long-term Minneapolis-St. Paul weather records is illustrated in Fig. 16, 17, and 18. The first two show the year by year variation in the calculated soil moisture for September 1 and November 1 of each year. The third, Fig. 18, is for the soil moisture content as of May 1 but the data have been smoothed. The smoothing permits the trends to be shown and obscures the usually distracting annual variations. The computer program which was used to prepare Fig. 16-18 was developed by Mr. James Zandlo of the State Climatology Office. Students and staff may be interested in the computer program and may contact Mr. Zandlo for the program.

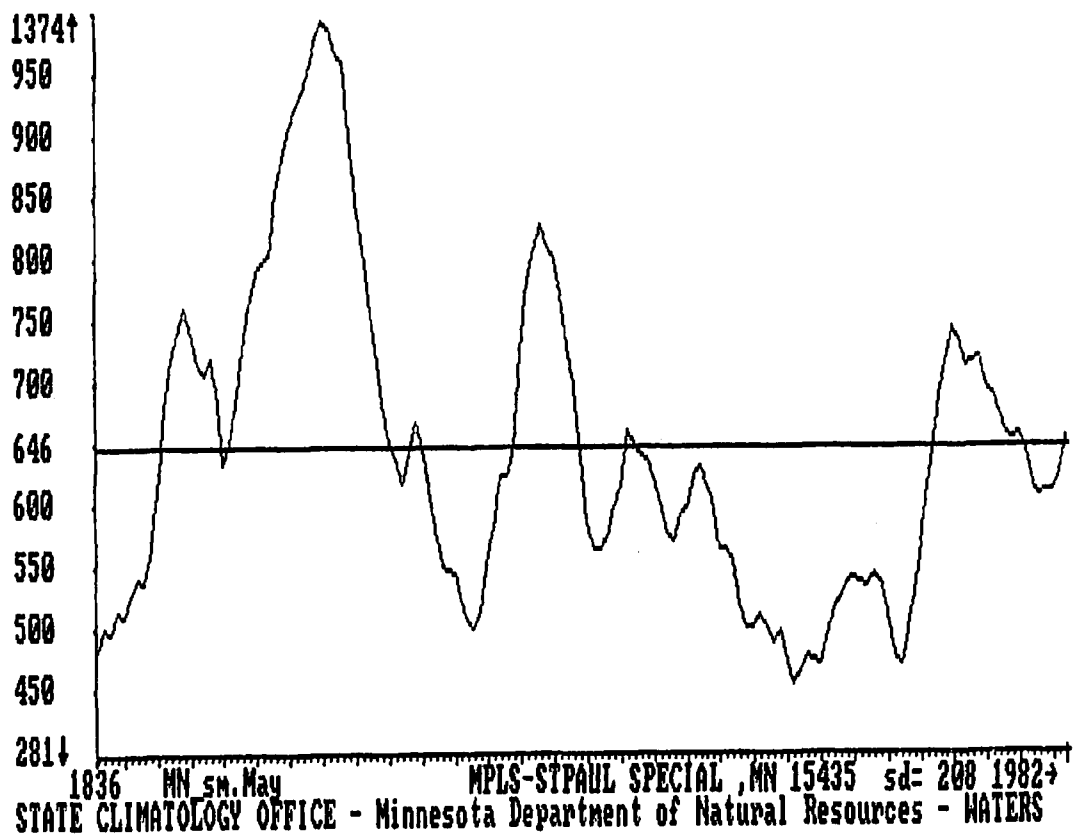

Figure 16.

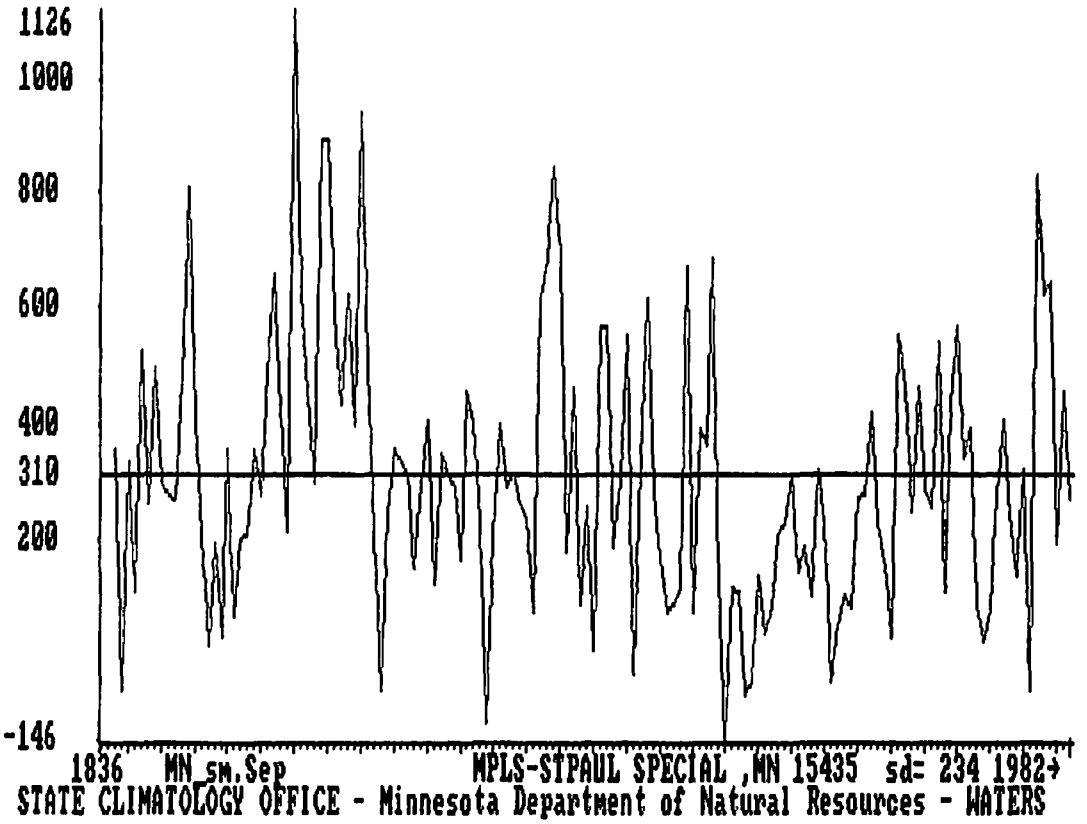

Figure 17.

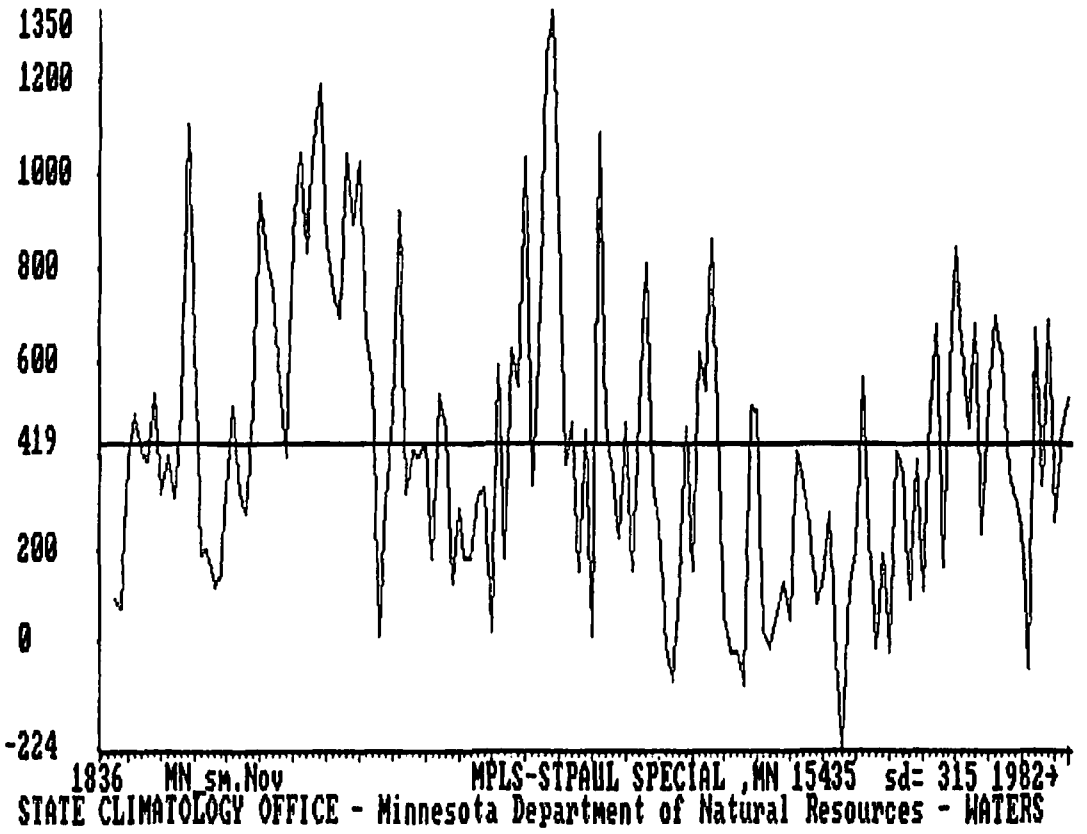

Figure 18.

THE TWIN CITY TEMPERATURE RECORD AND CLIMATIC STABILITY

L.G. Baker and D.L. Buschy

That climate is constantly changing is sometimes forgotten, and thus it is assumed to be approximately or absolutely constant. Even those of us who accept the dynamic aspect of climate sometimes forget the degree of change that has occurred in the recent past. The variation in precipitation at Minneapolis-St. Paul has already been shown in Fig. 1. In that figure the long curved line represents the general trend line with the annual variations suppressed. The temperature variation based upon the long-term Twin City record, 1820-1983, also shows marked variations, Fig. 19. A 30-year running average is shown. Two quite dramatic changes in direction of the temperature curve are shown. The temperature was declining until about 1890 when another change took place. This was an upward trend that reached a maximum in about 1960, which was succeeded by a decrease that has brought the mean down to about what it was in the 1930's.

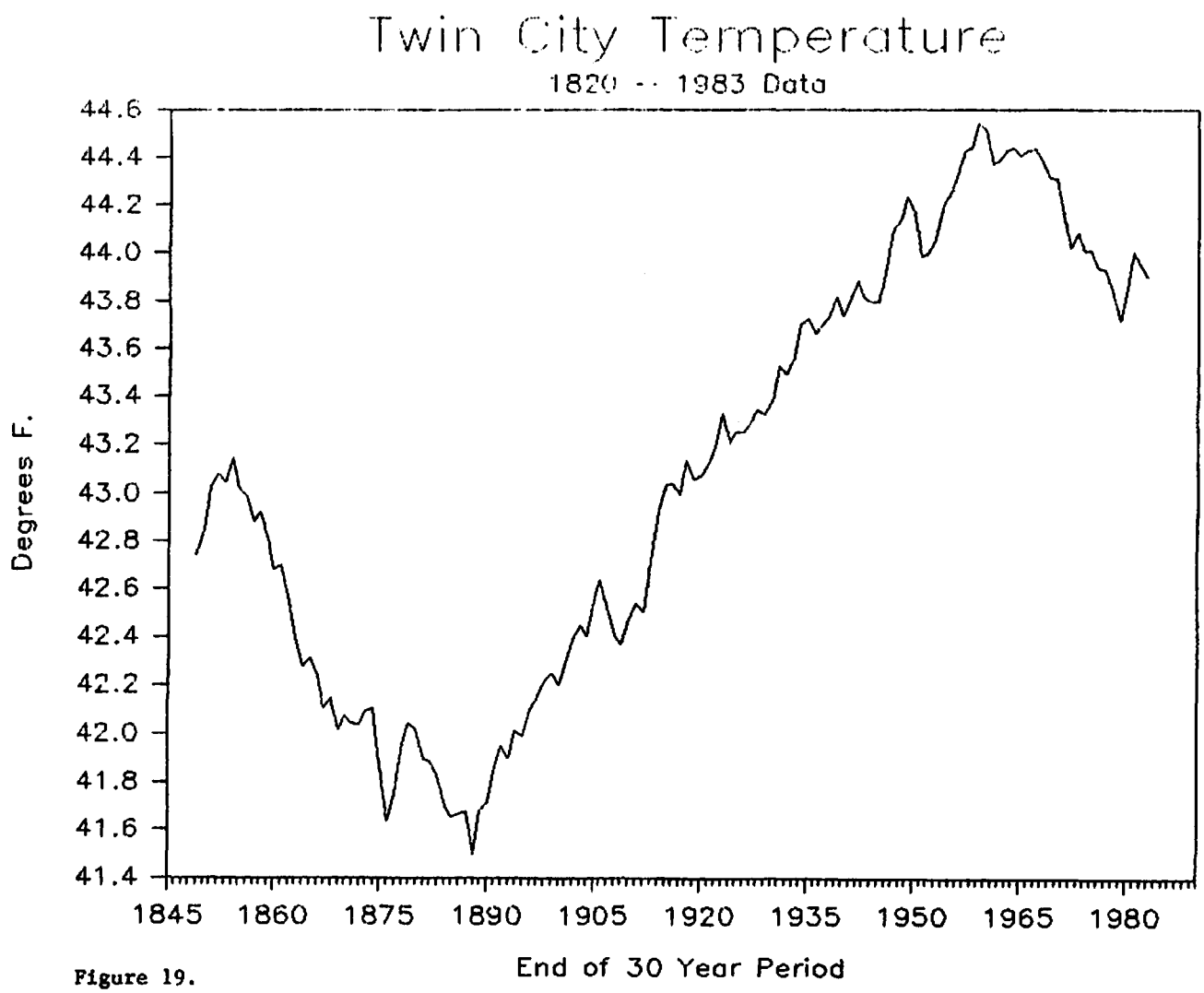

Figure 19.

Climatic anomalies (variations that appear to be out of the ordinary, an unusual event) are often difficult to pin down and verify. Some seem to be more or less legendary and might be termed "old wives' tales". Others are truly unusual events - or at least events that seem to be out of order. One is Indian summer, which is a real event that does elude a precise and quantitative definition. It does not occur every year and, of course, its duration varies from year to year. Nevertheless its occurrence is frequent enough that it is a recognized feature. Another event that has been difficult to prove but remains as something that we all seem to have heard of is the so-called January thaw. However, to be certain as to its occurrence (do we all agree on its time of occurrence: early, middle, or late January?) we must be able to define it before we can look for it in our records.

We did not have the "January thaw" in mind when we were calculating the mean daily temperature at the St. Paul campus weather station. When analyzing the 1963-1983 temperature record a marked temperature increase of about 7°F was noted centered on January 21. This is shown in Fig. 20. The same very noticeable feature was found in the Minneapolis-St. Paul airport record for the same period. In order to determine the confidence that could be placed in our finding we analyzed the Minneapolis-St. Paul record decade by decade for the 1891-1980 period. The "January thaw" could be observed in four of the nine decades. So it would appear that the "January thaw" remains an ephemeral feature in terms of its predictability. Upon occasion it apparently can be a strong and noticeable feature, but it remains inconstant and unpredictable in its appearance.

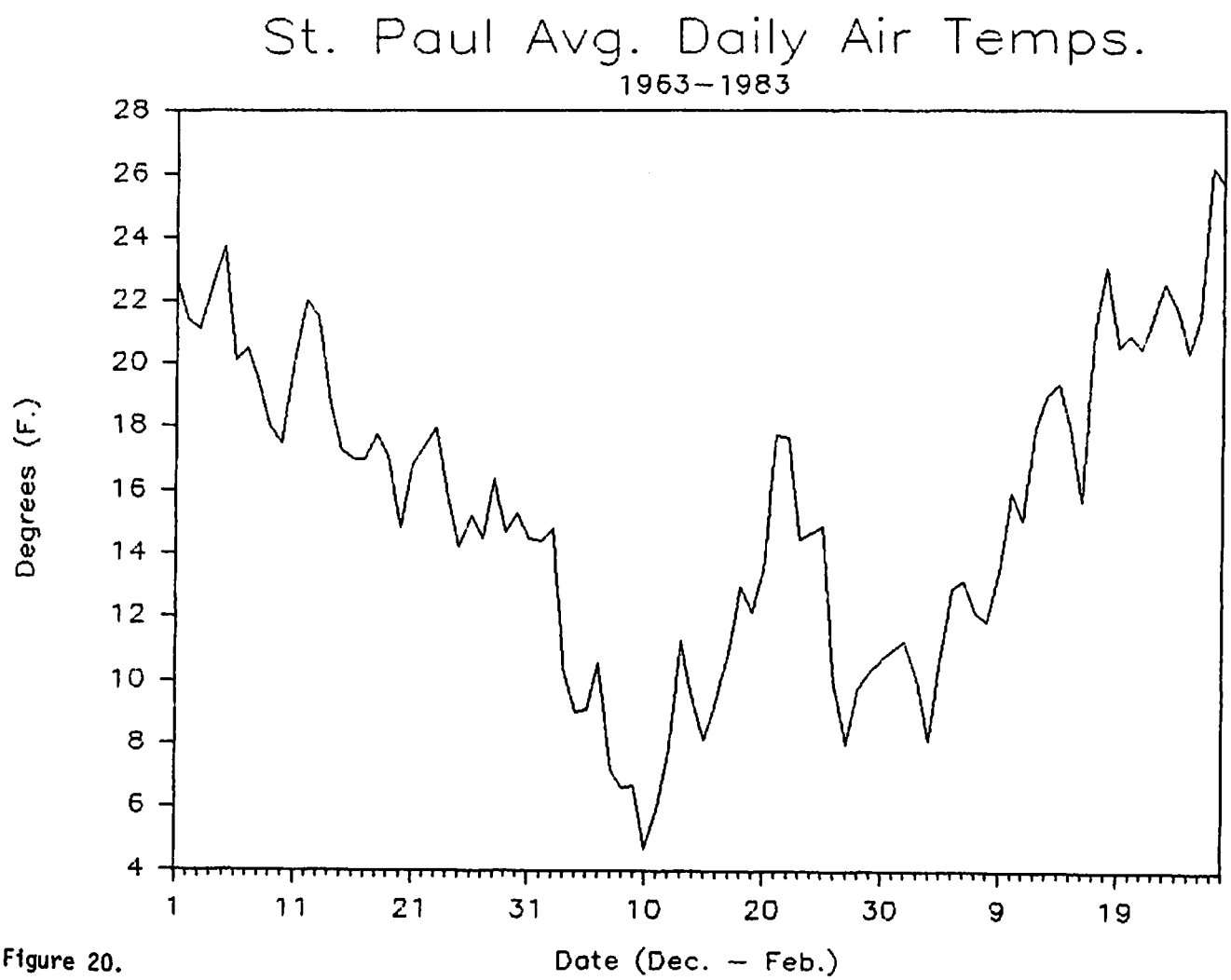

Figure 20.

AGRICULTURAL YEAR PRECIPITATION, SEPT. 1983 - AUG. 1984
E.L. Kuehnast and D.G. Baker

Based upon the long-term Lamberton soil moisture study it has become evident that the 12-month precipitation period of interest to Minnesota agriculture is not January-December, but it is September-August. This is because the soil moisture reached its minimum in late August but beginning in September the soil moisture reservoir begins to be recharged. This surplus then is not used until the next crop season. Thus the precipitation of importance to the 1984 crop was the precipitation which fell between September 1983 and August 1984.

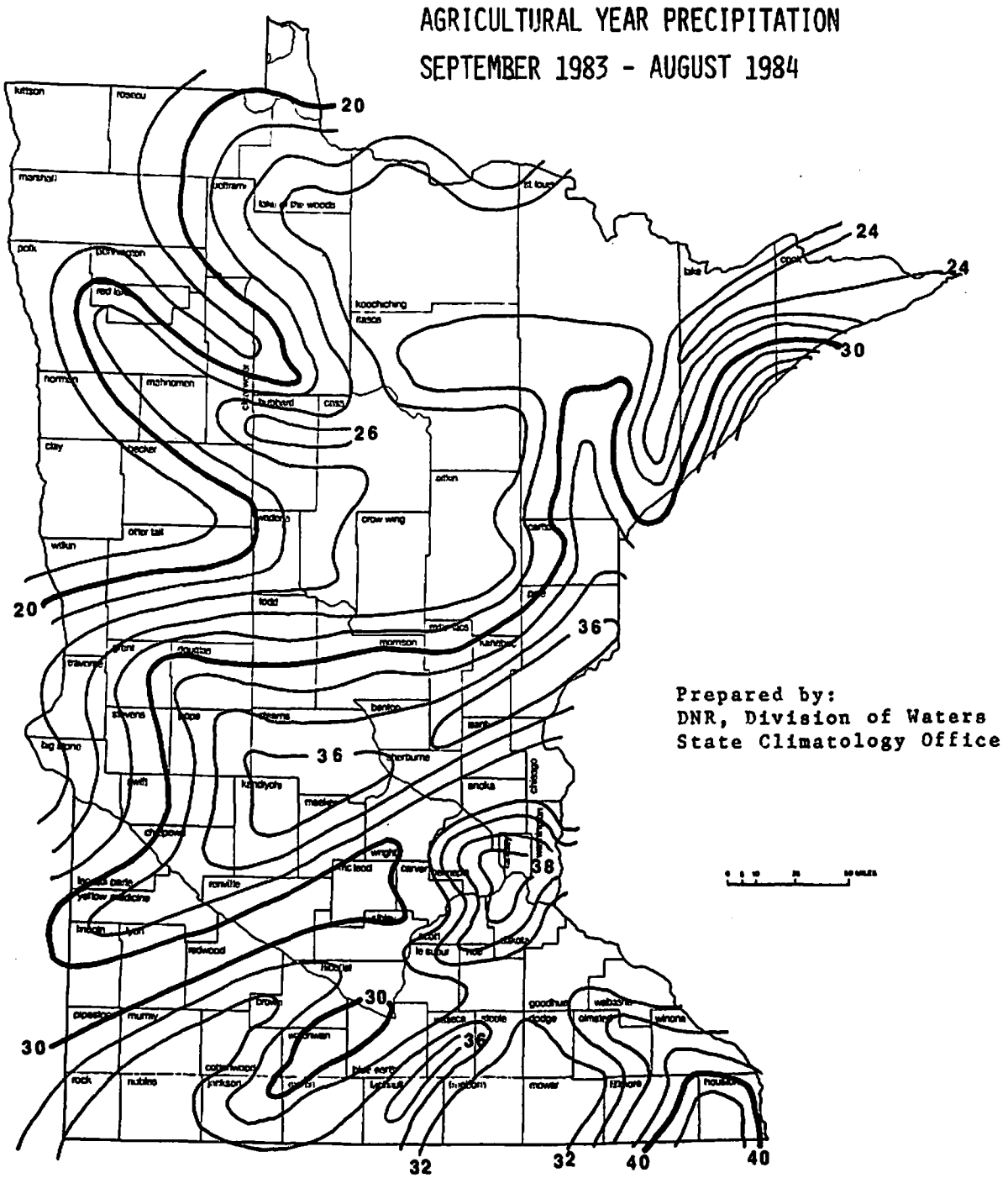

Figure 21.

It is evident from Figs. 21 and 22, which show the total annual precipitation and the departure from normal, respectively, that the southern half of the state was well supplied. Except for a small area over Waterman County in south-central Minnesota the departures from normal ranged all the way up to 8 to 10 inches in three different areas: one in the extreme southeast corner, another centered over the Twin City metropolitan area, and a third running in a narrow band from Kandiyohi County northeast to southern Pine County.

Below precipitation occurred in a large part of the northern half of the state. The driest was a small area in Pennington, Clearwater, and Beltrami counties in the northwest where the departure was at least 4 inches.

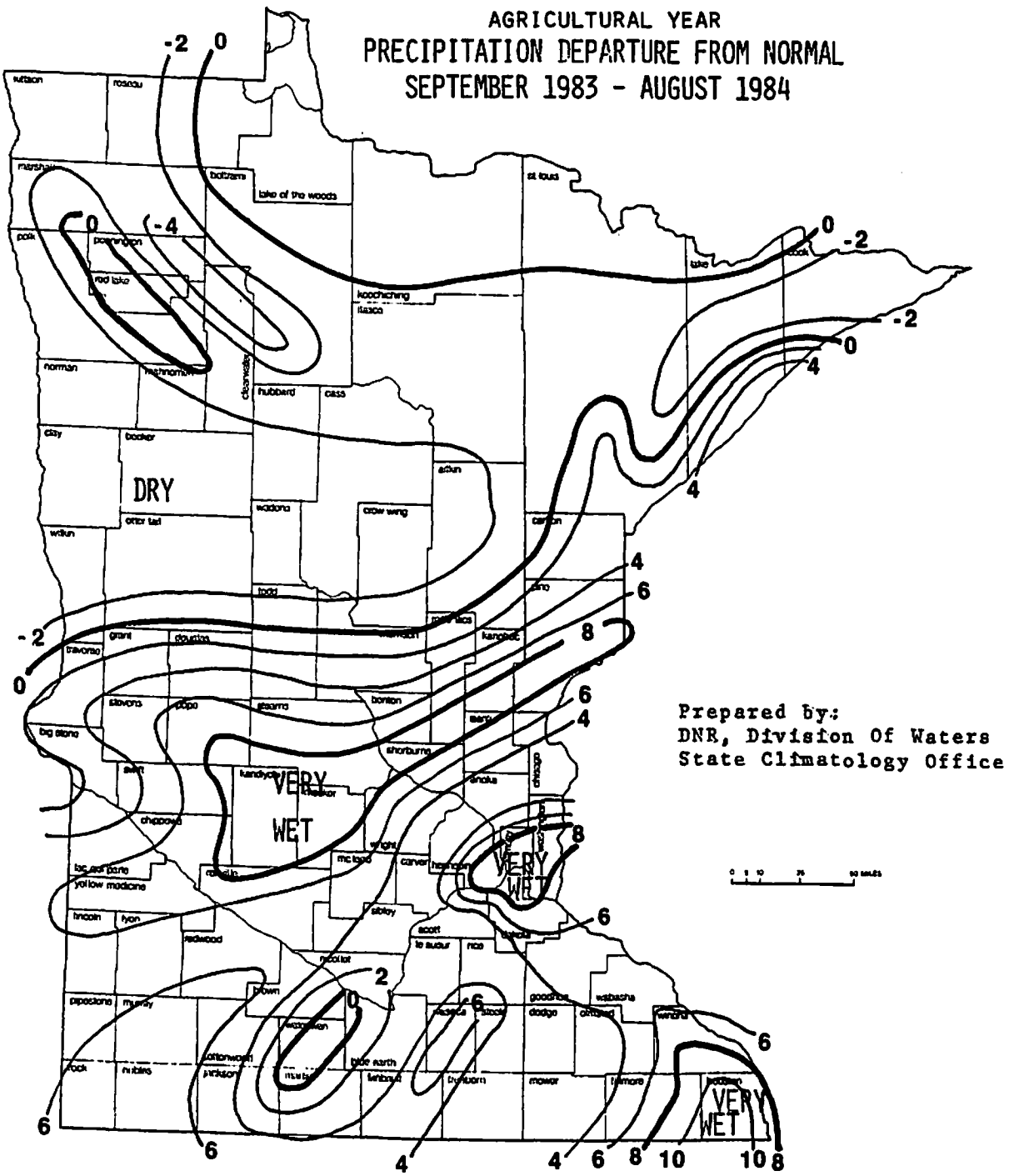

Figure 22.

SOIL MOISTURE SITUATION, SPRING 1985

E.L. Kuehnast and D.G. Baker

This report is from a mathematically modeled soil moisture analysis that is based on precipitation data. The model estimates the amount of plant available water that is contained within a 5 foot column of medium to fine textured soil. The indicated results should be adjusted according to whether the actual soil within a given area can hold more (a heavy or clay soil) or less (a light or sandy soil) than the basic 10 inches.

Areas with 10 inches or more of soil moisture in Fig. 23 are considered to be at or near their maximum water holding capcity. Soils in the 8 to 10 inch areas will be near maximum capacity with normal spring rains. Thus, all of Minnesota except the northwest is expected to have soils at their maximum capacity this spring. The areas with normal to slightly above normal soil moisture conditions are Kittson, Marshall, Pennington and Clay and parts of Roseau, Red Lake, Polk, Norman and Wilken counties.

The difference between the spring of 1984 versus 1985 is that last year the soils did not freeze because of the exceptionally heavy early snow cover. Thus the soil water from the upper layers percolated into the sub-soils all winter (W.W. Nelson, University of Minnesota, Southwest Experiment Station, stated that the "drainage tiles ran all winter"). This year is almost the reverse with little to no snow cover through December and minimum snow cover into February. This has resulted with deep frost depths of more thatn 24 inches across the state by February 1, 1985. Within the wet frozen soils there can be no percolation and most of the snow melt water and even the rains that may occur during snow melt will be lost as runoff. As a result there will be little change in the soil moisture conditions between the time of soil freeze-up and this spring's thaw period.

This is the fourth spring in a row, as a whole, across Minnesota there will be high soil moisture conditions. The question is, what affect does this have on spring planting? The mean date in Minnesota when 50% of the corn was planted in the last 10 years was the 13th of May. The five wet springs of the last 10 years were 1978, 1979, 1982, 1983 and 1984 and the 50% corn plant dates for Minnesota were May 16, May 23, May 13, May 18, May 17, respectively. (All planting dates - Federal Crop Reporting Service). Interpretation of these data show an average of about 5 days delay in planting, which also extended the maturity date about 5 days from 20th September to about the 25th of September. By extending the maturity 5 days it approximated 2 to 3% additional corn moisture at harvesting.

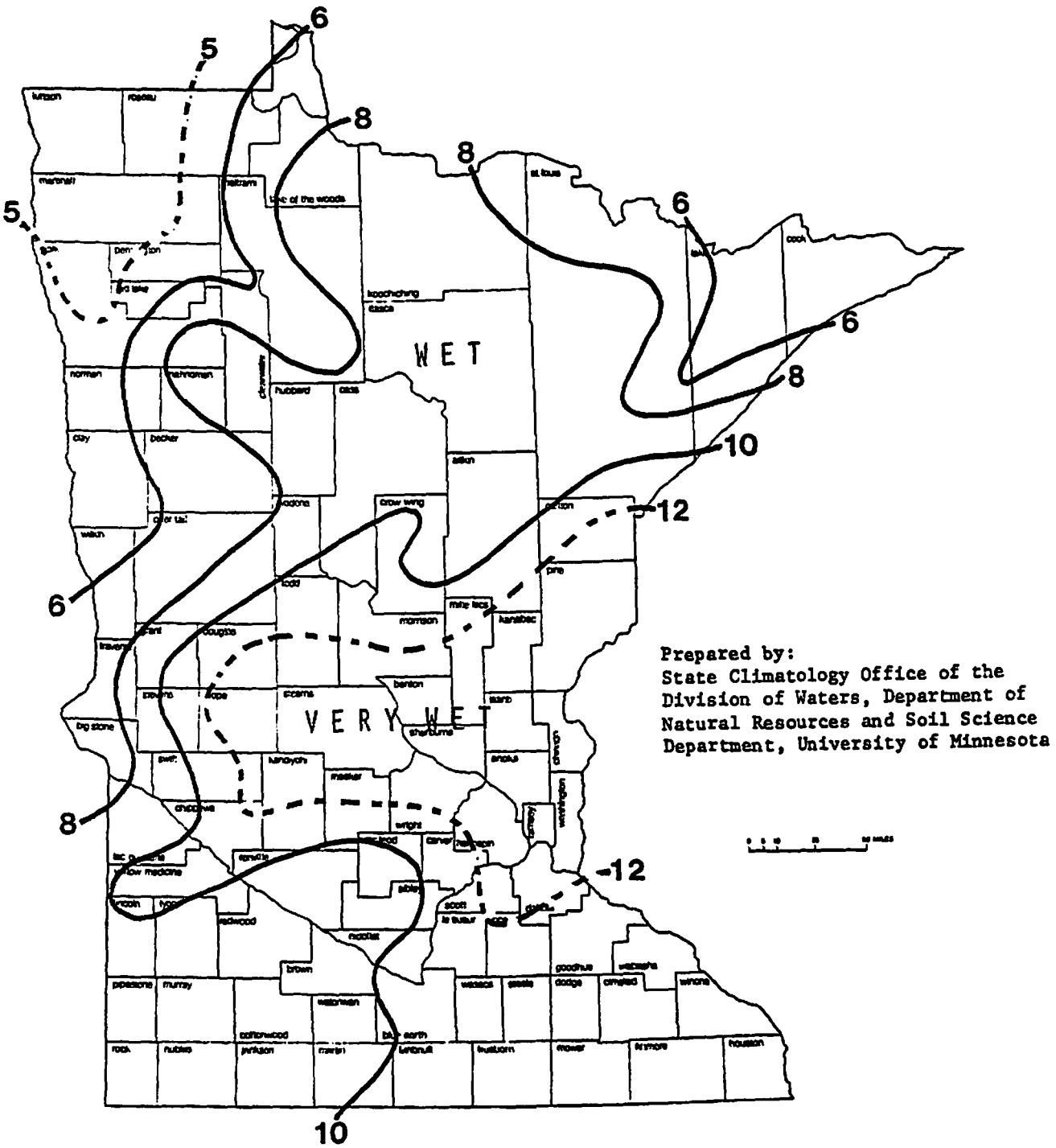

Figure 23. Plant available soil moisture on November 1, 1984 expressed in inches for the top five feet of medium to fine textured soils. Data derived from a soil moisture model based on precipitation data only.

INFLUENCE OF NITROGEN FORM, NITROGEN RATE, TIMING OF NITROGEN APPLICATION AND NITRIFICATION INHIBITORS FOR IRRIGATED CORN - BECKER, MN 1984

G.L. Malzer and T. Graff

Nitrogen management on the coarse textured irrigated soils of Minnesota is a major decision that all corn growers must make in their production system. Nitrogen management includes many aspects of nitrogen fertilization such as rates, forms, methods, times, equipment, and additives. Nitrogen fertilizer application is an essential component for top yields on these coarse textured soils, and many times the producer does not have the flexibility in nitrogen management that a producer on a finer textured soil might have. The use of nitrification inhibitors under irrigation also presents some new nitrogen management techniques that should be considered. The most common method for application of nitrification inhibitors is with simultaneous application of anhydrous ammonia. Under irrigation, nitrogen application may take place in several manners, ranging from one single application to multiple application, which may be facilitated through the irrigation water. With such management systems a variety of fertilizer nitrogen forms may be utilized. These management alternatives often add to the cost of production and require a reasonable amount of timeliness to avoid yield reductions. A new trial was established in 1982 to evaluate the significance of nitrogen rates, nitrogen form, timing of nitrogen application and the use of nitrification inhibitors for irrigated corn production.

Experimental Procedures

An experiment consisting of 25 treatments, with four replications was arranged in a randomized complete block design and established at the Sand Plain Research Farm near Becker, Minnesota. Variables in the experiment consisted of three nitrogen rates (0, 84, 168 kg/ha), three nitrogen sources (anhydrous ammonia, urea and 28% nitrogen solution), two types of application (preplant or sidedress at 10-leaf growth stage) and three nitrification inhibitors (none, N-Serve and DCD). Due to the different types and rates of material utilized, the experiment was not conducted in a complete factorial arrangement. Modifications include: 1) Nitrification inhibitor treatments were applied only with preplant N applications; 2) only 28% N solutions and anhydrous ammonia were applied as sidedress N application; 3) N-Serve applications were made at 0.56 kg/ha rate of application; 4) the DCD treatments were applied as a percentage of the total N applied. Urea and 28% N solution were applied at rates of 10% DCDN while anhydrous ammonia was applied at a rate of 2.5% and 5% N as DCD. Urea was supplied by SKW containing 10% DCDN, applications of DCDL were made to 28% N solution and DCDG to anhydrous ammonia to obtain the appropriate concentration of DCDN.

Prior to planting, broadcast application of potassium-magnesium sulfate (336 kg/ha 0-0-22), potassium (252 kg/ha 0-0-60), and phosphorus (112 kg/ha 0-46-0) were made and incorporated by plowing. Nitrogen applications were made prior to planting (May 2nd) and at the 10-leaf stage of growth (June 21st). Corn (Pioneer 3906 - 95 relative maturity) was planted on May 3rd in .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 Lasso (2.24 kg/ha) was applied on May 4th for weed control. The insecticide Lorsban was applied through the irrigation system on July 11th at the rate of 8.12 kg/ha for corn bore control.

Leaf samples from opposite and below the ear at mid-silking were obtained on July 19th, dried and analyzed for Kjeldahl nitrogen. Total dry matter production and final yields were determined on September 19th by hand harvesting 11.6 m^2 of plot area. Ears were separated from the stalks, field weights of each obtained, and samples removed for moisture and nitrogen determination. Grain yields were adjusted to 15.5% moisture.

The irrigation program was started on June 28th and continued through September 5th with a total of 31.4 cm being applied through irrigation. An additional 46.2 cm of water was obtained during the growing season as rainfall. Large rainfall events were received in mid-June and were responsible for significant leaching of nitrate-N especially with some of the treatments applied early in the season.

General Results

The experimental results and statistical analysis are presented in Tables 1 and 2. Due to the incomplete factorial nature of the treatments the statistical analysis was conducted utilizing several different combinations of the treatments. The different methods included: 1) mean

comparison of the 25 treatments, and factorial combinations including 2) two nitrogen rates with three nitrogen forms with and without N-Serve, 3) two N rates with two N forms applied at two different times of application, 4) two N rates with four nitrification inhibitor treatments applied with anhydrous ammonia, and 5) two N rates with three nitrification inhibitor treatments with urea.

The information included in Tables 1 and 2 present information regarding grain, stover, and total dry matter production as well as N concentrations within the plant parts and N removal. This brief discussion will include evaluation of only grain yields.

The leaching losses of nitrate-N associated with many of the early spring N applications were extremely severe at this location in 1984. This is primarily the result of the major precipitation event that occurred approximately five weeks after the early N applications. This time period allowed for substantial nitrification of ammonium-N to nitrate-N so relatively large quantities of nitrate were lost by leaching. The extent of N loss on yield reduction can be evaluated by comparing the yields associated with preplant N applications with treatments applied at the 10-leaf stage of growth.

Nitrogen rate - Grain yields was significantly (.05) increased up through the highest rate of N application (168 kg/ha). This would be expected since the highest N rate is slightly lower than the currently recommended rate of application. The factorial combinations for grain yield indicated significant interactions for rate x form, rate x time, rate x inhibitor, and rate x form x time. The number of interactions reflect the complexity of nitrogen rate as a component of nitrogen management. The rate x form interaction suggests that yields obtained with urea and 28% N solution were reduced dramatically at both N rates while anhydrous ammonia did not reflect as much N loss at the higher rate of N application. The rate x time of application interaction suggested that N losses were more severe at the low N rate than at the higher N rate. This would suggest that the conversion of ammonium-N to nitrate-N probably took place faster under the lower rate of N application. The N rate x inhibitor interaction would suggest that DCD performed better across N rates than did N-Serve. N-Serve demonstrated yield increases at the higher N rate, but provided minimal influence at the low N rate. The inhibitor DCD provided yield increases at both N rates.

Nitrogen Form - When nitrogen losses are minimal, different N fertilization sources would tend to provide similar results. However, in 1984 leaching losses due to mid-season precipitation were very severe. Under these conditions anhydrous ammonia was superior to the other nitrogen sources. Broadcast forms of fertilizer N such as urea and 28% solution produced similar results. Although urea is 100% ammonium forming, it is possible that differential nitrification due to method of application (broadcast incorporated vs. injected ammonia) coupled with the mid-season leaching events were responsible for the observed results.

Nitrification inhibitors - All nitrification inhibitors tested provided significant positive yield increases. At the low N rate DCD was the most effective inhibitor across all three N sources tested. At the higher N rate N-Serve and DCD provided similar results when used with anhydrous ammonia (both were effective in reducing N loss). The product DCD was clearly superior to N-Serve at the higher N rate when used with urea and 28% N solution.

Table 1. Influence of N form, N rates, nitrification inhibitors, and timing of application on yield grain, and dry matter production on irrigated corn Becker, MN - 1984.

Treatments				Grain Yields		Dry Matter Production		
N-Rates	N-Form	Inhibitor	Time			Grain	Stover	Total
kg/ha				Bu/A	mt/ha	----------mt/ha----------		
Control	------	---------	-----	57.6	3.62	3.04	3.00	6.04
84	AA	---------	PPL	98.3	6.18	5.20	5.35	10.57
84	AA	---------	10-lf	147.0	9.24	7.79	5.80	13.59
84	28%	---------	PPL	69.8	4.34	3.69	3.33	7.03
84	28%	---------	10-lf	99.1	6.23	5.24	4.75	9.99
84	UREA	---------	PPL	65.4	4.11	3.45	3.65	7.12
84	AA	N-Serve	PPL	92.6	5.82	4.90	5.06	9.97
84	28%	N-Serve	PPL	71.7	4.51	3.78	4.03	7.84
84	UREA	N-Serve	PPL	77.7	4.89	4.12	4.48	8.60
168	AA	---------	PPL	135.3	8.51	7.17	6.58	13.75
168	AA	---------	10-lf	169.9	10.68	9.00	6.27	15.27
168	28%	---------	PPL	72.9	4.58	3.85	3.92	7.77
168	28%	---------	10-lf	148.1	9.31	7.84	5.87	13.73
168	UREA	---------	PPL	58.3	3.67	3.09	3.06	6.16
168	AA	N-Serve	PPL	161.1	10.13	8.53	7.10	15.63
168	28%	N-Serve	PPL	75.5	4.75	3.99	4.55	8.55
168	UREA	N-Serve	PPL	88.4	5.56	4.68	5.67	10.35
84	UREA	10% DCDN	PPL	96.1	6.04	5.08	5.39	10.50
84	AA	2.5% DCDG	PPL	125.8	7.91	6.63	6.56	13.24
84	AA	5% DCDG	PPL	129.3	8.13	6.85	6.65	13.51
84	28%	10% DCDL	PPL	93.4	5.87	4.95	5.08	10.06
168	UREA	10% DCDN	PPL	176.6	11.11	9.34	7.84	17.20
168	AA	2.5% DCDG	PPL	166.7	10.48	8.82	7.21	16.04
168	AA	5% DCDG	PPL	164.8	10.36	8.74	7.43	16.19
168	28%	10% DCDL	PPL	104.0	6.35	5.51	5.71	11.22
P-Value				99	99	99	99	99
BLSD (.05)				13.2	0.83	0.69	0.74	1.32
Factorial Arrangement (N-Rate X N-Form X Inhibitor)								
N-Rate								
84				79.3	4.99	4.19	4.32	8.53
168				98.6	6.20	5.21	5.15	10.63
P-Value				99	99	99	99	99
N-Form								
AA				121.8	7.66	6.45	6.02	12.47
28%				72.5	4.56	3.83	3.96	7.79
UREA				72.4	4.55	3.83	4.21	8.06
P-Value				99	99	99	99	99
Inhibitor								
Control				83.3	5.23	4.41	4.32	8.73
N-Serve				94.5	5.94	4.99	5.15	10.17
P-Value				99	99	99	99	99
Rate X Form				99	99	99	97	99
Rate X Inhibitor				98	98	98	96	98
Form X Inhibitor				93	93	93	99	97
Rate X Form X Inhibitor				84	84	84	82	78

Table 1 continued on next page

Table 1 continued

Treatments N-Rate	N-Form	Inhibitor	Time	Grain Yield		Dry Matter Production Grain	Stover	Total
kg/ha				Bu/A	mt/ha	----------mt/ha----------		
Factorial Arrangement (N-Rate X N-Form X Time)								
N-Rate								
84				103.6	6.51	5.49	4.82	10.30
168				131.5	8.27	6.97	5.67	12.63
P-Value				99	99	99	99	99
N-Form								
AA				137.6	8.65	7.28	6.00	13.30
28%				97.5	6.13	5.15	4.46	9.63
P-Value				99	99	99	99	99
Time								
PPL				94.1	5.92	4.97	4.79	9.79
10-lf				141.0	8.87	7.46	5.67	13.15
P-Value				99	99	99	99	99
Rate X Form				39	39	39	2	20
Rate X Time				95	95	95	16	68
Form X Time				83	83	83	99	99
Rate X Form X Time				99	99	99	83	99
Factorial Arrangement (N-Rate X Inhibitor with AA)								
N-Rate								
84				111.1	6.99	5.91	5.91	11.83
168				157.0	9.87	8.31	7.08	15.41
P-Value				99	99	99	99	99
Inhibitor								
Control				116.8	7.34	6.18	5.96	12.16
N-Serve				126.9	7.98	6.72	6.07	12.81
2.5% DCDG				146.3	9.20	7.75	6.88	14.45
5% DCDG				147.1	9.25	7.79	7.03	14.85
P-Value				99	99	99	99	99
DLSD (.05)							0.65	
N-Rate X Inhibitor				99	99	99	83	97
Factorial Arrangement (N-Rate X Inhibitor with Urea)								
N-Rate								
84				79.7	5.01	4.21	4.50	8.74
168				107.8	6.78	5.71	5.53	11.24
P-Value				99	99	99	99	99
Inhibitor								
Control				61.8	3.89	3.27	3.36	6.63
N-Serve				83.1	5.23	4.39	5.06	9.47
10% DCDN				136.3	8.57	7.21	6.63	13.86
P-Value				99	99	99	99	99
N-Rate X Inhibitor				99	99	99	99	99

Table 2. Influence of N form, N rates, nitrification inhibitors, and timing of N application on leaf N content grain N content and total N removal by irrigated corn. Becker, MN - 1984

Treatments				N-Concentration			N-Removal		
N-Rates	N-Form	Inhibitor	Time	Leaf	Grain	Stover	Grain	Stover	Total
kg/ha				----------%----------			----------kg/ha---------		
Control	------	---------	-----	1.39	1.22	0.50	37.4	15.0	52.4
84	AA	---------	PPL	1.91	1.11	0.39	58.0	21.3	79.4
84	AA	---------	10-lf	2.83	1.29	0.53	100.5	30.9	131.5
84	28%	---------	PPL	1.49	1.20	0.49	44.7	16.5	61.1
84	28%	---------	10-lf	2.34	1.13	0.46	59.6	22.2	81.8
84	UREA	---------	PPL	1.39	1.08	0.43	37.5	15.8	53.4
84	AA	N-Serve	PPL	2.00	1.23	0.43	60.6	21.7	82.3
84	28%	N-Serve	PPL	1.20	1.11	0.41	42.2	16.6	58.9
84	UREA	N-Serve	PPL	1.39	1.18	0.43	49.0	19.5	68.6
168	AA	---------	PPL	2.50	1.21	0.47	86.9	31.6	118.5
168	AA	---------	10-lf	2.89	1.54	0.55	140.0	34.7	173.8
168	28%	---------	PPL	1.48	1.12	0.44	43.0	17.1	60.2
168	28%	---------	10-lf	2.64	1.39	0.61	109.3	35.9	145.4
168	UREA	---------	PPL	1.49	1.22	0.49	37.9	15.2	53.3
168	AA	N-Serve	PPL	2.60	1.26	0.54	108.4	38.5	146.9
168	28%	N-Serve	PPL	1.56	1.20	0.41	47.9	18.6	66.6
168	UREA	N-Serve	PPL	1.73	1.09	0.39	51.3	22.6	73.8
84	UREA	10% DCDN	PPL	1.55	1.16	0.41	59.5	22.5	80.3
84	AA	2.5% DCDG	PPL	2.22	1.22	0.41	81.7	26.7	108.5
84	AA	5% DCDG	PPL	2.35	1.23	0.43	85.5	28.6	114.3
84	28%	10% DCDL	PPL	1.15	1.19	0.41	58.6	21.0	79.6
168	UREA	10% DCDN	PPL	2.61	1.35	0.49	126.7	39.3	165.9
168	AA	2.5% DCDG	PPL	2.80	1.33	0.41	118.2	29.4	147.7
168	AA	5% DCDG	PPL	2.58	1.39	0.49	121.5	37.1	158.7
168	28%	10% DCDL	PPL	1.73	1.11	0.43	61.8	24.5	86.3
P-Value				99	99	99	99	99	99
BLSD (.05)				0.28	0.10	0.09	11.2	6.3	14.8
Factorial Arrangement (N-Rate X N-Form X Inhibitor)									
N-Rate									
84				1.56	1.15	0.43	48.7	18.6	67.3
168				1.89	1.18	0.46	62.6	23.8	86.6
P-Value				99	86	94	99	99	99
N-Form									
AA				2.25	1.20	0.46	78.5	28.2	106.8
28%				1.43	1.15	0.43	44.4	17.2	61.7
UREA				1.50	1.14	0.44	44.0	18.2	62.3
P-Value				99	92	67	99	99	99
Inhibitor									
Control				1.71	1.16	0.45	51.4	19.6	71.0
N-Serve				1.74	1.18	0.43	59.9	22.9	82.9
P-Value				43	62	80	99	99	99
Rate X Form				98	48	99	99	99	99
Rate X Inhibitor				89	43	23	94	89	95
Form X Inhibitor				73	87	99	94	89	95
Rate X Form X Inhibitor				49	99	90	76	35	62

Table 2 continued on next page

Table 2 continued

Treatments				N-Concentration			N-Removal		
N-Rate	N-Form	Inhibitor	Time	Leaf	Grain	Stover	Grain	Stover	Total
				----------%----------			----------kg/ha--------		
Factorial Arrangement (N-Rate X N-Form X Time)									
N-Rate									
84				2.14	1.18	0.47	65.7	22.7	88.5
168				2.38	1.31	0.52	94.5	29.9	124.5
P-Value				99	99	95	99	99	99
N-Form									
AA				2.53	1.29	0.49	96.1	29.7	125.8
28%				1.99	1.21	0.50	64.2	23.0	87.1
P-Value				99	99	40	99	99	99
Time									
PPL				1.84	1.16	0.45	58.1	21.6	79.8
10-lf				2.68	1.34	0.54	102.1	30.9	133.0
P-Value				99	99	99	99	99	99
Rate X Form				69	85	1	89	6	80
Rate X Time				46	99	82	99	63	99
Form X Time				95	98	54	74	87	9
Rate X Form X Time				98	89	98	99	98	99
Factorial Arrangement (N-Rate X Inhibitor in AA)									
N-Rate									
84				2.12	1.20	0.41	71.4	24.6	96.2
168				2.62	1.30	0.48	108.7	34.2	142.9
P-Value				99	99	97	99	99	99
Inhibitor									
Control				2.20	1.16	0.43	72.5	26.4	99.0
N-Serve				2.30	1.25	0.48	84.4	30.1	114.6
2.5% DCDG				2.51	1.28	0.41	99.9	28.1	128.1
5% DCDG				2.46	1.31	0.46	103.5	32.9	136.5
P-Value				92	99	81	99	80	99
N-Rate X Inhibitor				62	54	48	71	82	80
Factorial Arrangement (N-Rate X Inhibitor with Urea)									
N-Rate									
84				1.45	1.14	0.42	48.7	19.3	68.1
168				1.94	1.22	0.46	72.0	25.6	97.7
P-Value				99	98	94	99	99	99
Inhibitor									
Control				1.44	1.15	0.46	37.7	15.5	53.4
N-Serve				1.56	1.13	0.41	50.2	20.9	71.2
10% DCDN				2.08	1.25	0.45	93.1	30.9	123.9
P-Value				99	98	96	99	99	99
N-Rate X Inhibitor				99	99	97	99	99	99

INFLUENCE OF BORDER ROWS ON TPF YIELD AND NUTRIENT UTILIZATION OF SIX CORN HYBRIDS

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The agricultural producer is becoming increasingly aware of the importance of management for maximum economic return. With the severe economic pressures producers are currently encountering, the tendency is to cut back on some of the variable inputs used in crop production. The lowering of production cost is a viable consideration in increasing economic return, as long as decreased production does not offset the benefit from decreasing the production cost. An alternative to the above approach is improved management. If a producer can obtain higher yields with relatively little change in inputs, higher economic returns would result. Management for higher production and at the same time highest economic return is very complicated and it takes a top manager to evaluate all of the alternatives which are available. A trial was established at the Sand Plain Research Farm near Becker, Minnesota to evaluate the ability of six corn hybrids to respond to row competition in a "non-limiting" production environment.

Experimental Procedure

To examine the influence of border rows, hybrids were randomly allocated into experimental plots 45 ft. long and 20 ft. wide. Each experimental plot was split to allow for two hybrids. Four rows (30" spacing) of the randomly selected hybrid were planted to the right or left of the center split. Enough experimental plots were established to allow for the six hybrids with four replications to be established in a complete block arrangement. The experimental area therefore looked like eight rows of corn (two hybrids) separated from the next eight rows by 10 ft. of non-planted area. Each row within the experimental plot was treated as an individual experimental unit and evaluated separately. Row position was numbered 1-4 with 1 being closest to the non-planted area. The corn hybrids tested included DeKalb DK447, Northrup King PX9242, Pioneer 3906 (94-95 day relative maturity - R.M.), Jacques JX77 (100 day R.M.), Funks G4342 and Pioneer 3732 (105 day R.M.).

Prior to planting, potassium magnesium sulfate (300 #/a 0-0-22), phosphorus (80 #/a 0-46-0), and potassium (250 #/a 0-0-60) was broadcast and incorporated by plowing. Nitrogen was applied in split applications as anhydrous ammonia and 28% nitrogen solution (UAN). The first N application was made on May 2nd (prior to planting) of 175 #N/A as anhydrous ammonia with N-Serve (0.5 #ai/a). Three more applications of nitrogen were applied through the irrigation system by UAN solution. Applications of UAN were made on June 27th (20 #N/a), July 5th (50 #N/a), and July 31st (30 #N/a). These application times would correspond to the 9-10 leaf vegetative stage, pretassel, and post pollination. A portion of the N at the pretassel application (20%) was applied as ammonium sulfate rather then UAN.

Corn was planted on May 2nd in 30 inch rows at a population of 34,800 seeds/a. in a north to south orientation. Weed control was accomplished with a preemergence application of Atrazine (2 #ai/a) plus Lasso (2 #ai/A). To minimize corn bore damage, Lorsban was applied through the irrigation system on July 11th.

Leaf samples from opposite and below the ear at mid-silking were taken on July 19th. Samples were dried ground, and analyzed for elemental concentrations. Grain yields and total dry matter production was measured on September 24th. Samples were obtained by hand harvesting the whole plot area. Ears were separated from the stalks and separate field weights, and samples obtained from each portion (grain and stover) for moisture determination and elemental concentrations. Grain yields were adjusted to 15.5% moisture.

The irrigation program was started on June 26th and continued through August 30th with a total of 10.05 inches of water being applied through irrigation. An additional 19.42 inches of water was obtained during the growing season as rainfall.

General Results

A summary of the yield components and nutrient utilization characteristics are presented in Tables 1-7. As a general statement, both hybrid and row position influenced yield and nutrient uptakes. It is interesting to note that the yield components (Table 1) were influenced by hybrid and row position but there was no interaction. This suggests that all varieties reacted in a similar manner as row position changed. This relationship was not observed with most of the nutrient utilization data. Although hybrid and row position were important, there was in most cases a highly significant interaction. This would suggest that the hybrids did not respond equally to the change in

competition placed upon them by row position. Although this study did not isolate why these interactions existed, it does pose some interesting questions related to the effectiveness of a hybrid in taking up nutrients at various levels of competition.

Because of the volume of data collected and the number of additional calculations that can be made, it is impossible to completely interpret all of the data. With respect to grain yield, Funks G4342, Pioneer 3732 and DeKalb DK477 were among the highest yields while Jacques JX77, Pioneer 3906 and Northrup King PX9242 were somewhat lower. Although longer relative maturity hybrid are normally associated with high yields, this trend was not observed for all hybrids. DeKalb DK477 which was among the highest yielding had the lowest relative maturity. The yields from all hybrids responded to row position in the same manner, and there was no influence of row position on any yield parameter past the first row (outside).

Unlike the yield parameters, nutrient utilization characteristics of the hybrids did not respond to row position in the same manner (significant interactions). Pioneer 3732 in row position one had the highest total P uptake, and P uptake decreased substantially with increasing row number. Other hybrids exhibited little or no variation in total P uptake due to row position. Although Pioneer 3906 in row position one had the highest total K uptake, the highest yielding hybrid, Funks G4342, had the highest total K uptake across rows. This reflects the fact that row position had less influence on K uptake with Funks G4342 than with any other hybrid.

Table 1. Leaf N content, grain yield, dry matter production, grain N content and nitrogen removal by six corn hybrids Becker MN. 1984.

Treatments	Row No	Grain Yield	Dry Matter Production Grain	Stover	Total	N-Conc. Grain	Stover	N-Removal Grain	Stover	Total
		Bu/A	---T/A---			---%---		---#/A---		
Funks G4342	1	251.9	5.96	4.05	10.00	1.32	0.62	157.3	50.4	207.7
Funks G4342	2	203.8	4.82	3.54	8.37	1.30	0.65	126.0	46.4	172.4
Funks G4342	3	204.4	4.84	3.57	8.42	1.26	0.69	122.1	49.2	171.3
Funks G4342	4	217.3	5.14	3.58	8.72	1.22	0.59	125.8	42.5	168.3
Northrup King PX 9242	1	205.6	4.86	3.53	8.47	1.69	0.77	165.1	55.4	220.5
Northrup King PX 9242	2	182.2	4.31	3.27	7.59	1.49	0.69	129.1	45.5	174.6
Northrup King PX 9242	3	175.9	4.16	3.07	7.24	1.41	0.80	117.2	50.0	167.3
Northrup King PX 9242	4	179.6	4.25	3.42	7.67	1.27	0.72	108.1	49.6	157.8
Dekalb DK477	1	241.3	5.70	3.75	9.46	1.44	0.77	165.4	58.2	223.7
Dekalb DK477	2	197.1	4.66	3.07	7.73	1.33	0.63	125.0	38.6	163.7
Dekalb DK477	3	198.2	4.68	3.04	7.74	1.34	0.65	125.8	39.9	165.8
Dekalb DK477	4	204.7	4.84	3.12	7.12	1.22	0.61	118.8	38.4	157.2
Jacques JX77	1	214.8	5.08	3.69	8.77	1.36	0.69	138.9	51.3	190.2
Jacques JX77	2	193.2	4.57	3.01	7.58	1.32	0.68	121.1	41.0	162.1
Jacques JX77	3	192.6	4.55	3.01	7.57	1.29	0.70	118.3	42.2	160.6
Jacques JX77	4	191.3	4.52	2.89	7.42	1.26	0.67	114.2	39.1	153.3
Pioneer 3732	1	249.1	5.89	4.35	10.24	1.24	0.82	146.8	71.8	218.7
Pioneer 3732	2	201.8	4.77	3.61	8.38	1.23	0.77	117.2	55.9	173.1
Pioneer 3732	3	199.9	4.73	3.77	8.50	1.21	0.71	114.6	54.2	168.8
Pioneer 3732	4	213.4	5.04	3.76	8.80	1.16	0.66	117.6	50.3	167.9
Pioneer 3906	1	229.0	5.41	4.01	9.42	1.59	0.68	172.4	55.0	227.5
Pioneer 3906	2	189.7	4.48	3.44	7.93	1.57	0.65	141.4	45.0	186.5
Pioneer 3906	3	194.6	4.60	3.30	7.91	1.57	0.57	141.9	37.8	179.7
Pioneer 3906	4	188.9	4.47	3.34	7.81	1.36	0.59	121.5	39.9	161.4
Main Effects										
Hybrids										
Funks G4342		219.3	5.19	3.69	8.88	1.27	0.64	132.8	47.1	180.0
Northrup King PX9242		185.8	4.39	3.34	7.74	1.46	0.75	129.9	50.1	180.0
Dekalb DK477		210.3	4.97	3.24	8.22	1.33	0.67	133.7	43.8	177.6
Jacques JX77		198.0	4.68	3.14	7.82	1.31	0.68	123.1	43.4	166.6
Pioneer 3732		216.0	5.11	3.87	8.98	1.21	0.74	124.0	58.0	182.1
Pioneer 3906		200.5	4.74	3.52	8.27	1.51	0.62	144.3	44.4	188.7
P-Value		99	99	99	99	99	98	98	99	83
BLSD (.05)		7.3	0.17	0.17	0.33				4.5	
Row										
1		231.9	5.48	3.90	9.40	1.44	0.72	157.6	57.0	214.7
2		194.6	4.60	3.32	7.93	1.37	0.68	126.6	45.4	172.1
3		194.3	4.59	3.29	7.90	1.34	0.69	123.3	45.6	168.9
4		199.2	4.71	3.35	8.06	1.25	0.64	117.7	43.3	161.0
P-Value		99	99	99	99	99	99	99	99	99
BLSD).05)		5.8	0.14	0.15	0.26				3.8	7.0
Hybrids X Row		62	62	3	8	99	90	90	66	49

Table 2. The elememtal concentration of silage stover by six corn hybrids.

Treatment	Row No	N	P	K	Ca	Mg	Mn	Zn	Cu	B
		Elemental Concentration Silage Stover								
		%					ppm			
Funks G4342	1	0.62	0.05	1.57	0.46	0.27	64	23	12	14
Funks G4342	2	0.65	0.07	1.63	0.45	0.26	83	31	13	16
Funks G4342	3	0.69	0.06	1.81	0.44	0.24	90	22	10	18
Funks G4342	4	0.59	0.06	1.54	0.51	0.27	82	20	11	17
Northrup King PX 9242	1	0.77	0.07	1.44	0.41	0.26	79	26	12	15
Northrup King PX 9242	2	0.69	0.06	1.42	0.44	0.20	76	21	9	17
Northrup King PX 9242	3	0.80	0.06	1.59	0.50	0.29	79	21	12	13
Northrup King PX 9242	4	0.72	0.07	1.51	0.41	0.26	76	30	13	13
Dekalb 4DK477	1	0.77	0.06	1.83	0.44	0.25	95	23	12	15
Dekalb DK477	2	0.63	0.05	1.48	0.46	0.26	87	22	10	15
Dekalb DK477	3	0.65	0.10	1.50	0.37	0.25	76	29	14	14
Dekalb DK477	4	0.61	0.07	1.60	0.47	0.23	84	22	11	16
Jacques JX77	1	0.69	0.05	1.51	0.51	0.29	61	21	14	15
Jacques JX77	2	0.68	0.08	1.65	0.44	0.28	92	30	14	19
Jacques JX77	3	0.70	0.06	1.92	0.51	0.26	94	23	15	19
Jacques JX77	4	0.67	0.47	1.27	0.48	0.25	87	18	11	16
Pioneer 3732	1	0.82	0.07	1.38	0.40	0.28	69	30	15	15
Pioneer 3732	2	0.77	0.05	1.45	0.49	0.25	81	20	12	19
Pioneer 3732	3	0.71	0.06	1.38	0.52	0.26	89	21	13	17
Pioneer 3732	4	0.66	0.07	1.50	0.44	0.27	86	29	14	16
Pioneer 3906	1	0.68	0.05	1.84	0.46	0.27	101	20	12	17
Pioneer 3906	2	0.65	0.05	1.43	0.48	0.27	92	20	12	16
Pioneer 3906	3	0.57	0.07	1.46	0.41	0.27	79	26	14	15
Pioneer 3906	4	0.59	0.07	1.39	0.43	0.22	86	21	11	17
Main Effects										
Hybrids										
Funks G4342		0.64	0.06	1.64	0.47	0.26	80	24	11	16
Northrup King PX 9242		0.75	0.06	1.49	0.44	0.25	78	24	12	15
Dekalb DK477		0.67	0.07	1.60	0.43	0.25	85	24	12	15
Jacques JX77		0.68	0.06	1.59	0.48	0.27	83	23	14	17
Pioneer 3732		0.74	0.06	1.43	0.46	0.27	81	25	13	17
Pioneer 3906		0.62	0.06	1.53	0.45	0.26	89	22	12	16
P-Value		98	94	99	78	83	69	74	99	99
BLSD (.05)										
Row										
1		0.72	0.06	1.59	0.45	0.27	78	24	13	15
2		0.68	0.06	1.51	0.46	0.25	85	24	12	17
3		0.69	0.07	1.61	0.46	0.26	83	23	12	16
4		0.64	0.06	1.47	0.46	0.25	83	23	12	16
P-Value		99	99	99	15	96	87	29	99	99
BLSD (.05)										
Hybrids X Row		90	99	99	99	99	99	99	99	99

Table 3. The elememtal concentration of grain by six corn hybrids.

Treatment	Row No	N	P	K	Ca	Mg	Mn	Zn	Cu	B
		Elemental Concentration Grain								
		%					ppm			
Funks G4342	1	1.32	0.25	0.34	0.003	0.11	6	28	9	3
Funks G4342	2	1.30	0.30	0.39	0.002	0.14	7	27	9	4
Funks G4342	3	1.26	0.25	0.37	0.005	0.13	7	28	9	2
Funks G4342	4	1.22	0.26	0.36	0.003	0.13	6	28	9	3
Northrup King PX 9242	1	1.69	0.29	0.38	0.003	0.12	7	27	9	5
Northrup King PX 9242	2	1.49	0.32	0.38	0.004	0.15	8	32	9	4
Northrup King PX 9242	3	1.41	0.27	0.35	0.004	0.12	7	28	9	3
Northrup King PX 9242	4	1.27	0.33	0.40	0.003	0.15	7	27	9	6
Dekalb DK477	1	1.44	0.26	0.36	0.005	0.13	7	30	10	3
Dekalb DK477	2	1.33	0.26	0.36	0.003	0.13	7	28	9	3
Dekalb DK477	3	1.34	0.30	0.38	0.003	0.12	7	28	10	6
Dekalb DK477	4	1.22	0.31	0.37	0.004	0.14	8	30	10	4
Jacques JX77	1	1.36	0.26	0.38	0.004	0.12	6	28	9	2
Jacques JX77	2	1.32	0.32	0.41	0.003	0.15	8	27	9	4
Jacques JX77	3	1.29	0.28	0.39	0.004	0.15	8	32	9	3
Jacques JX77	4	1.26	0.26	0.37	0.003	0.13	7	27	9	2
Pioneer 3732	1	1.24	0.30	0.39	0.003	0.12	7	28	9	5
Pioneer 3732	2	1.23	0.28	0.38	0.004	0.14	8	30	10	3
Pioneer 3732	3	1.21	0.25	0.36	0.004	0.11	7	26	9	3
Pioneer 3732	4	1.16	0.29	0.38	0.003	0.13	7	26	10	4
Pioneer 3906	1	1.59	0.27	0.37	0.004	0.14	7	28	9	3
Pioneer 3906	2	1.57	0.28	0.39	0.003	0.14	7	25	8	5
Pioneer 3906	3	1.54	0.29	0.37	0.002	0.12	7	25	8	5
Pioneer 3906	4	1.36	0.31	0.39	0.004	0.15	9	29	9	4
Main Effects										
Hybrids										
Funks G4342		1.27	0.27	0.37	0.004	0.13	7	28	9	3
Northrup King PX 9242		1.46	0.30	0.38	0.003	0.13	7	29	9	5
Dekalb DK477		1.33	0.28	0.37	0.004	0.13	7	29	9	4
Jacques JX77		1.31	0.28	0.39	0.004	0.14	7	29	9	3
Pioneer 3732		1.21	0.28	0.38	0.003	0.13	7	27	9	4
Pioneer 3906		1.51	0.28	0.38	0.003	0.14	8	27	9	4
P-Value BLSD (.05)		99	93	87	99	89	95	98	89	99
Row										
1		1.44	0.27	0.37	0.004	0.12	7	28	9	4
2		1.37	0.29	0.38	0.003	0.14	8	28	9	4
3		1.34	0.27	0.37	0.004	0.13	7	28	9	4
4		1.25	0.29	0.38	0.003	0.14	8	28	9	4
P-Value BLSD (.05)		99	99	99	99	99	99	37	83	90
Hybrids X Row		99	93	99	99	99	99	99	5	99

Table 4. The elememtal concentration of the leaf opposite and below the ear at silking by six corn hybrids.

Treatment	Row No	N	P	K	Ca	Mg	Mn	Zn	Cu	B
		Elemental Concentration Leaf								
		%					ppm			
Funks G4342	1	2.75	0.27	2.70	0.46	0.27	80	26	11	14
Funks G4342	2	2.70	0.27	2.77	0.38	0.29	73	28	9	12
Funks G4342	3	2.71	0.27	3.01	0.41	0.24	76	26	9	16
Funks G4342	4	2.66	0.27	3.09	0.61	0.30	58	20	9	17
Northrup King PX 9242	1	2.76	0.29	2.54	0.40	0.29	72	29	10	13
Northrup King PX 9242	2	2.55	0.28	2.72	0.52	0.31	79	29	10	14
Northrup King PX 9242	3	2.74	0.27	2.73	0.43	0.26	73	24	9	13
Northrup King PX 9242	4	2.70	0.28	2.62	0.42	0.31	70	27	8	11
Dekalb DK477	1	2.69	0.26	3.03	0.37	0.23	68	24	8	13
Dekalb DK477	2	2.68	0.27	3.12	0.53	0.31	63	20	9	13
Dekalb DK477	3	2.56	0.27	2.60	0.39	0.28	67	27	8	11
Dekalb DK477	4	2.85	0.27	2.75	0.45	0.32	64	25	8	12
Jacques JX77	1	2.68	0.27	2.69	0.45	0.26	72	30	15	15
Jacques JX77	2	2.63	0.27	2.63	0.43	0.31	81	28	10	15
Jacques JX77	3	2.96	0.25	3.24	0.36	0.23	75	27	12	13
Jacques JX77	4	2.65	0.24	3.47	0.48	0.29	70	20	9	17
Pioneer 3732	1	2.49	0.27	2.60	0.37	0.29	66	29	11	13
Pioneer 3732	2	2.63	0.26	2.79	0.43	0.31	66	28	13	12
Pioneer 3732	3	2.64	0.27	2.58	0.46	0.26	85	28	14	16
Pioneer 3732	4	2.50	0.26	2.53	0.42	0.29	87	30	13	18
Pioneer 3906	1	2.74	0.24	3.02	0.38	0.24	79	27	12	15
Pioneer 3906	2	2.85	0.26	2.88	0.53	0.28	58	22	12	13
Pioneer 3906	3	2.82	0.27	2.44	0.39	0.29	75	30	13	18
Pioneer 3906	4	2.68	0.28	2.63	0.48	0.31	77	32	13	12
Main Effects										
Hyrids										
Funks G4342		2.70	0.27	2.92	0.46	0.28	72	25	10	15
Northrup King PX 9242		2.69	0.28	2.65	0.44	0.29	74	27	10	13
Dekalb DK477		2.69	0.26	2.88	0.43	0.28	66	24	8	12
Jacques JX77		2.73	0.26	3.01	0.43	0.27	75	26	11	15
Pioneer 3732		2.56	0.26	2.62	0.42	0.29	76	29	13	14
Pioneer 3906		2.77	0.26	2.74	0.44	0.28	72	28	12	15
P-Value		92	99	99	85	95	98	99	99	99
BLSD (.05)										
Row										
1		2.68	0.27	2.76	0.40	0.26	73	28	11	14
2		2.67	0.27	2.82	0.47	0.31	70	26	11	14
3		2.74	0.27	2.78	0.41	0.26	75	27	11	15
4		2.67	0.27	2.85	0.47	0.30	71	26	10	14
P-Value		61	7	96	99	99	80	99	99	99
BLSD (.05)										
Hybrids X Row		96	99	99	99	99	99	99	99	99

Table 5. The total elemental removal of silage stover at physiological maturity by six corn hybrids.

Treatment	Row No	P	K	Ca	Mg	Mn	Zn	Cu	B
		Total Elemental Removal Silage Stover							
		#/A							
Funks G4342	1	4.4	126.8	38.1	22.3	0.52	0.19	0.09	0.11
Funks G4342	2	5.0	115.5	32.7	19.2	0.59	0.22	0.09	0.11
Funks G4342	3	4.8	129.9	32.0	17.6	0.64	0.16	0.07	0.13
Funks G4342	4	4.4	110.2	36.8	19.7	0.59	0.14	0.07	0.12
Northrup King PX 9242	1	5.4	103.4	30.3	18.9	0.58	0.18	0.09	0.11
Northrup King PX 9242	2	3.9	93.3	28.8	13.2	0.50	0.14	0.06	0.11
Northrup King PX 9242	3	3.8	98.2	31.4	18.0	0.49	0.12	0.07	0.08
Northrup King PX 9242	4	5.4	103.7	28.6	18.1	0.52	0.20	0.09	0.09
Dekalb DK477	1	4.4	137.6	33.2	19.0	0.71	0.17	0.09	0.11
Dekalb DK477	2	3.4	90.7	28.2	16.0	0.54	0.13	0.06	0.09
Dekalb DK477	3	6.2	91.5	23.0	15.5	0.46	0.17	0.08	0.08
Dekalb DK477	4	4.2	99.4	29.9	14.5	0.52	0.13	0.07	0.10
Jacques JX77	1	3.7	112.2	37.9	21.8	0.44	0.16	0.10	0.11
Jacques JX77	2	4.8	100.1	26.6	17.5	0.55	0.18	0.08	0.11
Jacques JX77	3	3.6	115.7	31.1	16.1	0.56	0.14	0.09	0.11
Jacques JX77	4	2.7	73.9	27.8	14.6	0.50	0.11	0.06	0.09
Pioneer 3732	1	6.5	120.4	35.4	24.9	0.60	0.26	0.13	0.13
Pioneer 3732	2	4.1	104.7	35.8	18.6	0.58	0.15	0.08	0.14
Pioneer 3732	3	4.7	104.8	39.5	20.3	0.68	0.15	0.10	0.13
Pioneer 3732	4	5.4	112.8	33.8	20.3	0.65	0.21	0.10	0.12
Pioneer 3906	1	4.1	147.4	37.2	21.7	0.81	0.16	0.10	0.14
Pioneer 3906	2	4.0	98.3	33.3	18.6	0.63	0.14	0.08	0.11
Pioneer 3906	3	5.0	97.2	27.2	18.2	0.52	0.17	0.09	0.10
Pioneer 3906	4	4.8	93.7	28.8	15.2	0.57	0.14	0.07	0.11
Main Effects									
Hybrids									
Funks G4342		4.7	120.6	34.9	19.7	0.58	0.18	0.08	0.12
Northrup King PX 9242		4.6	99.7	29.8	17.0	0.52	0.16	0.08	0.10
Dekalb DK477		4.5	104.8	28.6	16.2	0.56	0.15	0.07	0.10
Jacques JX77		3.7	100.5	30.9	17.4	0.51	0.14	0.08	0.11
Pioneer 3732		5.2	110.7	36.1	21.0	0.63	0.19	0.10	0.13
Pioneer 3906		4.4	109.1	31.6	18.4	0.63	0.15	0.08	0.11
P-Value		99	99	98	99	99	99	99	99
BLSD (.05)									
Row									
1		4.7	124.6	35.4	21.4	0.61	0.19	0.10	0.12
2		4.2	100.4	30.9	17.1	0.56	0.16	0.08	0.11
3		4.7	106.2	30.7	17.6	0.56	0.15	0.08	0.10
4		4.5	99.0	31.0	17.1	0.56	0.15	0.08	0.10
P-Value		99	99	99	99	89	99	99	99
BLSD (.05)									
Hybrids X Row		99	99	94	99	96	99	99	99

Table 6. The total elemental removal of grain at physiological maturity by six corn hybrids.

Treatment	Row No	P	K	Ca	Mg	Mn	Zn	Cu	B
		Total Elemental Removal Grain							
		#/A							
Funks G4342	1	30.7	41.4	0.50	14.1	0.07	0.33	0.11	0.03
Funks G4342	2	29.8	37.7	0.28	14.0	0.07	0.26	0.08	0.04
Funks G4342	3	25.0	36.5	0.51	13.1	0.07	0.27	0.08	0.02
Funks G4342	4	27.2	37.7	0.36	14.0	0.06	0.29	0.09	0.02
Northrup King PX 9242	1	28.4	37.3	0.27	11.6	0.06	0.27	0.08	0.05
Northrup King PX 9242	2	27.6	33.1	0.34	13.0	0.07	0.27	0.08	0.03
Northrup King PX 9242	3	22.5	29.2	0.31	10.1	0.05	0.23	0.07	0.02
Northrup King PX 9242	4	28.7	34.5	0.24	12.6	0.06	0.23	0.08	0.04
Dekalb DK477	1	29.9	41.6	0.53	15.8	0.08	0.34	0.11	0.03
Dekalb DK477	2	24.8	34.3	0.30	12.5	0.06	0.26	0.08	0.02
Dekalb DK477	3	28.2	36.4	0.28	11.4	0.06	0.27	0.09	0.05
Dekalb DK477	4	30.2	35.9	0.36	14.3	0.08	0.29	0.10	0.04
Jacques JX77	1	27.1	38.7	0.37	12.4	0.06	0.29	0.09	0.02
Jacques JX77	2	30.1	38.2	0.25	14.3	0.07	0.24	0.08	0.04
Jacques JX77	3	25.5	36.2	0.44	13.6	0.07	0.29	0.08	0.02
Jacques JX77	4	24.0	34.2	0.28	11.9	0.06	0.25	0.08	0.02
Pioneer 3732	1	35.5	46.9	0.30	14.7	0.08	0.33	0.10	0.05
Pioneer 3732	2	27.6	36.5	0.34	14.2	0.07	0.28	0.09	0.03
Pioneer 3732	3	23.9	34.0	0.35	10.7	0.06	0.24	0.08	0.02
Pioneer 3732	4	29.3	38.5	0.33	14.0	0.07	0.26	0.10	0.04
Pioneer 3906	1	29.5	41.0	0.45	16.0	0.08	0.30	0.09	0.03
Pioneer 3906	2	25.3	35.2	0.27	12.8	0.06	0.23	0.07	0.02
Pioneer 3906	3	27.0	34.8	0.23	11.5	0.06	0.22	0.07	0.04
Pioneer 3906	4	27.5	35.3	0.33	13.6	0.08	0.25	0.08	0.03
Main Effects									
Hybrids									
Funks G4342		28.2	38.3	0.41	13.8	0.07	0.29	0.09	0.03
Northrup King PX 9242		26.8	33.5	0.29	11.8	0.06	0.25	0.08	0.04
Dekalb DK477		28.3	37.1	0.37	13.5	0.07	0.29	0.09	0.04
Jacques JX77		26.7	36.8	0.33	13.1	0.06	0.27	0.08	0.02
Pioneer 3732		29.1	39.0	0.33	13.4	0.07	0.28	0.09	0.03
Pioneer 3906		27.3	36.6	0.32	13.5	0.07	0.25	0.08	0.03
P-Value		85	99	99	99	95	99	99	99
BLSD (.05)									
Row									
1		30.2	41.2	0.40	14.1	0.07	0.31	0.10	0.03
2		27.5	35.8	0.30	13.5	0.07	0.26	0.08	0.03
3		25.4	34.5	0.35	11.7	0.65	0.25	0.08	0.03
4		27.8	36.0	0.32	13.4	0.07	0.26	0.09	0.03
P-Value		99	99	99	99	99	99	99	99
BLSD (.05)									
Hybrids X Row		90	93	99	99	99	99	18	99

Table 7. The total elemental removal of silage stover plus grain at physiological maturity by six corn hybrids.

Treatment	Row No	P	K	Ca	Mg	Mn	Zn	Cu	B
		Total Elemental Removal Silage Stover + Grain							
		#/A							
Funks G4342	1	35.2	168.3	38.6	36.5	0.59	0.53	0.21	0.15
Funks G4342	2	34.8	153.2	32.9	33.2	0.66	0.48	0.18	0.16
Funks G4342	3	29.9	166.4	32.5	30.7	0.72	0.43	0.16	0.15
Funks G4342	4	31.6	148.0	37.2	33.8	0.66	0.43	0.17	0.15
Northrup King PX 9242	1	33.8	140.7	30.6	30.5	0.64	0.45	0.17	0.16
Northrup King PX 9242	2	31.5	126.5	29.1	26.3	0.57	0.42	0.14	0.15
Northrup King PX 9242	3	26.4	127.5	31.7	28.1	0.55	0.36	0.15	0.11
Northrup King PX 9242	4	34.1	138.2	28.9	30.7	0.58	0.43	0.17	0.14
Dekalb DK477	1	34.3	179.3	33.8	34.8	0.79	0.51	0.21	0.14
Dekalb DK477	2	28.2	125.1	28.5	28.6	0.60	0.39	0.14	0.12
Dekalb DK477	3	34.5	127.9	23.3	26.9	0.05	0.45	0.18	0.13
Dekalb DK477	4	34.5	135.4	30.2	28.9	0.60	0.43	0.17	0.14
Jacques JX77	1	30.9	150.9	38.3	34.3	0.51	0.45	0.20	0.14
Jacques JX77	2	35.0	138.4	26.8	31.6	0.62	0.42	0.17	0.16
Jacques JX77	3	29.2	152.0	31.6	29.8	0.64	0.43	0.17	0.14
Jacques JX77	4	26.7	108.2	28.1	26.5	0.56	0.35	0.15	0.11
Pioneer 3732	1	42.0	167.3	35.7	39.6	0.68	0.59	0.24	0.19
Pioneer 3732	2	31.8	141.2	36.2	32.9	0.66	0.44	0.18	0.17
Pioneer 3732	3	28.6	138.9	39.8	31.1	0.74	0.40	0.18	0.15
Pioneer 3732	4	34.7	151.3	34.1	34.4	0.72	0.47	0.21	0.16
Pioneer 3906	1	33.6	188.4	37.6	37.8	0.89	0.46	0.19	0.17
Pioneer 3906	2	29.3	133.6	33.6	31.5	0.69	0.37	0.15	0.13
Pioneer 3906	3	32.1	132.0	27.4	29.7	0.58	0.40	0.17	0.14
Pioneer 3906	4	32.3	129.1	29.1	28.9	0.65	0.40	0.16	0.15
Main Effects									
Hybrids									
Funks G4342		32.9	159.0	35.3	33.5	0.66	0.47	0.18	0.15
Northrup King PX 9242		31.4	133.2	30.1	28.9	0.59	0.42	0.16	0.14
Dekalb DK477		32.9	141.9	29.0	29.8	0.63	0.45	0.17	0.13
Jacques JX77		30.5	137.4	31.2	30.5	0.58	0.41	0.17	0.13
Pioneer 3732		34.3	149.7	36.5	34.5	0.70	0.47	0.20	0.17
Pioneer 3906		31.8	145.8	31.9	32.0	0.70	0.41	0.17	0.15
P-Value		96	99	99	99	96	99	99	99
BLSD (.05)					2.1				
Row									
1		35.0	156.8	35.8	35.6	0.68	0.50	0.20	0.16
2		31.8	136.3	31.2	30.7	0.63	0.42	0.16	0.15
3		30.1	140.8	31.1	29.4	0.63	0.41	0.17	0.14
4		32.3	135.0	31.3	30.5	0.63	0.42	0.17	0.14
P-Value		99	99	99	99	94	99	99	99
BLSD (.05)					1.6				
Hybrids X Row		99	99	94	83	99	99	92	99

Evaluation of Formolene foliar feed N source on potatoes at Becker, 1984.

W. E. Fenster, M. O'Leary and G. Buzicky

Experiments on the Formolene product were conducted on potatoes at Becker in 1983 and 1984. The objective of using a liquid nitrogen product is to add substantial amounts to the potato foliage when the nutrient demand is the greatest. The Formolene fertilizer (30-0-2) efficiency was compared to normal amounts of soil applied ammonium nitrate (34-0-0) on irrigated sandy textured soils. Fifty pounds per acre of N were applied during tuberization to the control plots to offset the possibility of blight spreading from the control area to the adjacent plots. All plots were replicated 4 times.

Soil test means were: pH=6.5, P=65, K=223, Mg=325, Zn=.8 ppm, S=4 ppm O.M=Med.

Treatments were as follows:

1. Control
2. U. of MN recommendations (soil applied)

across all plots except control	P_2O_5	= 100#/A (planting time)
	K_2O	= 300#/A (planting time)
	S	= 15#/A (planting time)
	N	= 25#/A (planting time)
	Total N	= 210#/A split

Splitting of 210# N as follows:
85# N/A at emergence
50# N/A at tuberization
50# N/A at canopy closure

3. Formolene foliar at 60# N/A
   + 25# N at planting and 85# N/A at emergence as ammonium nitrate to soil (total of 170# N/A).

   Foliar scheme

   a. 10# N/A at 10" to 12"
   b. 30# N/A at tuberization
   c. 20# N/A at canopy closure.

4. Formolene foliar at 100# N/A
   + 25# N/A at planting and 85# N/A at emergence to soil (total of 210# N/A).

   Foliar scheme

   a. 20# N/A at 10" to 12"
   b. 20# N/A at tuberization
   c. 30# N/A at plant bloom
   d. 30# N/A at canopy closure.

5. U. of MN rate of soil applied, with 40# N/A reduction from recommendation (170# N/A total).

   25# N/A at planting
   85# N/A at emergence
   30# N/A at tuberization
   30# N/A at canopy closure.

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

Table 1. Yields and size difference of potatoes comparing Formolene and ammonium nitrate fertilizer 1984.

Treatment Treatment	Tuber yield CW 7/A	% of sample by weight (oz.) 0-3	3-6	6-9	9-12	>12
1	332	3	27	36	22	12
2	478	4	31	33	18	14
3	418	3	27	35	17	18
4	437	3	25	33	24	15
5	457	3	24	29	27	17
Significance	**	ns	ns	ns	ns	ns
BLSD	42	--	--	--	--	--
C.V.	7	78	25	24	36	51

Summary

Where equal amounts of N were applied there were no significant differences in tuber yield due to nitrogen sources. Even though there was 50 pounds of N applied to the control plots the fertilizer treatments from both N sources showed a significant yield increase over the control.

There was no significant effect on tuber size due to method of treatment.

NITROGEN FERTILIZATION FOR PROCESSING SWEET CORN ON AN IRRIGATED SAND: INFLUENCE OF RATES, TIMING AND A NITRIFICATION INHIBITOR -- 1984

C. J. Rosen and H. J. Buchite

Nitrogen fertilizer management for processing sweet corn is an important concern to processors and their growers. Coarse-textured soils are subject to excessive drainage which consequently increases nitrate-nitrogen losses from the root zone. Although many studies have been conducted dealing with nitrogen management for field corn, the differences in growing season and harvested product make it difficult to extrapolate the data from these studies to processing sweet corn. The objectives of the present study were to: 1) optimize rates and timing of nitrogen fertilizer for sweet corn on coarse-textured irrigated soils, and 2) evaluate the effectiveness of N-Serve, a nitrification inhibitor, for sweet corn production.

Procedures:

The experiment was conducted at the Sand Plains Research Farm in Becker, Minnesota on a Hubbard loamy sand (1.9% organic matter). Prior to planting, phosphorus, potassium and sulfur were broadcast according to soil test recommendations. There were nine treatments which included a control, 4 nitrogen rates (50, 100, 150, 200 lb N/A), 100 lb N/A plus N-Serve (0.5 lb ai/A), 150 lb N/A plus N-Serve (0.5 lb ai/A), 100 lb N/A split (1/2 preplant, 1/2 6-8 leaf stage), 150 lb N/A split (1/3 preplant, 1/3 6-8 leaf stage, 1/3 12 leaf stage). Nitrogen source for all preplant applications was anhydrous ammonia. For the split applications, anhydrous ammonia was used preplant and ammonium nitrate as a sidedress. All preplant treatments were applied 3 May 1984. Each treatment was replicated 4 times in a randomized complete block design.

Two varieties, Code 5 (early maturing) and Jubilee (midseason maturing), were planted on 4 May 1984 along with a banded application of 160 lb/A 0-26-26. Plant population was approximately 22,000/A. Each plot consisted of 4 - 40 ft rows with 2.5 ft between the rows.

Whole plant samples collected at the 6-8 leaf stage (before any sidedress application) and leaf samples from opposite and above ear collected at mid-silking were dried, ground and analyzed for total nitrogen content. Leaf samples from the 100 and 150 lb N/A treatment with and without inhibitors were analyzed for P, K, Ca, Mg, Fe, Mn, Zn, Cu, and B using an inductively coupled plasma emission spectrometer.

Total yield (ear and husk), husked yield, and stover yield were obtained by harvesting 2 - 15 ft rows within each plot. Subsamples of ears, husk and stover were taken to determine % moisture for nitrogen uptake calculations. The following quality measurements were also made: ear length, % moisture in kernels, and % usable ears (5.5 inches or greater with tip removed).

From May through July, approximately 7 inches of water was supplied by an overhead irrigation system and 14.8 inches was provided from rainfall. Code 5 was harvested 30 July 1984 and Jubilee was harvested 7 August 1984.

Results:

Both sweet corn varieties responded to nitrogen applications up to 200 lb N/A compared to the check plot. No significant gain in ear fresh weight yields was obtained over the 150 lb N/A rate (Tables 1 and 3). Code 5 had significantly greater ear yields with N-Serve or split N applications at the 100 lb rate compared to the 100 lb N/A preplant. There was no significant difference between 100 lb N/A plus N-Serve and 150 lb N/A as a preplant, split application or with N-Serve. Although similar trends were observed with Jubilee, 150 lb N/A as a preplant gave superior yields compared to 100 lb N/A as a preplant, split application or with N-Serve. For both varieties, yields on plots receiving preplant applications at 150 lb N/A were not significantly different from those receiving 150 lb N/A with N-Serve or split applied. In general, ear length and % COC eligible followed yield trends. Maximum quality was obtained from sweet corn that received 100 lb N/A or more regardless of whether applications were split, preplant or with N-Serve added.

Nitrogen concentrations in whole plant samples at the 6-8 leaf stage were lower for the control and 50 lb N/A treatments compared to the other nitrogen treatments (Tables 2 and 4). At the 6-8 leaf stage all split application treatments had received only 50 lb N/A. In general, plants having nitrogen concentrations less than 3.3% at the 6-8 leaf stage without subsequent sidedress applica-

tions ended up deficient in nitrogen at silking as measured by leaf nitrogen. It should be noted that subsequent nitrogen deficiency may still occur on plants with nitrogen concentrations greater than 3.3% at the 6-8 leaf stage if nitrogen availability is limited after this point. Ear leaf nitrogen concentrations increased with nitrogen applications rate. N-Serve and split applications had no effect on ear leaf nitrogen concentration at a given rate. Ear, husk and stover N concentrations generally increased with nitrogen application rate. Total nitrogen uptake increased with increasing nitrogen rates. N-Serve and sidedress applications appeared to enhance N uptake compared to the preplant application at the 100 lb rate. There were no differences in total N uptake between preplant, N-Serve addition or split application at the 150 lb rate.

Leaf elemental concentrations of calcium at mid-silking were significantly lower in N-Serve treatments compared to those without N-Serve (Tables 5 and 6). In Code 5, leaf K and Mg were also significantly lower when N-Serve was used.

General Comments:

Results from these experiments are based on one year of data. Differences in time and amount of rainfall can profoundly alter nitrogen leaching and subsequent plant response on coarse-textured soils. In general, N-Serve and split applications at 150 lb N/A offered no advantage over a single preplant application. At the 100 lb N/A rate, N-Serve or split application were necessary in order to avoid yield loss. This research will be conducted next year to gain a broader data base for sweet corn response to nitrogen fertilization and management on coarse-textured soils.

The assistance of G. Titrud, G. Buzicky and T. King during the course of this research is gratefully acknowledged.

Table 1. Effect of nitrogen rate, nitrification inhibitor and sidedress applications on Code 5 sweet corn yield and quality.

Treatment lb N/A	Yield (T/A) Green	Yield (T/A) Husked	Ear Length inches	% Moisture in Kernels	% COC Eligible
0	2.29	1.58	5.9	77.2	31.2
50	3.76	2.66	6.8	76.1	58.1
100	5.52	3.48	7.6	75.2	70.0
150	7.22	4.61	8.4	73.3	83.9
200	7.54	4.72	8.1	74.0	72.1
100+N-Serve	7.09	4.32	7.8	74.0	74.2
150+N-Serve	7.26	4.53	8.1	75.7	79.9
100 2 splits	6.82	4.22	7.8	73.2	76.1
150 3 splits	7.54	4.65	8.1	72.7	72.5
Significance	**	**	**	NS	**
BLSD (.05)	0.85	0.52	0.8	—	16.4

Table 2. Effect of nitrogen rate, nitrification inhibitor and sidedress applications on nitrogen concentration in various plant tissues during the growing season and total nitrogen uptake (Code 5).

Treatment lb N/A	% N Whole Plant (6-8 Leaf)	% N Leaf Above Ear (Silking)	% 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
0	3.19	2.88	1.60	0.57	1.46	8.1	1.5	39.9	49.5
50	3.53	2.97	1.65	0.53	1.24	14.8	2.0	44.9	61.8
100	3.55	3.42	1.66	0.56	1.30	24.1	4.0	54.0	82.0
150	3.63	3.73	1.72	0.62	1.63	29.8	6.0	74.5	110.3
200	3.79	3.79	1.75	0.64	1.88	31.6	6.4	81.7	119.7
100+N-Serve	4.13	3.48	1.70	0.61	1.66	29.5	6.5	76.1	114.0
150+N-Serve	3.84	3.75	1.71	0.73	1.51	29.0	7.6	66.9	103.6
100 2 splits	3.16	3.58	1.59	0.68	1.36	25.7	6.5	58.7	90.9
150 3 splits	3.37	3.80	1.61	0.70	1.84	27.8	7.2	65.4	100.4
Significance	**	**	NS	NS	*	**	**	**	**
BLSD (.05)	0.37	0.20	--	—	0.40	5.6	1.6	16.2	18.6

Table 3. Effect of nitrogren rate, nitrification inhibitor and sidedress applications on Jubilee sweet corn yield and quality.

Treatment lb N/A	Yield (T/A) Green	Yield (T/A) Husked	Ear Length inches	% Moisture in Kernels	% COC Eligible
0	3.40	2.47	6.2	75.4	34.8
50	3.91	2.81	6.5	74.2	46.6
100	7.10	4.96	7.5	75.5	84.3
150	9.60	6.60	7.5	75.3	75.6
200	9.11	6.27	7.7	74.7	75.9
100+N-Serve	8.00	5.80	7.6	75.0	79.2
150+N-Serve	9.00	6.29	7.6	75.8	80.0
100 2 splits	7.66	5.43	7.5	75.0	79.2
150 3 splits	8.18	5.86	7.7	74.6	80.6
Significance	**	**	**	NS	**
BLSD (.05)	1.65	0.98	0.4	--	14.8

Table 4. Effect of nitrogen rate, nitrification inhibitor and sidedress applications on nitrogen concentration in various plant tissues during the growing season and total nitrogen uptake (Jubilee).

Treatment lb N/A	% N Whole Plant (6-8 Leaf)	% N Leaf Above Ear (Silking)	% 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
0	3.11	2.03	1.52	0.49	0.93	15.9	1.4	22.4	39.7
50	3.16	1.89	1.42	0.46	0.92	17.6	1.6	23.6	42.8
100	3.85	2.66	1.48	0.53	1.18	37.4	4.2	48.6	90.2
150	3.81	3.32	1.71	0.94	1.40	50.4	9.9	58.5	118.5
200	3.85	3.24	1.60	0.76	1.45	47.9	6.8	58.5	113.3
100+N-Serve	3.80	3.11	1.48	0.63	1.37	42.2	3.9	63.2	109.4
150+N-Serve	4.01	3.31	1.65	0.65	1.57	50.4	5.8	64.2	120.4
100 2 splits	3.31	3.02	1.48	0.72	1.30	38.5	5.7	49.8	93.7
150 3 splits	3.25	3.38	1.74	0.74	1.66	43.1	5.6	68.0	116.7
Significance	**	**	*	**	**	**	*	**	**
BLSD (.05)	0.42	0.27	0.25	0.24	0.36	12.6	4.4	14.2	24.4

Table 5. Influence of N-Serve and N rate on leaf elemental concentrations at mid-silking: Code 5.

Treatment lb N/A	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
100	3.42	0.36	3.22	0.54	0.32	126	104	29	21	5
150	3.73	0.36	3.19	0.56	0.33	132	142	31	22	5
100+N-Serve	3.48	0.34	3.07	0.50	0.29	122	88	30	22	6
150+N-Serve	3.75	0.37	3.06	0.50	0.28	126	112	31	22	5
N rate effect	**	NS	NS	NS	NS	NS	NS	NS	NS	NS
N-Serve effect	NS	NS	*	*	**	NS	*	NS	NS	NS
N rate X N-Serve	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 6. Influence of N-Serve and N rate on leaf elemental concentrations at mid-silking: Jubilee.

Treatment lb N/A	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
100	2.66	0.30	2.82	0.63	0.35	91	116	21	8	6
150	3.32	0.37	2.97	0.65	0.39	106	162	31	11	6
100+N-Serve	3.11	0.37	3.04	0.58	0.37	100	91	28	10	6
150+N-Serve	3.31	0.39	2.91	0.59	0.38	103	120	27	10	6
N rate effect	*	*	NS	NS	NS	*	*	NS	*	NS
N-Serve effect	NS	*	NS	**	NS	NS	*	NS	NS	NS
N rate X N-Serve	NS	NS	*	NS	NS	NS	NS	NS	*	NS

1984 WEATHER

R. K. Severson

Mild temperatures during January and February of 1984 kept the snow depth to a minimum. The maximum snow depth of 5 inches occurred during the first week of February regressing to only a trace of snow on the ground by the last week of February. On the average, February 1984 was the fourth warmest February recorded at Crookston since 1890. February 16 set a new daily record maximum for precipitation with 0.53 inches of moisture of which .35 inches fell as rain. Two new all-time high temperature records were also set in January with readings of 38°F on January 4 and 40°F on January 6.

The ground frost reached a maximum of 39 inches during the first week of March. By March 18 the entire snow-pack had melted and the surface ground frost began thawing. By April 1, the frost was out to six inches from the surface. March and April were about normal in regard to average temperature and one-inch below normal in average precipitation.

May was unusually dry receiving only one-third the normal precipitation for this period as can be noted in the following table. On the other hand, June marked a period of well-above normal precipitation. In a six-day period from June 3-8, 5.65 inches of rain fell leaving water standing in most fields which was devastating to some crops. On June 7, 3.28 inches of the 5.65 inches were received. In the 95-year history of weather records for the month of June in Crookston, June 1984 ranked fourth in most precipitation.

July marked the driest July recorded in the weather station history. The .48 inches of rain received was only 15% of the normal 3.09 inches expected for this month. August and September were also below normal for precipitation with deficits of .81 inches and 1.42 inches, respectively. August was also about 3.5°F above normal in regard to average temperature with a record high temperature of 98°F recorded August 28. August 20 set a new record for daily precipitation with 1.23 inches of rain recorded.

October will be remembered for years by many people in the sugarbeet industry. Above-normal temperatures during the first third of the month halted piling operations. October 13 marked the beginning of a 9-day period of rain dumping 3.31 inches again halting piling operations. The last week of October the temperatures dropped to the mid-teens and then to single digits freezing the remaining sugarbeet crop in the ground. October ranked as the third wettest October in weather station history with 3.91 inches of precipitation. A new record low temperature record was also set October 31 when the mercury dipped to 5°F surpassing the old mark of 10°F set in 1906.

November was well-below normal in regard to precipitation with .13 inches recorded of which .11 inches was received in 2 inches of snow. Another temperature record was surpassed November 25 with a reading of 54°F recorded. The old record was 50°F set in 1914.

The mean temperature for the year was 0.7°F above normal. The last spring frost was recorded May 25 (29°) which initiated a 111-day growing season ending September 14 (29°) when the first fall frost occurred.

The precipitation for 1984 totaled 18.42 inches of which 16.69 inches were recorded as rain and 1.73 inches were contained in 24.2 inches of snow.

Table 1. Weather summary for 1984 with averages for precipitation and mean temperature (1890-1979).

	Precipitation					Mean Temperature	
Month	Snow	Precip.	Rain	Total	1890-1979	1984	1890-1979
	Inches					°F	
January	5.5	.23	--	.23	.56	6.6	3.7
February	3.8	.55	.35	.90	.59	21.4	8.1
March	6.9	.24	.01	.25	.84	21.1	22.9
April	--	--	1.19	1.19	1.57	44.5	41.4
May	--	--	.79	.79	2.59	52.5	54.6
June	--	--	7.11	7.11	3.56	64.5	64.4
July	--	--	.48	.48	3.09	70.0	69.6
August	--	--	2.09	2.09	2.90	71.0	67.4
September	--	--	.74	.74	2.16	51.5	51.5
October	T	T	3.91	3.91	1.43	45.3	45.3
November	2.0	.11	.02	.13	.78	26.0	26.7
December	6.0	.60	--	.60	.60	6.4	11.5
TOTAL	24.2	1.73	16.69	18.42	20.67	40.1	39.4

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

J. A. Lamb and R. K. Severson

The objective of this study was to measure the effects of different fertilizer programs, so called maintenance versus build, over a 10-year period on soil test levels and crop quality in a continuous wheat cropping system. Soil test and crop quality measurements are taken to provide information for evaluation and determination of the most effective program. The study was originated in the spring of 1978.

Experimental Procedure: Five treatments with 4 replications were arranged in a randomized complete block design. Each of the 5 fertilizer treatments was based upon soil test data from the plots on which that treatment had been applied to in the previous years. All of the treatments were applied in the fall of 1983 and plowed down. Marshall wheat was planted May 2, 1984 and harvested August 16, 1984. Whole plant samples were taken at maturity (July 30, 1984) for elemental analyses. Whole plant samples taken at maturity (soft dough) were used to determine forage yields and to calculate N, P, and K uptake. Soil samples were taken after crop removal to measure the effects of the treatments.

Results and Discussion: The effect of the treatments on elemental analyses at maturity is shown in Table 1. Significant differences in analyses occurred between the check and other treatments for N, K, Ca, Mg, Zn, and B.

The plants receiving fertilizer treatments had greater concentrations of N, K, Ca, Mg, and B. The addition of N, P, and K above the recommendations did not increase the concentration of these minerals. Plant Zn concentration decreased by the increased P fertilizer supplied to the plant.

Table 1. The effect of 5 fertilizer programs on the elemental analyses of whole plant samples taken at maturity (soft dough) of spring wheat.

Treatment			Elemental Analyses								
N	P_2O_5	K_2O	N	P	K	Ca	Mg	Mn	Zn	Cu	B
- - - - lb/ac - - - -			- - - - - - - - - % - - - - - - - - -					- - - - - - ppm - - - -			
0	0	0 1/	1.15	0.23	0.90	0.09	0.14	35	24	1	2
90	35	30 2/	1.52	0.24	1.38	0.14	0.19	39	22	1	3
90	35	30 3/	1.47	0.24	1.26	0.12	0.18	38	22	1	3
80	35	30 4/	1.51	0.23	1.29	0.15	0.19	36	20	1	3
50	35	30 5/	1.46	0.23	1.26	0.14	0.19	38	16	1	3
Significance			**	N.S.	**	**	**	N.S.	+	N.S.	**
B.L.S.D. (.05)			0.20		0.13	0.03	0.02		5.9		0.30
C.V. (%)			9.0	4.1	7.3	16.4	8.1	12.9	16.6	23.8	8.1

1/ Check
2/ Soil test recommendation
3/ Soil test recommendation + 30 lb K_2O/ac
4/ Soil test recommendation + 30 lb N/ac
5/ Soil test recommendation + 30 lb P_2O_5/ac
** and + are 0.01 and 0.10 significance levels, respectively.

The grain yield, protein, grain N removal, D.M. yield, forage P uptake, and K uptake were significantly affected by the addition of fertilizer from any of the 4 fertilizer treatments (Table 2). There were no differences in these variables between fertilizer treatments. The forage N uptake was significantly affected by the use of the 4 fertilizer programs. The additional P treatment had a lower N uptake but still considerably greater than the check.

Table 2. The effect of 5 fertilizer programs on grain yield, test weight, protein, grain N removal, forage yield, N, P, and K uptake of spring wheat.

Treatment			Grain				Forage			
				Test		N	D.M.	Uptake		
N	P_2O_5	K_2O	Yield	Weight	Protein	Removal	Yield	N	P	K
- - - - lb/ac - - - -			Bu/ac	lb/Bu	%	lb/ac	- - - - - - lb/ac - - - - -			
0	0	0 1/	41.9	62.0	12.45	55.4	5604	64.7	13.0	50.2
90	35	30 2/	67.4	61.3	14.55	103.3	9689	146.8	22.7	134.7
90	35	30 3/	70.8	61.7	14.54	108.2	9487	139.8	22.7	119.3
80	35	30 4/	69.0	61.9	15.05	109.3	10388	157.4	23.9	134.1
50	35	30 5/	71.1	62.4	14.61	110.2	9141	132.3	21.1	114.4
Significance			**	N.S.	**	**	**	**	**	**
B.L.S.D. (.05)			5.0		1.15	11.8	1410	26.6	2.6	26.0
C.V. (%)			5.5	1.0	5.2	8.5	10.9	14.2	8.7	16.1

1/ Check
2/ Soil test recommendation
3/ Soil test recommendation + 30 lb K_2O/ac
4/ Soil test recommendation + 30 lb N/ac
5/ Soil test recommendation + 30 lb P_2O_5/ac
** is the 0.01 significance level

The soil test values for the 5 treatments are shown in Table 3. The only soil nutrient significantly affected by fertilizer treatments was P at both the 0-6" and 6-12" depths. The check had a significantly lower soil P level compared to the fertilized treatments. The +30# P_2O_5 showed a trend toward higher soil P values of both depths.

Table 3. The effect of 5 fertilizer programs on residual NO_3-N, P, and K soil test levels after seven years in a continuous wheat cropping system.

Treatment			Soil Test Levels										
			NO_3-N							$NaHCO_3$ P 6/		Exchangeable K 6/	
N	P_2O_5	K_2O	0-1'	1-2'	2-3'	3-4'	4-5'	0-2'	0-5'	0-6"	6-12"	0-6"	6-12"
- - - - lb/ac - - - -			- - - - - - -lb/depth - - - - - -							- - - - - - - - - lb/ac - - - - - - - -			
0	0	0 1/	15.5	8.0	7.0	8.0	17.0	23.5	55.5	8.0	4.3	281	226
90	35	30 2/	25.0	12.0	15.5	22.5	20.0	37.0	95.0	19.3	9.3	294	225
90	35	30 3/	21.0	10.5	19.5	25.5	22.5	31.5	99.0	17.8	11.3	309	235
80	35	30 4/	25.0	16.0	30.0	31.5	26.5	41.0	129.0	13.5	10.0	274	208
50	35	30 5/	27.5	17.0	26.0	31.5	25.5	44.5	127.5	19.3	12.5	318	231
Significance			N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	**	**	N.S.	N.S.
B.L.S.D. (.05)										5.0	5.0		
C.V. (%)			28.5	58.1	75.7	60.1	43.1	35.9	44.2	22.3	29.9	12.7	11.7

1/ Check
2/ Soil test recommendation
3/ Soil test recommendation + 30 lb K_2O/ac
4/ Soil test recommendation + 30 lb N/ac
5/ Soil test recommendation + 30 lb P_2O_5/ac
6/ ppm = lb/ac times 0.05
** is the 0.01 significance level

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

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

Objectives: The overall objectives of this study are to measure the effects of residual NO_3^--N, fertilizer N, seed inoculation, the interactions of these three variables on soybean production in the Red River Valley of Minnesota.

Procedures: Four locations were established in Spring 1984 with residual NO_3^--N for 0-2 ft. ranging from 13 to 102 lb NO_3^--N/ac. The textures ranged from sandy loam to a silty clay. The statistical design was a split plot with four replications. The main plots were inoculated or noninoculated seed and the split plots were N rates (0, 30, 60, 90, and 120 lbs N/ac). The N fertilizer was applied as urea and incorporated before the plots were planted. The Hegne, Wheatville, and R. Peterson locations were planted May 16, 1984. The R. Buchholz location was planted May 25, 1984. Plant samples were taken from the last full trifoliate leaves at early bloom. Periodic root observations were made to determine the status of nodule formation through the growing season. The plots were hand harvested September 25-26, 1984.

Results and Discussion: The soybean yields for 1984 are reported in Table 1. Three locations responded to the application of N fertilizer. The Hegne location showed the largest N response. This was caused by the low residual NO_3^--N in the soil (Table 2) at the beginning of the study. The noninoculated treatment had lower yields than the inoculated and a response was detected ($P < 0.20$). This effect could not be documented by root observations during the growing season. Very few nodules (<3) were found on plants in any treatment at any location. An inoculation x N rate interaction occurred and indicates the lower yield from lack of inoculation can be made up by the addition of N fertilizer. The plant analysis (Table 3) at the Hegne location indicates no effect of inoculation but did indicate a positive relationship between yield and plant N content ($r = 0.51$).

The Wheatville location had a quadratic response caused by N fertilizer. The majority of the positive response occurred with the first 30 lb increment. The plant trifoliate N concentration increased linearly with the amount of N applied. This increase did not correlate with yield. The smaller N response and lack of response to inoculation was caused by the larger amount of NO_3^--N in the soil (72 lb/ac).

Table 1. Soybean grain yields for inoculation - N rate study in 1984.

	Site							
	NWES				Off Station			
	Hegne		Wheatville		R. Peterson		R. Buccholz	
N Rate	0[1/]	I[2/]	0	I	0	I	0	I
lb/ac	bu/ac							
0	15.7	24.9	27.2	25.0	27.4	26.6	29.0	28.5
30	19.9	26.0	31.1	29.1	27.8	28.0	27.5	31.4
60	21.4	26.1	31.1	32.8	29.0	28.4	28.7	30.1
90	26.6	27.4	32.0	29.5	26.3	29.0	28.9	31.1
120	28.8	27.0	31.1	28.5	26.1	27.8	27.2	28.8
STATISTICS								
Inoculation	+		N.S.		N.S.		+	
N Rate	**		N.S.		N.S.		++	
Linear	**		N.S.		N.S.		N.S.	
Quadratic	N.S.		++		N.S.		*	
Inoculation x N Rate	*		N.S.		N.S.		N.S.	
C.V.	13.6		5.8		10.8		5.4	

1/ 0 = Not inoculated
2/ I = Inoculated
**, *, ++, and + are 0.01, 0.05, 0.10, and 0.20 probability levels, respectively.

Table 2. Soil parameters for soybean study locations in 1984.

Site	Organic Matter	pH	P 1,2/ 0-6"	K 0-6"	NO_3^--N 0-6"	6-12"	12-24"	0-24"	Soluble Salts
	%		lb/ac						mmhos
NWES Hegne	2.7	7.9	12	343	16	10	13	39	.4
NWES Wheatville	4.3	7.7	13	282	28	16	28	72	.5
R. Peterson	2.1	8.0	17	145	28	25	49	102	.25
R. Buchholz	5.5	8.0	12	240	—	--	--	85 3/	.5

1/ $NaHCO_3$ Extractable P
2/ ppm = lb/ac times 0.5
3/ Sampled only to 18"

Table 3. Nitrogen concentration of the youngest full trifoliate petiole at bloom for soybean study in 1984.

	Site							
	NWES				Off Station			
	Hegne		Wheatville		R. Peterson		R. Buchholz	
N Rate	O 1/	I 2/	O	I	O	I	O	I
lb/ac	% N							
0	4.49	4.57	5.19	5.39	5.31	5.28	5.73	5.28
30	4.35	4.80	5.32	5.23	5.29	5.27	5.33	5.06
60	4.80	4.80	5.31	5.30	5.34	5.33	5.79	5.48
90	5.11	5.17	5.29	5.51	5.27	5.34	5.71	5.23
120	5.13	5.21	5.76	5.67	5.33	5.40	5.46	5.30
STATISTICS								
Inoculation	N.S.		N.S.		N.S.		++	
N Rate	**		*		N.S.		++	
Linear	**		**		N.S.		N.S.	
Quadratic	N.S.		++		N.S.		N.S.	
Inoculation x N Rate	N.S.		N.S.		N.S.		N.S.	
C.V.	7.0		5.1		4.0		5.2	

1/ O = Not inoculated
2/ I = Inoculated
**, *, ++, and + are 0.01, 0.05, 0.10, and 0.20 probability levels, respectively.

No response to any treatment was found at the R. Peterson location. This particular location had a high soil NO_3^--N of 102 lb/ac in the top 2 feet.

A small quadratic yield response to N occurred at the R. Buchholz location. This was not expected because of the high soil NO_3^--N level (85 lb/ac in top 1.5 feet). The positive response was only one bushel but was statistically significant. A positive response in yield was caused by inoculation. As stated earlier no visual increase in nodules from inoculation was observed. The plant trifoliate N concentration analysis indicated no response to N. There was a negative response from inoculation. The reason for this is not clear.

Overall, this study has revealed that soil NO_3^--N levels do influence yield response to N fertilizer in Northwest Minnesota. Also, some unknown factor, besides high soil NO_3^--N levels, is restricting the plant's ability to produce N fixing nodules.

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HIGH PHOSPHORUS AND POTASSIUM RATES ON CONTINUOUS SPRING WHEAT

J. A. Lamb and R. K. Severson

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

Experimental procedure: Ten treatments consisting of P and K combinations have been used. Treatment combinations and applications made to date are shown in Table 1. Treatments applied in the fall of 1983 were broadcast and plowed down. Nitrogen, as urea, was fall applied at 90 lb N/A and incorporated with a field cultivator on September 26, 1983. Marshall wheat was planted on May 2, 1984 and harvested for grain yields on August 15, 1984. Whole plant samples were taken at soft dough July 30, 1984 for elemental analyses and used to determine forage yields and N, P, and K uptake. Soil samples were taken after crop removal to measure the residual effects of the treatments.

Results: Elemental analyses of the whole plant samples taken at soft dough are shown in Table 2. Significant differences in N, P, K, Ca, Mg, and Zn at soft dough (Table 2) were obtained between treatments.

Grain yield, protein, test weight, forage yield, N, P, and K uptake values shown in Table 3 indicate that yield, grain protein, dry matter yield, test weight, and P uptake were affected by the treatments.

Soil test results from the fall of 1984 sampling date are shown in Table 4. Samples were analyzed by North Dakota State University's soil testing laboratory. Significant differences in residual P and K levels were obtained.

Discussion: Grain yields (Table 3) were very good this year because of ideal environment conditions for small grains. A response in grain yield to treatments that involved the addition of P and K fertilizers was shown. The soil test results (Table 4) would indicate that the increased P and K levels in the soil increased grain yields with a majority of the increase from P fertilization. Treatments 9 and 10 involved one application at the establishment of the study and had smaller yield responses and lower soil test values. The soil data indicates that current recommendations for addition of K fertilizer when the soil test level is less than 300 lb K/ac (150 ppm) is correct.

Plant P (soft dough) and P uptake (forage) correlated well with yield (r = .83 and .94). Potassium uptake (forage) and plant K (soft dough) correlated moderately (r = .56) and poorly (r = .18) with yield, respectively.

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

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

Table 2. Effect of P and K rate combinations on the elemental analyses of whole plant samples of spring wheat taken at maturity (soft dough).

Treatment No.	Elemental Analyses								
	N	P	K	Ca	Mg	Mn	Zn	Cu	B
	%					ppm			
1	1.63	0.22	1.27	0.13	0.20	41	24	3	3
2	1.56	0.22	1.38	0.14	0.18	42	26	2	3
3	1.36	0.24	1.13	0.11	0.17	38	16	2	3
4	1.47	0.25	1.35	0.14	0.19	42	14	2	3
5	1.43	0.24	1.31	0.14	0.16	38	16	2	2
6	1.51	0.24	1.11	0.12	0.20	40	11	2	3
7	1.53	0.25	1.22	0.14	0.18	40	13	2	3
8	1.36	0.25	1.19	0.14	0.18	36	15	2	3
9	1.53	0.23	1.19	0.15	0.20	39	20	2	3
10	1.59	0.23	1.28	0.17	0.19	40	23	6	3
Significance	**	**	*	*	*	N.S.	**	N.S.	N.S.
B.L.S.D. (.05)	.17	.02	.21	.03	.03		4		
C.V. (%)	6.9	5.0	9.4	14.0	9.8	8.7	18.2	107.8	19.9

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

Table 3. Effect of P and K rate combinations on grain yield, protein, test weight, forage yield, N, P, and K uptake.

Treatment No.	Forage			Forage			
					Uptake		
	Yield	Protein	Test Weight	D.M. Yield	N	P	K
	Bu/A	%	lb/Bu	lb/ac			
0	50.36	15.58	58.3	7029	114.4	15.1	89.8
2	55.88	14.92	60.4	8063	126.3	17.7	112.0
3	63.12	13.78	62.1	8470	115.2	20.5	96.2
4	62.41	14.19	61.5	8256	121.7	20.2	111.3
5	64.95	14.51	60.9	8893	127.2	21.0	117.0
6	59.38	14.26	60.6	8677	131.4	20.4	96.5
7	63.42	13.85	61.6	8940	137.4	21.9	109.3
8	61.97	13.61	61.8	8682	117.8	21.2	103.2
9	57.32	14.56	59.8	7911	121.1	17.8	93.5
10	58.93	14.78	60.1	8320	132.3	19.2	106.5
Significance	**	**	**	*	N.S.	**	N.S.
B.L.S.D. (.05)	5.50	1.08	1.3	1219		2.7	
C.V. (%)	6.3	4.6	1.5	8.5	13.2	9.6	15.3

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

Table 4. Effect of P and K rate combinations on residual P and K soil test levels after five years of application

Treatment No.	pH 0-6"	pH 6-12"	$NaHCO_3$ P 0-6"	$NaHCO_3$ P 6-12"	Exchangeable K 0-6"	Exchangeable K 6-12"
			- - - - - - - - - - - - lb/ac[1/]		- - - - - - - -	
1	8.1	8.2	7	6	281	243
2	8.0	8.1	8	7	356	299
3	8.1	8.1	26	16	359	304
4	8.1	8.1	48	23	365	281
5	8.0	8.0	27	16	373	304
6	8.1	8.1	41	27	270	238
7	8.0	8.1	42	23	315	253
8	8.0	8.1	55	28	359	291
9	8.0	8.1	14	9	296	246
10	8.1	8.0	11	9	279	249
Significance	N.S.	+	**	**	**	**
B.L.S.D. (.05)		0.1	5	4	41	35
C.V. (%)	1.0	0.9	13.6	16.5	8.9	8.8

1/ ppm = lb/ac times 0.5
** and + are 0.01 and 0.10 significance levels, respectively

AVAILABILITY OF RESIDUAL NITRATE-N TO CORN

Lamberton, 1983 and 1984

G. W. Randall and W. W. Nelson

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

Experimental Procedures

Nitrogen fertilizer was applied as urea annually from 1973-1979 to tile drained plots each measuring 45' x 50' and lined with plastic at Lamberton. Rates of 18, 100, 200, and 400 lb N/A were replicated three times. An additional treatment (200 lb N/A as soybean meal) was applied to isolated plots which were not within the original replications. Consequently, statistical analyses have been performed only on the former four treatments.

Corn has been grown continuously from 1973 thru 1984. The grain has been removed and all remaining residue plowed down annually. Nitrogen removal in the grain has been measured. In addition, N losses thru the tile lines have been determined by measuring flow rate and NO_3-N concentrations when tile flow occurred. Each fall (when possible) soil samples have been taken to a 10-foot depth to determine residual NO_3-N in the soil.

Because some of the N treatments exceeded the N removal rates, substantial amounts of NO_3-N accumulated from 1973-1979. Consequently, no fertilizer N has been applied to the plots since May 1979. Research efforts since 1979 have attempted to monitor the availability of the residual NO_3-N to corn and to follow the movement of NO_3-N either in the soil or into the tile lines. Results from 1980-82 can be found in University of Minnesota Agr. Exp. Stn. Misc. Pub 2 (revised) - 1983. p 78-81.

In 1983 and 1984, 125 lb N/A as anhydrous ammonia was applied to an isolated 6-row strip between the plots so that crop response to the residual N could be compared to this annual application. Because the soil NO_3-N concentrations in the top 3' were very low in the fall of 1983, 40 lb N/A was applied as urea to all plots in the spring of 1984. Weeds and insects were controlled adequately on all plots by pesticides. All plots have been moldboard plowed each fall.

Results - 1983

Because of extremely wet conditions in the fall of 1982, deep soil samples were not taken until May, 1983. Residual NO_3-N concentrations from this spring sampling are presented in Table 1 and do show the effects of the previous N applications over the 7-year period (1973-79). A slight increase in NO_3-N throughout the 10-foot profile was found with the 100-lb rate compared to the 18-lb rate. Nitrate-N remaining in the profile 4 years after discontinuing the 200- and 400-lb annual applications was 2X and 5X, respectively, that remaining with the recommended N rate (100-lb N/A). Moreover, most of the residual NO_3-N was below five feet and, thus, was below the rooting depth of corn. Even though slightly less residual remained with the 200-lb organic N treatment the distribution was very similar to the 200-lb fertilizer N treatment.

Corn yields shown in Table 2 were very low due to the hot and dry conditions during July and August, 1983. Grain yields from all of the previous N treatments were substantially below the yield of 86.1 bu/A obtained from the 6-row strip where N was applied in 1983. Although the grain yield from the 400-lb treatment appeared to be slightly higher than from the other treatments, the differences among treatments were not consistent and were not significant at the 95% level. Grain N concentration was not affected by the previous N treatments. Silage yield and total N uptake (silage yield x N concentration) were both increased by the carryover N from the 400-lb N treatment. In summary, residual NO_3-N found in the soil profile in May did not have a consistent effect on corn production in 1983. Perhaps the NO_3-N, which had accumulated with the 200- and 400-lb rates, was too deep for sufficient plant uptake.

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

Table 1. Residual NO_3-N in the 0-10' soil profile in May, 1983 as influenced by previous N application at Lamberton.

Profile depth	Annual N rate (lb/A) 1/				
	18	100	200	400	200 org.
feet	ppm				
0-1	1.6	2.7	3.7	4.5	3.4
1-2	0.7	1.0	1.5	1.7	1.3
2-3	0.7	0.9	1.5	2.1	1.8
3-4	0.8	1.1	1.8	8.7	2.9
4-5	0.7	1.5	2.7	20.4	3.7
5-6	0.8	2.1	5.8	24.8	5.2
6-7	1.3	3.4	8.0	20.8	5.2
7-8	1.6	3.2	5.3	15.8	3.8
8-9	1.7	2.4	4.1	8.9	2.3
9-10	1.8	2.0	4.8	6.6	1.9
Total lb NO_3-N in 10-foot profile	47	81	157	457	126

1/ Annual application over 7-year period (1973-79).

Table 2. Corn production and N utilization in 1983 as influenced by residual NO_3-N from annual N applications from 1973-1979 at Lamberton.

Annual N rate	Final popl'n.	Fodder N	Silage Yield	Silage N uptake	Grain Yield	Grain N	Grain N removal
lb N/A	ppA x 10^{-3}	%	T DM/A	lb N/A	bu/A	%	lb N/A
18	25.1	.52	2.20	34.9	39.7	1.24	23.3
100	23.1	.43	2.10	32.2	39.0	1.27	23.3
200	23.5	.49	2.11	32.8	36.8	1.27	22.0
400	23.0	.53	2.49	40.6	46.4	1.24	27.3
Signif. Level (%): 1/	83	92	99	99	92	82	94
BLSD (.05) :			.31	7.1			
CV (%) :	5.0	11.	7.7	11.	13.	4.2	15.
200 org.	23.3	.41	2.46	38.9	47.9	1.30	29.4

1/ Probability level that a difference among the four means listed above is significant.

The tile lines flowed from March thru mid-July in 1983. Tile flow among the treatments was extremely uniform and averaged 15.5 acre inches (Table 3). Average flow-weighted NO_3-N concentrations for 1983 ranged from 6.0 mg/L with the 18-lb treatment to 64.8 mg/L with the 400-lb treatment. Even the 100- and 200-lb treatments which did not contain enough residual NO_3-N in the crop rooting zone to improve corn yields resulted in average NO_3-N concentrations of 11.0 and 25.8 mg/L, respectively.

Table 3. Tile line flow, average NO_3-N concentration and total NO_3-N losses into the tile lines in 1983 as related to annual N application rates from 1973-1979 at Lamberton.

Annual N rate	Total tile flow	Nitrate N Avg. Concentration	Nitrate N Losses
lb N/A	acre-inches	mg/L	lb/A
18	15.45	6.0	21.1
100	14.54	11.0	36.3
200	14.15	25.8	82.6
400	16.70	64.8	245.1
200 org.	16.83	15.2	58.0

Nitrate N concentrations in the tile water decreased during the 1983 season (data not shown). Concentrations decreased from 12 mg/L in March to 10 mg/L in July with the 100-lb, from 31 to 17 mg/L with the 200-lb rate, from 79 to 45 mg/L with the 400-lb rate, and from 19 to 12 mg/L with the 200-lb rate as organic N. Nitrate-N concentrations in the 18-lb rate did not change during 1983.

Nitrate-N losses thru the tile lines were quite high (Table 3) and on a relative basis compared very closely to the amount of residual N found in the 10-foot profile (Table 1). The 200-lb organic N treatment gave a lower NO_3-N concentration and resulted in slightly less NO_3-N losses than did the 200-lb N treatment as urea.

Summary - 1983

Large quantities of residual N found below three feet were lost via tile discharge. The amount of loss and NO_3-N concentrations were directly related to residual NO_3-N levels found at these depths. Corn production with the exception of silage yield and total N uptake, however, was not consistently influenced by the carryover NO_3-N. Perhaps the corn roots were not deep enough to extract the carryover N which was susceptible to tile loss.

Results - 1984

Residual NO_3-N remaining in the soil profile after the 1983 season and available for the 1984 crop is shown in Table 4. Very little carryover N was found following the 18-lb treatment. Carryover of NO_3-N in the top 10-feet was 3X and 9X more with the 200- and 400-lb N treatments compared to the 18-lb treatment. Most of the NO_3-N was found below 5' with the 200-lb treatment and below 4' with the 400-lb treatment. Highest NO_3-N concentrations were found in the 6-8' zone and 5-7' zone with each of these treatments, respectively. Although the NO_3-N distributions were similar, approximately 30% less NO_3-N was found in the soil profile with the 200-lb organic N treatment compared to the same N rate as urea.

Table 4. Residual NO_3-N in the 0-20' soil profile in October, 1983 as influenced by previous N application at Lamberton

Profile depth	Annual N rate (lb/A)[1/]			
	18	200	400	200 org.
feet	ppm			
0-1	2.1	2.7	4.7	3.5
1-2	0.3	0.6	1.0	0.6
2-3	0.5	1.1	1.1	0.8
3-4	0.4	1.8	7.4	1.5
4-5	1.2	3.7	18.8	2.2
5-6	1.0	6.8	30.7	4.1
6-7	2.2	10.5	26.6	6.7
7-8	2.1	9.7	17.7	5.8
8-9	2.4	6.5	15.0	4.9
9-10	2.6	5.3	10.1	4.0
10-11	2.2		5.7	
11-12	2.1		5.5	
12-13	1.8		9.6	
13-14	1.8		9.4	
14-15	1.1		5.6	
15-16	1.2		4.6	
16-17	1.7		4.1	
17-18	1.1		6.7	
18-19	0.9		3.5	
19-20	1.4		2.8	
Total lb NO_3-N in 10-foot profile	59	195	533	136

[1/] Annual application over 7-year period (1973-79).

Soil samples were taken to 20' to determine if NO_3-N had moved through the profile over the 11-year period of this experiment. Very low NO_3-N concentrations were found throughout the profile with the 18-lb N treatment (Table 4). Residual NO_3-N from the 400-lb rate moved to at least the 20-foot depth at the end of 11 years.

With the exception of grain N, none of the corn production parameters shown in Table 5 were affected significantly by the carryover NO_3-N in the soil profile (Table 4). Even though a 40-lb rate of N was added to all plots to stimulate plant growth and root development there was little consistent evidence that the corn was obtaining much of the residual NO_3-N. Because of the high plot variability the "apparent" 12 and 30 bu/A responses with the 200- and 400-lb N rates were not significant (P = 61%). High plot variability also erased the apparent silage yield, total N uptake, and grain N removal responses with the 400-lb rate. Corn yields from all plots were substantially below the 138.3 bu/A yield from the 6-row strip where 125 lb NA was added in 1984. Grain N averaged 1.18% N from this 6-row strip.

Table 5. Corn production and N utilization in 1984 as influenced by residual NO_3-N from annual N applications from 1973-1979 at Lamberton.

Annual N rate	Final popl'n.	Leaf N	Fodder N	Silage Yield	Silage N uptake	Grain Yield	Grain N	Grain N removal
lb N/A	ppA x 10^3	%	%	T DM/A	lb N/A	bu/A	%	lb N/A
18	23.5	2.19	.42	3.38	53.3	86.0	1.10	44.7
100	23.1	2.04	.39	3.30	50.9	82.6	1.09	42.8
200	22.7	1.70	.40	3.78	61.9	97.6	1.14	52.8
400	23.7	2.10	.45	4.34	75.3	116.0	1.18	64.5
Signif. Level (%):[1/]	62	86	68	66	81	61	93	83
CV (%) :	3.6	11.	9.1	21.	23.	25.	3.5	24.
200 org.	23.3	1.84	.40	3.18	48.3	77.6	1.08	39.8

[1/] Probability level that a difference among the four means listed above is significant.

Tile lines flowed from March thru mid-July in 1984, but flow was not as consistent among the treatments as in 1983. This was perhaps due to the extremely heavy rains in June (7.73 inches between June 8 and 23). Tile flow averaged 19.7 acre-inches for the 5-month period. Because of the high rainfall amounts it is possible that some water from the untiled borders around the plots may have moved under the plastic barriers and into the tile plots. This could partially explain the high tile flow which almost exceeded precipitation during this 5-month period (20.20").

Table 6. Tile line flow, average NO_3-N concentration and total NO_3-N losses into the tile lines in 1984 as related to annual N application rates from 1973-1979 at Lamberton.

Annual N rate	Total tile flow	Nitrate-N Avg. Concentration	Nitrate-N Losses
lb N/A	acre-inches	mg/L	lb/A
18	18.27	11.9	49.2
100	16.90	14.6	56.1
200	17.15	18.0	69.7
400	20.77	33.0	155.1
200 org.	25.60	16.2	94.1

Average flow-weighted NO_3-N concentrations ranged from 11.9 to 33.0 mg/L in 1984 (Table 6). Concentrations from the 200- and 400-lb treatments were markedly less than in 1983. However, NO_3-N concentrations from the 18-lb and 100-lb treatments were slightly higher than in 1983, probably due to the 40-lb N addition to all plots and to mineralized N which had accumulated during the dry previous year but which had not been taken up by the 1983 crop.

Nitrate-N losses in the tile discharge were again quite sizable in 1984 (Table 6). Even though NO_3-N concentrations have decreased since 1979, the large flow volumes coupled with concentrations between

12 and 33 mg/L resulted in losses ranging from 49 lb/A with the 18-lb treatment to 155 lb/A with the 400-lb treatment. Both NO_3-N concentrations and losses were higher for the 200-lb organic N treatment compared to the same N rate as urea.

Residual NO_3-N remaining in the soil profile after the 1984 season is shown in Table 7. Approximately 2X and 5X as much NO_3-N was found in the 0-10' profile with the 200- and 400-lb N rates, respectively, compared to the 18-lb N rate. Similar to October, 1983, most of the NO_3-N was found below 5' with the 200-lb treatment and below 4' with the 400-lb treatment. Highest NO_3-N concentrations were found in the 6-8' zone and 5-7' zone with each of the treatments, respectively. Although the distribution of NO_3-N within the profiles was similar, 20% less NO_3-N was found in the soil profile with the 200-lb organic N treatment compared to the same N rate as urea.

Table 7. Residual NO_3-N in the 0-10' soil profile in October, 1984 as influenced by previous N application at Lamberton.

Profile depth	Annual N rate (lb/A)[1/]			
	18	200	400	200 org.
feet	ppm			
0-1	1.9	2.8	3.1	2.5
1-2	1.0	1.7	1.8	1.3
2-3	1.2	2.1	2.7	1.2
3-4	1.4	2.6	4.8	1.9
4-5	1.6	3.2	11.7	3.0
5-6	1.7	4.7	19.9	3.8
6-7	2.2	7.1	19.8	6.9
7-8	2.3	8.1	15.7	6.0
8-9	2.8	7.2	13.5	4.9
9-10	2.9	4.8	10.7	3.8
Total lb NO_3-N in 10-foot profile	76	177	415	141

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

Summary - 1984

Large quantities of residual N were lost via tile discharge again in 1984. The source of that lost N was thought to be primarily from N mineralized during the previous season as well as that which had accumulated at depths below 4' from the 1973-79 fertilizer applications. Even though NO_3-N concentrations in the water from the high N rates were lower than in past years, the high flow volumes in 1984 resulted in substantial NO_3-N losses via the tile lines. Corn production, with the exception of grain N concentration, was not affected by the carryover NO_3-N from the previous N treatments. Significant amounts of residual NO_3-N still remained in the soil profile below 5' and 4' at the end of 1984 with the 200- and 400-lb N rates, respectively.

12-YEAR TILE DRAIN SUMMARY

Total NO_3-N losses via tile discharge water are presented in Table 8 for the fertilized period (1973-79) and for the residual period (1980-84). Due to higher precipitation in the last 5 years, approximately two-thirds of the 12-year tile flow occurred in the 5-year residual period. Nitrate-N losses during the residual phase of the study approximated the losses during the 7-year fertilizer application period. From 29 to 41% of the fertilizer applied at the 200- and 400-lb N/A rates (the recommended rate is 100 lb N/A) were lost from the soil thru the tile lines during this 12-year period.

Table 8. Summary of NO_3-N losses thru tile discharge from 1973-84 at Lamberton.

Total Applied N (1973-79) 1/	Nitrate-N Lost thru Tiles 2/			Percent of applied N lost
	1973-79	1980-84	1973-84	
lb N/A	lb NO_3-N/A			%
126	80	87	167	-
700	161	138	299	23
1400	299	239	538	29
2800	639	637	1276	41

1/ Does not include the 40-lb rate applied in 1984.

2/ 20.8 acre-inches tile drainage in 1973-79, 43.0 acre-inches in 1980-84.

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

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

(Annual reports of this experiment have been reported in Soil Series 74 through 113 and some of this information will not be included here).

The fertilizer treatments have now been applied annually to the same plots area for 25 years. After ear corn removal and stalks cutting, the fall plow down treatments are broadcast on their respective plots and the entire area is then plowed to an approximate 12 inch depth. The fall surface N treatments are then broadcast, with no further working of the plow area. Each plot is 20' by 77.5' and the 4 replications are arranged in a randomized block. Spring N treatments are broadcast before seedbed preparations late in April or early May. The corn is planted in 30 inch rows at a plant population of 20,000 plants/A, using a band starter fertilizer of 8-24-12 at a rate of 180#/A over the entire expermintal area, thus supplying an additional 14 #N/A to all plots. Nitrogen sidedressing treatments were broadcast in June.

The yields obtained in 1984 were below average when considering the long term previous average for this experiment. Treatments averages in 1984 appeared to follow the trends which had been established with the long term average yields.

TWENTY-FOUR YEAR AVERAGE

The average grain yields for the twenty-four years of this experiment are shown in Table 2. Only modest differences were obtained between nitrogen forms, time of application and incorporation in the 1984 experiment. In 1984 with 40 #N/A applied as urea fall plow down was superior to ammonium nitrate fall plow down. When both materials were applied at the same rate to the surface there was essentially no difference. When urea was applied as a spring top dressed treatment, it was also superior to ammonium nitrate. This is observed in the long term average.

Plowing down 160 #N/A in the fall was much more effective than the lower N rates and approached the yields that were obtained with the sidedress application of nitrogen. Urea applied in the fall produced similar yields to spring applications,ammonium nitrate also produced similar yields.

Table 1 Influence of nitrogen form, nitrogen rates,on grain N content, grain N removal, and grain yield on a Webster loam near Lamberton MN. 1984.

N-Rate	N-Cont. Grain	N-Removal Grain	Rep 1	Rep 2	Rep 3	Rep 4	Ave
#/A [1]	%	#/A		Bu/A 15.5 %			
Check	1.09	28.9	43.8	60.1	51.8	69.7	56.4
40 NH_4NO_3 - fpd [2]	1.02	32.2	68.1	72.2	48.4	78.3	66.8
40 Urea fpd	1.06	36.4	65.3	80.1	65.5	79.3	72.6
40 NH_4NO_3 - fps [3]	1.03	32.4	64.4	63.9	62.2	73.8	66.1
40 Urea - fps	1.08	32.3	50.2	72.3	53.4	76.3	63.0
80 NH_4NO_3 - fpd	1.12	38.9	63.0	114.1	53.1	57.2	71.8
80 Urea - fpd	1.00	36.4	62.1	94.5	70.3	79.5	76.6
160 NH_4NO_3 - fpd	1.08	49.9	102.2	102.2	103.2	81.9	97.4
160 Urea - fpd	1.14	51.9	99.3	120.7	79.3	85.2	96.1
40 NH_4NO_3 - std [4]	1.03	31.8	32.7	95.8	59.5	75.5	65.9
40 Urea - std	1.03	38.5	69.6	62.0	82.9	99.6	78.5
80 NH_4NO_3 - std	0.97	36.9	81.8	81.8	72.5	84.2	80.1
80 Urea - std	1.13	44.4	81.0	91.5	57.9	103.1	83.4
40 NH_4NO_3 - sd [5]	1.04	43.1	85.2	88.9	92.5	81.2	87.0
40 Urea - sd	0.99	42.8	76.7	101.3	108.9	81.0	92.0
80 NH_4NO_3 - sd	1.16	58.1	113.8	115.4	83.2	112.0	106.1
80 Urea - sd	1.27	58.1	92.3	92.4	93.5	107.2	96.4
160 NH_4NO_3 - sd	1.13	58.8	84.1	123.9	116.2	114.2	109.6
P-Value	99	99					99
(BLSD.05)	0.12	9.7					19.0

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

[2] fpd - fall plow down

[3] fps - fall plow surface

[4] std - spring top dress

[5] sd - sidedress

Table 2. Yields of ear corn during 24 years on tiled Webster loam near Lamberton with annual applications of NH_4NO_3 or urea nitrogen at different rates, times, and placement.

N-Rate	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
#/A [1]						Bu/A								
Check	49.5	88.2	26.1	132.6	72.9	33.1	11.1	53.4	102.4	92.8	85.7	40.8	75.6	69.2
40 NH_4NO_3-fpd [2]	42.3	87.5	30.9	148.6	88.6	34.9	26.8	75.7	131.6	109.3	96.3	88.7	113.6	92.0
40 Urea-fpd	55.1	78.2	29.1	148.8	100.3	38.8	19.8	86.9	132.5	124.5	120.4	100.7	113.9	101.2
40 NH_4NO_3-fps [3]	49.0	96.7	29.6	140.1	101.5	45.6	24.3	75.1	135.2	124.6	122.5	81.5	109.9	93.0
40 Urea-fps	62.3	101.3	37.0	140.7	84.1	57.4	30.9	87.2	134.0	136.1	121.2	82.4	106.7	97.8
80 NH_4NO_3-fpd	67.4	97.9	43.6	149.6	100.8	63.4	47.3	114.3	131.2	146.8	134.7	108.0	143.1	121.7
80 Urea-fpd	61.7	76.9	36.7	154.5	104.9	73.0	37.8	117.2	142.6	144.3	141.4	107.8	140.1	117.9
160 NH_4NO_3-fpd	69.8	97.9	46.7	147.7	100.9	70.8	38.5	127.4	140.2	158.7	141.7	120.2	147.6	121.0
160 Urea-fpd	79.4	112.5	43.5	152.8	112.4	73.5	37.7	121.3	149.9	161.0	140.4	110.6	151.7	114.9
40 NH_4NO_3-std [4]	66.2	92.0	45.4	152.2	99.8	63.4	23.7	99.8	128.0	142.0	125.6	84.0	117.0	104.0
40 Urea-std	45.4	91.1	31.4	147.6	100.6	59.8	33.8	95.0	140.5	143.4	118.9	94.6	116.5	97.1
80 NH_4NO_3-std	59.3	90.0	32.7	149.2	112.5	74.2	49.0	128.3	144.7	159.5	140.4	122.7	142.7	118.0
80 Urea-std	57.7	99.1	40.5	149.3	115.7	84.4	41.8	128.6	138.7	155.9	146.2	116.0	142.1	117.6
40 NH_4NO_3-sd [5]	63.6	92.6	39.5	148.6	90.4	54.8	38.6	96.8	133.4	142.3	127.1	104.5	136.0	99.1
40 Urea-sd	57.7	95.6	24.9	142.3	94.1	48.4	50.4	86.1	132.2	143.3	117.1	100.5	133.9	103.9
80 NH_4NO_3-sd	50.4	98.4	46.7	140.7	113.0	68.1	43.8	101.6	137.7	140.3	127.7	97.6	124.7	109.4
80 Urea-sd	76.9	86.4	48.2	143.8	121.4	64.7	47.3	117.0	146.9	166.2	140.5	124.4	149.8	124.0
160 NH_4NO_3-sd	40.7	97.4	77.7	151.7	109.5	77.6	51.4	120.2	141.5	148.3	136.9	104.2	150.0	117.1
Ave. Bu/A	58.6	93.3	39.4	147.5	101.3	60.3	37.8	101.8	135.7	140.9	127.0	99.4	128.6	106.6

	1974	1975 @	1977	1978	1979	1980	1981	1982	1983	1984	24 yr. Ave
Check	53.4	58.4	141.2	64.6	37.6	46.5	65.8	71.0	30.0	56.3	61.8
40 NH_4NO_3-fpd [2]	80.5	88.6	145.1	98.1	63.1	67.6	77.4	91.5	43.0	66.7	79.2
40 Urea-fpd	96.9	96.6	165.2	110.2	76.7	65.2	87.0	119.1	41.0	72.5	86.3
40 NH_4NO_3-fps [3]	88.3	78.2	149.4	101.3	64.6	69.7	89.4	107.4	41.0	66.0	82.2
40 Urea-fps	85.0	78.9	156.8	101.4	80.2	63.8	80.5	113.0	44.0	63.0	84.8
80 NH_4NO_3-fpd	103.6	89.2	156.9	128.4	94.8	90.3	89.6	132.0	55.0	71.8	98.3
80 Urea-fpd	107.2	96.9	146.0	123.6	86.2	84.7	101.8	131.4	46.0	76.6	97.0
160 NH_4NO_3-fpd	113.1	90.4	149.8	129.3	108.7	109.3	91.3	138.2	66.0	97.3	103.9
160 Urea-fpd	105.1	82.4	163.0	124.4	127.3	103.7	97.6	133.8	63.0	96.1	105.4
40 NH_4NO_3-std [4]	82.8	88.0	160.0	97.4	86.6	77.2	90.0	115.0	46.0	65.8	89.1
40 Urea-std	94.5	89.0	165.2	103.9	74.5	64.3	86.6	102.4	47.0	78.5	88.1
80 NH_4NO_3-std	92.9	97.6	162.9	117.1	87.3	74.4	101.4	134.9	57.0	80.0	100.1
80 Urea-std	108.5	93.6	162.2	127.4	100.3	84.4	102.8	125.9	62.0	83.3	102.1
40 NH_4NO_3-sd [5]	82.7	91.8	153.8	106.8	99.2	71.9	83.6	116.1	49.0	86.9	91.3
40 Urea-sd	80.4	92.6	165.4	104.8	94.2	80.4	87.4	116.2	51.0	91.9	91.2
80 NH_4NO_3-sd	87.6	95.3	163.2	110.6	106.3	76.9	79.3	135.2	49.0	106.1	95.6
80 Urea-sd	95.6	90.1	162.8	126.7	118.1	89.6	87.4	131.0	55.0	96.3	103.4
160 NH_4NO_3-sd	105.5	91.3	160.3	126.0	148.0	109.8	96.7	136.3	70.0	109.6	106.4
Ave Yield Bu/A	92.4	88.3	157.2	111.2	91.9	79.4	88.6	119.5	51.0	81.4	92.6
P-Value										99	99
BLSD(.05)										19.0	5

[1] The entire area receivied an additional 14 #N/A as starter fertilizer annually (8-24-12 @ 180 #/A).
@ 1976 No Yields Taken

[2] fpd - fall plow down

[3] fps - fall plow surface

[4] std - spring top dress

[5] sd - sidedress

WEST CENTRAL EXPERIMENT STATION - MORRIS

WEATHER SUMMARY - 1984

Month	Period	Precipitation 1984	Precipitation 94-yr av.	Precipitation Dev. from av.	Temperature 1984	Temperature 94-yr. av.	Temperature Dev. from av.	Soil Temperature (10 cm depth) 1984	Soil Temperature (10 cm depth) 10-yr. av.
January	1-31	0.74	0.68	+ .06	9.7	8.0	+1.7	*	20.7
February	1-29	1.05	0.67	+ .38	24.8	12.6	+12.2	*	23.9
March	1-31	1.28	1.09	+ .19	21.4	26.7	-5.3	*	29.2
April	1-10	0.05	0.58	- .53	42.8	37.9	+4.9	*	
	11-20	1.65	0.65	+1.00	45.2	44.4	+0.8	*	
	21-30	0.64	1.08	- .44	48.6	48.2	+0.4	44.0	
Total or av.		2.34	2.31	+ .03	45.5	43.5	+2.0	*	41.4
May	1-10	1.70	0.78	+ .92	45.8	51.9	-6.1	44.6	
	11-20	0.39	0.95	- .56	58.6	55.8	+2.8	57.5	
	21-31	0.45	1.25	- .80	55.7	60.1	-4.4	59.6	
Total or av.		2.54	2.98	- .44	53.5	56.1	-2.6	54.0	57.1
June	1-10	2.70	1.26	+1.44	65.6	63.1	+2.5	65.6	
	11-20	2.04	1.27	+ .77	63.1	66.5	-3.4	63.6	
	21-30	1.50	1.38	+ .12	68.0	68.2	-0.2	71.0	
Total or av.		6.24	3.91	+2.33	65.6	66.0	-0.4	66.8	69.3
July	1-10	0.68	1.48	- .80	68.2	70.0	-1.8	74.7	
	11-20	0.38	1.03	- .65	69.0	71.3	-2.3	75.6	
	21-31	0.26	1.03	- .77	71.5	71.5	0	77.5	
Total or av.		1.32	3.54	-2.22	69.6	71.0	-1.4	75.9	76.7
August	1-10	1.84	1.05	+ .79	73.5	70.3	+3.2	76.0	
	11-20	0.08	0.90	- .82	72.4	69.2	+3.2	79.4	
	21-31	4.42	0.98	+3.44	66.7	66.9	-0.2	70.2	
Total or av.		6.34	2.93	+3.41	70.7	68.7	+2.0	75.1	73.9
September	1-30	1.82	2.19	- .37	53.2	59.1	-5.9	58.2	61.5
October	1-31	9.21	1.62	+7.59	47.2	47.3	-0.1	48.2	47.8
November	1-30	0.16	0.96	- .80	30.6	29.7	+0.9	32.2	33.6
December	1-31	1.15	0.68	+ .47	13.0	15.5	-2.5	24.5	23.4
April-August Growing Season		18.78	15.67	+3.11	61.0	61.1	-0.1	*	63.8
January-December Annual		34.19	23.56	+10.63	42.1	42.0	+0.1	*	46.7

*Equipment inoperative.

MANURE RATE STUDY

West Central Experiment Station - Morris

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

Solid and liquid beef manures were applied at three rates and the effects were compared against check plots. Results from previous years are given in Soils Series 91, 95, 97, 99, 103, 105, 107, 109, and Misc. Publ. 2-1982-84. 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 1, 1984, @ 24,300 seeds/acre. Counter was applied @ 8.8 lbs/acre (1 lb/acre active ingredient) in the row to the entire area at planting. The fertilized plots received 120 + 50 + 50 ($N + P_2O_5 + K_2O$) lbs/acre on October 25, 1983. Lasso @ 2.5 lbs/acre and Bladex @ 2.2 lbs/acre were applied broadcast on May 11. Silage samples were taken by hand on September 17 and the grain harvest was taken with a plot combine on November 2 and 5.

II. Soil Sampling and Analysis

A. 1983 Measurements

NO_3-N was the only variable measured in the fall of 1983. The values shown in Table 1 indicate some changes from NO_3-N level one year earlier. The NO_3-N in the 0-1' zone increased slightly for all treatments, while values decreased or stayed the same for LB and check treatments in the 1-2' zone. Conversely, in the SB and FE treatments, the NO_3N level in the 1-2' zone increased. NO_3-N levels were consistently lower in both the 2-3' and 3-4' zones.

B. 1984 Measurements

Extremely wet conditions prevented NO_3-N samples from being taken in the fall of 1984.

III. Plant Tissue Analysis

The nutrient concentrations in the ear leaves at silking in 1984 are given in Table 2. There were significant effects on all elements. Solid beef manure generally increased leaf levels of P, K, and Fe and decreased leaf levels of Mg and Zn as compared to the fertilized check. The effects of liquid beef manure were similar to those of solid beef manure but the effects were reduced.

IV. Yield Measurements

A. Grain - Yields of the solid beef manure treatments were not significantly different from the fertilized check, but the LB1 and LB2 treatments were both significantly less.

B. Silage - The LB1 and LB2 treatments yielded significantly less than the fertilized check.

V. Summary

The 1984 season was the sixth since manure had been applied. The LB1 and LB2 treatments of manure were no longer adequate for grain yields to be equal to the fertilized check.

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

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 1983.

Depth	Treatment							
	CK	FE	SB1	SB2	SB3	LB1	LB2	LB3
- ft -	- - - - - - - - - - - - NO_3-N, ppm - - - - - - - - - - -							
0-1	8.5	11.1	16.3	35.4	43.1	13.6	11.9	15.5
1-2	3.4	28.5	36.4	126.7	77.7	9.5	8.5	29.7
2-3	2.0	71.9	78.9	203.3	169.3	31.9	36.6	88.7
3-4	2.3	61.8	41.7	181.0	162.0	29.4	48.0	120.7

Table 2. Summary of analysis of corn leaves at silking - 1984.

Treatment	Elements									
	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	- - - - - - % - - - - - -					- - - - - ppm - - - - -				
CK	1.87	0.17	1.42	0.45	0.44	82.0	12.3	3.2	60.3	7.4
FE	2.90	0.26	1.74	0.52	0.40	104.9	19.6	4.8	100.3	6.5
SB1	2.67	0.28	2.10	0.47	0.27	109.3	13.7	5.6	92.7	6.7
SB2	2.74	0.37	2.33	0.47	0.22	155.2	11.5	4.5	90.2	6.9
SB3	2.90	0.43	2.46	0.44	0.20	147.6	13.9	4.6	78.9	6.6
LB1	2.37	0.24	1.74	0.51	0.40	99.6	13.1	5.0	86.9	5.6
LB2	2.55	0.29	1.81	0.50	0.36	113.2	12.3	5.1	100.1	7.3
LB3	2.69	0.34	2.10	0.49	0.32	140.0	11.8	5.2	92.0	7.7
Signif. level (%)	99	99	99	94	99	99	99	99	86	99
BLSD(.05)	0.50	0.05	0.12	0.07	0.04	14.4	2.3	1.2	36.4	0.9
CV(%)	10.5	10.4	3.9	6.5	8.1	7.5	10.2	13.1	18.7	7.0

Table 3. Summary of plant measurements - 1984.

Treatment	Grain		Silage		
	Moisture at harvest	Yield @ 15.5% M	Dry matter at harvest	Silage yield (D.M.)	Ear wt. ÷ Silage wt.
	- % -	- Bu/A -	- % -	lbs/A	- % -
CK	25.1	57.0	44.7	6817	54.7
FE	24.8	136.2	42.4	13401	55.7
SB1	22.9	120.0	46.1	13844	59.2
SB2	23.3	116.9	47.9	16107	60.6
SB3	23.1	132.3	45.2	14060	55.9
LB1	24.0	109.0	46.0	10786	57.7
LB2	25.4	112.2	47.7	12563	58.2
LB3	24.3	120.2	48.7	14568	61.0
Signif. level (%)	47	99	93	99	21
BLSD(.05)	-	22.6	4.6	1962	-
CV(%)	7.2	11.8	4.8	9.4	9.4

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

West Central Experiment Station - Morris
S. D. Evans, P. R. Goodrich and R. C. Munter

The experiment initiated in 1970 was continued. Treatments and results from previous years are given in Soil Series 88, 89, 91, 95, 97, 99, 103, 105, 107, 109, and Misc. Publ. 2-1982-84. 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 1, 1984, @ 24,000 seeds/acre. Counter was applied @ 8.8 lbs/acre (1 lb/acre active ingredient) in the row to the entire area at planting. The fertilized plots received 120 + 50 + 50 ($N + P_2O_5 + K_2O$) lbs/acre on October 25, 1983. Lasso @ 2.5 lbs/acre and Bladex @ 2.2 lbs/acre were broadcast on May 11. Silage samples were taken by hand on September 17 and the grain harvest was taken with a plot combine on November 5.

II. Soil Sampling and Analysis

A. 1983 Measurements

NO_3-N was the only variable measured in the fall of 1983 (Table 1). In the fall of 1982 the total NO_3-N in the 0-4' profile was greater on all manure treatments than on the fertilized check. The 1983 values indicate that total NO_3-N of LB in the 0-4' profile is greater than the fertilized check, while SB and LH are now less.

B. 1984 Measurements

Extremely wet conditions prevented NO_3-N samples from being taken in the fall of 1984.

III. Plant Tissue Analysis

The nutrient concentrations in the ear leaves at silking in 1984 are given in Table 2. There were significant effects on many elements. The N and Zn concentrations were less for all manure treatments when compared to the fertilized check. Concentrations of Mg were less for SB and LB, and Fe was less for LH as compared to the fertilized check. The SB and LB treatments had significantly greater concentrations of K than did the fertilized check leaves.

IV. Yield Measurements (Table 3)

A. Grain - The LH treatment was the only treatment which had a significantly lower grain yield than the fertilized check.

B. Silage - The silage yield for the LH treatment was also the only one significantly lower than the fertilized check.

V. Summary

This is the first year since manure treatments were applied in 1970 and 1971 that yields were significantly lower for a manure treatment as compared to the fertilized check. Grain and silage yields were both significantly lower for the LH treatment. However, plant analysis indicates that the other two manure treatments may be approaching critically low levels of nutrients, especially N, Mg and Zn.

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

Table 1. Levels of NO_3-N in a Tara soil thirteen years (Fall 1983) after the application of high rates of manure.

Depth	Treatment				
	CK	FE	SB	LB	LH
- ft -	- - - - - - - - - - - NO_3-N, ppm - - - - - - - - - - -				
0-1	7.4	8.8	11.9	10.3	7.4
1-2	1.7	20.8	3.1	17.7	3.0
2-3	1.1	58.1	22.6	65.9	26.6
3-4	1.8	52.1	56.2	105.0	33.9

Table 2. Summary of analysis of corn leaves at silking - 1984.

Treatment	Elements									
	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	- - - - - - % - - - - - -					- - - - - - ppm - - - - -				
CK	1.38	0.14	1.53	0.45	0.38	80.3	10.6	4.0	62.8	7.7
FE	2.92	0.26	1.68	0.52	0.39	108.6	19.4	5.0	75.4	7.1
SB	2.28	0.27	2.13	0.46	0.24	100.8	12.0	5.1	86.5	7.4
LB	2.24	0.30	2.15	0.47	0.25	102.6	11.7	5.6	74.8	7.3
LH	2.09	0.28	1.93	0.47	0.31	90.7	14.3	4.8	65.7	7.5
Signif. level (%)	99	99	99	94	99	99	99	77	77	17
BLSD(.05)	0.52	0.05	0.25	0.05	0.09	13.9	2.1	-	-	-
CV(%)	12.8	10.3	7.2	5.2	14.7	7.4	8.6	15.8	16.6	8.7

Table 3. Summary of plant measurements - 1984.

Treatment	Grain		Silage		
	Moisture at harvest	Yield @ 15.5% M	Dry matter at harvest	Silage yield (D.M.)	Ear wt. ÷ Silage wt.
	- % -	- Bu/A -	- % -	- lbs/A -	- - % - -
CK	23.4	52.6	44.5	7614	51.7
FE	23.7	122.5	43.4	15172	56.1
SB	22.9	117.6	48.8	13630	58.5
LB	22.6	109.9	47.3	13030	54.8
LH	23.8	76.7	48.1	11215	55.0
Signif. level (%)	50	99	82	99	83
BLSD(.05)	-	28.7	-	3877	6.4
CV(%)	3.9	16.0	6.1	16.4	5.4

SOIL TEST LAB COMPARISON

West Central Experiment Station - Morris

S. D. Evans and G. A. Regimbal

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 1980-83 trials were summarized previously (Soil Series 109 and Misc. Publ. 2).

In the fall of 1983 soil samples from the plow layer and 0-2' 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') 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/A and spring wheat at a yield goal of 65 Bu/A. Analyses requested were (1) a complete analysis on the plow layer samples and (2) a nitrate-N analysis and recommendation on the 0-2' 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 build-up with Lab C. Lab C gave no indication that the 0-2' sample was used for the nitrogen recommendation on wheat.

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 N, P, K and S were applied by hand on October 26, 1983. Zinc, manganese, copper and boron were dissolved in water and sprayed on the plots on October 27. All plots were then moldboard plowed. In the spring the plots were field cultivated and dragged. On April 24, 1984, the plots were seeded to Era wheat @ 1 3/4 Bu/A. Hoelon was applied @ 3 pts/A on May 29 and Bromate @ 1 pt/A on June 1. The plots were harvested with a plot combine on August 9.

Corn

N, P, K and S were applied by hand on October 26, 1983. Zinc, Manganese, copper and boron were dissolved in water and sprayed on the plots on October 27. All plots were then moldboard plowed. In the spring the plots were field cultivated and dragged. On May 1, 1984, the plots were planted to Dekalb-Pfizer T950 @ 24,300 seeds/acre. Counter was applied at planting @ 1 lb/A (active ingredient). Lasso @ 3 lbs/A and Bladex @ 2.2 lbs/A were applied broadcast on May 3. The plots were harvested on October 23 with a plot combine.

Results and Discussion of the Wheat Trial

The soil tests and fertilizer recommendations are shown in Table 1. The soil test results were somewhat variable between labs. The recommended amounts of N, P and K had wide variations and labs B, C and D suggested applying sulfur. Lab B also recommended zinc, manganese, and copper and lab C recommended boron. There was a significant difference in lodging between labs, but no differences in grain yield, grain moisture or plant height (Table 3).

Lab E had the lowest fertilizer cost ($30.45) and the highest return over fertilizer ($323.55), while lab D had the highest fertilizer cost ($57.70) and the lowest return over fertilizer ($275.10), except for the check ($151.60) (Table 4).

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

Results and Discussion of the Corn Trial

Soil test results are shown in Table 2. Once again recommendations varied for N, P, K and micronutrients. Sulfur was recommended by labs B, C and D and lab B also recommended manganese and copper and lab D recommended boron.

Table 3 shows no significant difference between labs in plant height, plant weight, grain yield or grain moisture.

Fertilizer costs ranged from $42.40 (lab E) to $67.58 (lab B) (Table 4). Economic return over fertilizer had a range of $245.46 (lab B) to $282.91 (lab D).

Five-Year Summary

The combined average return per year for 1980-1984 shows a range of $38.82 (lab B) to $79.80 (lab E) over the check. For wheat, lab C shows the smallest return over the check, while lab E shows the greatest. For corn, lab B is showing a negative return over the check, while after five years, lab E has returned $101.64 over the check. It appears that the recommendations of labs for sulfur and micronutrients are not resulting in significantly higher yields over those which do not; consequently, economic returns over fertilizers are less for those labs.

Table 1. Soil test results and the suggested fertilizer program for wheat in 1984.

	Soil Test Results				
Test	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	8.0	7.9	7.8	7.9	7.9
P (Bray 1), ppm	-	13 L	-	-	6.0
($NaHCO_3$), ppm	8 L	12 L	23	8 L	7.0
K, ppm	108 H	133 M	127	120	120
O.M., %	3.4	3.7 H	2.6	MH	M
Ca, ppm	5100	2650 H	4422	3720 M	-
Mg, ppm	480	467 VH	453	560 H	-
Na, ppm	9	-	7	-	-
S, ppm	4 L	5 L	3	6 L	1.0
Fe, ppm	12.5 H	12 M	13.1	7.8 H	-
Mn, ppm	4.5 VH	5 L	5.9	2.1 ADQ	-
Zn, ppm	1.02 H	1.9 M	1.3	1.6 H	1.3
Cu, ppm	0.65 H	0.9 M	0.6	0.54 H	-
B, ppm	-	1.4 H	0.6	1.4 M	-
ENR (lb/A)	-	85	-	-	-
Nitrate-N (lb/A)	60	14 M	6	38	16
C.E.C. (meq/100 g)	29.8	17.5	26.2	23.8	-
Soluble salts (mmhos/cm)	0.3	-	0.2	-	-

	Suggested Fertilizer Program[1]				
Nutrient	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
	- - - - - - - - - -		(lb/A)	- - - - - - - - - -	
Nitrogen	92	100	115	70	100
Phosphorus (P_2O_5)	62	70	40	40	40
Potassium (K_2O)	63	95	190[2]	65	30
Sulfur	0	12	20	35	0
Zinc	0	1.5	0	0	0
Manganese	0	3	0	0	0
Copper	0	0.5	0	0	0
Boron	0	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]Values include maintenance plus 1/2 of suggested buildup.

Table 2. Soil test results and the suggested fertilizer program for corn in 1984.

Test	Soil Test Results				
	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	7.8	7.7	7.4	7.7	7.7
P (Bray 1), ppm	-	17 M	-	-	14
($NaHCO_3$), ppm	17 L	7 L	18	12 M	10
K, ppm	123 H	142 M	151	129 H	128
O.M., %	4.3	3.8	2.7	MH	H
Ca, ppm	4000	2620 H	2753	3400 M	-
Mg, ppm	595	565 VH	543	460 M	-
Na, ppm	10	-	17	-	-
S, ppm	3 L	4 L	2	8 ML	2.0
Fe, ppm	14.6 H	17 H	20.6	9.6 H	-
Mn, ppm	5.8 VH	6 L	7.5	2.3 ADQ	-
Zn, ppm	1.27 H	2.2 M	2.0	1.4 H	1.8
Cu, ppm	0.59 H	0.7 L	0.6	0.52 H	-
B, ppm	-	1.3 H	1.0	0.9 L	-
ENR (lb/A)	-	86	-	-	-
Nitrate N (lb/A)	-	-	-	-	-
C.E.C. (meq/100 g)	25.3	18.2	18.7	21.5	-
Soluble salts (mmhos/cm)	0.38	-	0.2	-	-

Nutrient	Suggested Fertilizer Program[1]				
	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
	- - - - - - - - - -		(lb/A)	- - - - - - - - - -	
Nitrogen	132	145	140	145	90
Phosphorus (P_2O_5)	97	80	55	75	90
Potassium (K_2O)	54	125	125[2]	75	40
Sulfur	0	15	24	30	0
Zinc	0	0	0	0	0
Manganese	0	3	0	0	0
Copper	0	1	0	0	0
Boron	0	0	0	1	0

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

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

Table 3. Effect of fertilizer recommendations on various plant measurements - 1984.

Lab	Wheat				Corn			
	Plant Lodging	Plant Height at Harvest	Grain Yield	Grain Moisture	Early Plant Height	Early Plants (10) Dry Weight	Grain Yield	Grain Moisture
	- Score[1] -	- in -	- Bu/A -	- % -	- in -	- grams -	- Bu/A -	- % -
A	1.8	32.5	85.1	13.4	29.6	66.5	116.2	25.4
B	2.2	31.5	84.2	13.4	30.6	81.0	111.8	24.9
C	2.5	31.2	87.0	13.4	30.0	75.5	118.7	25.4
D	1.5	32.5	83.2	13.3	29.4	76.0	121.3	25.0
E (UM)	1.8	32.2	88.5	13.3	29.0	70.0	113.9	25.5
Check	1.0	25.2	37.9	13.2	28.6	68.0	88.3	26.2
Signif. level (%)	91	99	99	47	30	41	97	96
BLSD (.05)	0.7	2.2	8.0	-	-	-	22.2	0.9
CV (%)	24.1	5.0	7.5	1.7	6.3	17.5	11.7	2.1

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

Table 4. Economic return over fertilizer costs - 1984.

Lab	Wheat: Value of Crop @ $4/Bu	Wheat: Fertilizer Cost*	Wheat: Return over Fertilizer	Wheat: Return over Check	Corn: Value of Crop @ $2.80/Bu	Corn: Fertilizer Cost	Corn: Return over Fertilizer	Corn: Return over Check
	$/A							
A	340.40	38.39	302.01	150.41	325.36	52.90	272.46	25.22
B	336.80	53.59	283.21	131.61	313.04	67.58	245.46	-1.78
C	348.00	36.38	311.62	160.02	332.36	60.32	272.04	24.80
D	332.80	57.70	275.10	123.50	339.64	56.73	282.91	35.67
E (UM)	354.00	30.45	323.55	171.95	318.92	42.40	276.52	29.28
Check	151.60	0	151.60	-	247.24	0	247.24	-

*Values used ($/lb) were as follows: N = $0.26, P_2O_5 = $0.25, K_2O = $0.12, S = $0.20, Zn = $0.95, Mn = $1.05, Cu = $2.40, B = $2.30.

Table 5. Five-year summary of yields and economic returns - 1980-84.

Lab	Wheat*: Total 5-year Yield	Wheat*: Total 5-year Fertilizer Cost	Wheat*: Economic Return over Fertilizer	Wheat*: Return over Check	Corn**: Total 5-year Yield	Corn**: Total 5-year Fertilizer Cost	Corn**: Economic Return over Fertilizer	Corn**: Return over Check	Combined Average Return per Year
	-Bu/A-	$/A			-Bu/A-	$/A			-$/A-
A	312.0	137.37	1110.63	252.23	572.9	250.53	1269.17	58.59	62.16
B	320.4	204.23	1077.37	218.97	563.4	300.03	1185.71	-24.87	38.82
C	319.4	235.16	1042.44	184.04	584.2	326.63	1223.01	24.80	41.77
D	302.6	161.55	1048.85	190.45	577.9	291.10	1241.66	31.08	44.31
E (UM)	317.1	112.63	1155.77	297.37	572.1	203.72	1312.22	101.64	79.80
Check	214.6	0	858.40	-	458.6	0	1210.58	-	-

*Wheat valued at $4/Bu, 1980-84.

**Corn valued at $3.00, $2.40, $2.00, $3.00, and $2.80/Bu in 1980, 1981, 1982, 1983, and 1984, respectively.

EFFECTS OF NITROGEN AND PHOSPHORUS APPLICATION METHODS ON SPRING WHEAT - 1984

West Central Experiment Station - Morris

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

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

Experimental Procedures

Soil sample results by rep are given in Table 1. The broadcast 0-46-0 was applied by hand on November 2, 1983. The anhydrous ammonia and 10-34-0 were applied with a dual applicator the same day. The material was placed at about an 8-inch depth with a knife spacing of 12 inches. In the spring of 1984 the plots were field cultivated and drug on April 25. The study was seeded to Era wheat @ 1 3/4 bu/acre.

Whole plant samples were collected on July 26 and were used to calculate forage yield and N and P uptake. The plots were harvested on August 10 with a plot combine.

Yield and Nutrient Uptake

The nutrient uptake and yield results are given in Table 2. A significant difference in dry matter yield occurred between treatment 5 and treatment 8. The difference appears to be due to fertilizer rate and not application method.

The phosphorus concentration in the tissue and phosphorus uptake at the soft dough stage tended to decrease or stay the same as N was increased, except with drill applications where levels stayed the same or increased slightly.

The N concentration and uptake was not significantly different between 50 and 100 lbs N or application methods, but the trend was for increased levels as N was increased.

Grain yield was not significantly affected by N rate except for the N only treatment in which yield was decreased when N was increased. At the 100 N rate the NP1, NP2 drill placement and N knife, P broadcast treatments all outyielded the N only treatment.

Grain protein levels were not significantly different between N rates or placement methods.

The 1984 study on placement methods shows very few effects due to placement or rates on any of the variables measured.

Table 1. Soil test results October 1984.

Rep	P Soil Test Olsen	P Soil Test Bray	Exch. K	Soil pH	NO_3-N[1]
	- - lb/A - -		- lb/A -		- lb/A -
1	8	14	278	8.0	43.2
2	16	17	302	7.8	
3	14	17	289	7.8	53.6
4	9	16	281	8.0	
5	9	14	283	7.9	44.0
6	11	14	297	7.7	

[1]Nitrate samples were taken in October 1983 (0-2') and are an average of reps 1-2, 3-4, and 5-6.

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

Table 2. The effect of N and P application methods on spring wheat.

Trt. No.	Treatment Description: Placement	Fertilizer Treatment: Source[1]	N	P_2O_5	Whole Plants @ Soft Dough Stage: D.M. Yield	Phosphorus	Phosphorus Uptake	Nitrogen	Nitrogen Uptake	Grain Yield	Grain Protein
			- lb/A -		lb/A	%	lb/A	%	lb/A	Bu/A	%
1	Check	-	0	0	7865	.204	16.1	1.20	95.0	53.5	12.2
2	Dual NP, Knife	AA,APP	50	40	8844	.217	19.2	1.34	119.6	65.7	12.3
3	Dual NP, Knife	AA,APP	100	40	9022	.192	17.3	1.51	135.8	63.4	13.3
4	N Knife, P BCST	AA,TSP	50	40	8883	.243	21.6	1.34	119.7	65.5	12.7
5	N Knife, P BCST	AA,TSP	100	40	9232	.203	18.8	1.52	140.5	65.4	13.4
6	N Knife, NP1 DRILL[2]	AA,UR,TSP	50	40	9098	.225	20.6	1.33	122.2	68.2	12.3
7	N Knife, NP1 DRILL[2]	AA,UR,TSP	100	40	9151	.226	20.7	1.46	133.1	65.7	13.0
8	N Knife	AA	50	0	8303	.210	17.5	1.27	107.0	64.2	12.2
9	N Knife	AA	100	0	8473	.190	16.1	1.41	120.8	59.4	12.9
10	NP Knife, NP2 DRILL[3]	AA,APP,UR,TSP	50	40	8616	.203	17.4	1.22	105.2	64.6	12.6
11	NP Knife, NP2 DRILL[3]	AA,APP,UR,TSP	100	40	8880	.209	18.6	1.48	131.2	66.0	12.7
Significance level (%):					98	98	99	95	99	99	96
BLSD(.05)					894	.035	3.7	0.29	29.3	4.6	1.1
CV(%)					7.4	11.9	14.9	14.3	17.8	6.4	5.8

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

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

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

EFFECT OF RESIDUAL SOIL NITRATE-NITROGEN ON SOYBEAN YIELDS

West Central Experiment Station - Morris
S. D. Evans and G. L. Malzer

Many studies in Minnesota and other midwestern states have shown little effect of nitrogen fertilization on soybeans. Trials in Nebraska by Rehm and Sorenson (1977) showed some response to carryover nitrate-nitrogen. There are some reports from farmers in Minnesota that soybeans seem to yield more following corn which was well fertilized with nitrogen. This study was set up to determine if NO_3-N deep in the soil profile would affect soybean yields in Minnesota. The study was set up on a Doland silt loam on a site where a nitrogen fertilization study on corn had been carried out since 1973. Nitrogen rates in this study ranged from a low of 9 lbs/acre (starter fertilizer only) to a high of 160 lbs/acre.

Experimental Procedures

Soil samples were taken in 1-foot increments to a depth of 5 feet in the fall of 1983 to measure the level and location of the residual NO_3-N from the previous treatments. In the spring of 1984 the area was field cultivated once. Treflan @ 3/4 lb/acre and Amiben @ 2 1/5 lbs/acre were applied, the area was field cultivated twice and drug once. The experiment was seeded to Evans soybeans @ 9.5 seeds/foot in 30-inch rows on May 17. Soil samples were taken again to a 5-foot depth on June 17, just as the soybeans were beginning to bloom. The plots were harvested with a plot combine on September 28.

Results and Discussion

The results of the NO_3-N samplings are shown in Tables 1 and 2. The previous N treatments greatly affected the NO_3-N levels in the soil. Soybean yields (Table 3) were not significantly different. Further analysis of the data will be carried out to analyze individual plot yields in relation to the NO_3-N in the various depth increments.

Table 1. Effect of previous N treatment on the residual soil nitrate-nitrogen on a Doland silt loam (October 12, 1983).

Depth Increment	Previous N Treatment (lbs/acre)				
	9	40	80	120	160
- ft -	- - - - - -		NO_3-N (ppm)	- - - - - -	
0-1	2.5	2.9	3.8	5.1	8.6
1-2	1.4	1.4	2.4	7.1	28.5
2-3	1.1	2.0	15.2	33.1	65.0
3-4	1.9	6.4	15.3	42.9	44.3
4-5	4.2	6.6	9.9	30.7	16.5
Average	2.2	3.9	9.3	23.8	31.4

Table 2. Effect of previous N treatment on the residual soil nitrate-nitrogen on a Doland silt loam (June 17, 1984).

Depth Increment	Previous N Treatment (lbs/acre)				
	9	40	80	120	160
- ft -	- - - - - -		NO_3-N (ppm)	- - - - - -	
0-1	13.6	12.8	13.3	17.3	14.8
1-2	6.0	6.6	8.6	9.4	23.4
2-3	5.0	13.9	8.7	13.7	38.2
3-4	5.7	9.5	16.1	24.4	42.5
4-5	5.7	9.7	15.6	35.3	44.0
Average	7.2	10.5	12.5	20.0	32.6

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Table 3. Effect of previous N treatment on soybean yields.

Previous N Treatments	Soybean Yields
- - lbs/acre - -	- bu/acre -
9	40.6
40	40.2
80	43.0
120	43.1
160	42.5
Significance Level (%)	36
BLSD (.05)	-
C.V. (%)	8.2

CONTINUOUS CORN SILAGE

West Central Experiment Station - Morris

S. D. Evans

I. Experimental Description

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

II. 1984 Operations

In 1984 the variety was Dekalb-Pfizer T950 and was planted @ 24,300 seeds/acre. Counter was applied @ 1 lb/acre (active ingredient) at planting on May 23. Lasso @ 3 lbs/acre and Bladex @ 2.2 lbs/acre were applied broadcast on May 24. Silage yields were taken on September 28 and grain yields on November 2 and 5.

III. Silage Yields - Dry matter; tons/acre

Treatment	1984 yield	1966-84 yield
Silage, low fertility	5.47	5.67
Silage, high fertility	6.44	6.15
Grain, low fertility	5.90	5.71
Grain, high fertility	6.72	5.99

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

	1984 yield	1966-84 yield
Grain, low fertility	91.8	90.5
Grain, high fertility	103.0	94.0

V. Check Yields

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

	1984 yield	1966-84 yield
Grain (0 + 0 + 0)	20.8	46.5
Silage (0 + 0 + 0)	2.99	3.68

VI. Discussion

A. In 1984 the grain high fertility silage yields were significantly higher than the grain low fertility or silage low fertility treatments. The silage high fertility plots had significantly higher silage yields than did the silage low fertility plots.

B. The 19-year average yields show very little difference between silage and grain plots, but there is still a slight advantage for the higher fertility level.

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

ALFALFA FERTILITY--MANAGEMENT STUDY

West Central Experiment Station - Morris
S. D. Evans and C. C. Sheaffer

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 site that tested medium in Bray P (19 lbs/acre) and high in exchangeable K (234 lbs/acre). The experiment was direct seeded on May 23-24, 1983. The design was four replications of a split-split plot. 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 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 lbs/acre was applied after the first cutting and the remainder after the second cutting. The 4-cut schedule was harvested on May 30, June 28, July 30 and August 29. The 3-cut schedule was harvested on June 13, July 13 and August 16. 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

Total seasonal yields (Tables 1 and 2) were not significantly affected by any treatment (Table 3). Significant treatment effects were found when the data was analyzed by individual cuttings. With the 3-cut schedule, variety (Table 4) was significant on both the 2nd and 3rd cuttings (P=94%). With the 4-cut schedule only the PK treatment was significant (P=98%). The effect is due to P fertilization with No-P yielding 1798 lbs/acre, 50-P @ 2086 lbs/acre and 100-P @ 2182 lbs/acre.

Dry matter percentage (Table 5) was significantly affected by PK treatment in 5 of 7 cuttings. In all cases the No-P treatment was drier than the 50-P and 100-P treatments.

Statistical analysis of the soil tests show many significant fertilizer effects on the 0 to 2-inch soil zone (Table 6). In all cases increasing either P or K fertilizer increased the P soil test and K soil test, respectively (Tables 7 and 8). Fertilizer did not affect soil tests in the 2- to 8-inch zone.

Table 1. Effect of cutting schedules, P and K fertilization and varieties on alfalfa yields at Morris in 1984.

Fertilizer Rate		1/2 Bud (4 cuttings)			1/10 Bloom (3 cuttings)			Average over Fertilizer
		Variety			Variety			
P_2O_5	K_2O	Vernal	Answer	Average	Vernal	Answer	Average	
- - lb/A - -		- - - - - - - - - - - -			Dry Matter (T/A) - - - - - - - - - - - -			
0	200	5.32	5.33	5.33	4.82	4.95	4.88	5.10
50	200	5.46	5.44	5.45	5.24	5.40	5.32	5.38
100	200	5.23	5.31	5.27	5.30	5.29	5.29	5.28
50	0	5.13	5.33	5.23	5.21	5.29	5.25	5.24
50	100	5.48	5.39	5.44	5.14	5.09	5.12	5.28
50	200	5.30	5.29	5.30	5.22	5.08	5.15	5.22
50	300	5.60	5.64	5.62	5.35	5.45	5.40	5.51
50	400	4.84	5.47	5.16	5.40	5.47	5.43	5.30
Average		5.29	5.40	5.35	5.21	5.25	5.23	5.29
CV = 5.8%								

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

Table 2. Effect of P and K fertilization and variety on alfalfa yields at Morris in 1984.

Fertilizer Rate		Varieties	
P_2O_5	K_2O	Vernal	Answer
- - lb/A - -		- Dry Matter (T/A) -	
0	200	5.07	5.14
50	200	5.35	5.42
100	200	5.26	5.30
50	0	5.17	5.31
50	100	5.31	5.24
50	200	5.26	5.18
50	300	5.47	5.54
50	400	5.12	5.47
Average		5.25	5.33
CV = 5.8%			

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

Variable	Std. Error	Signif. Level[1]
	- T/acre -	- - % - -
Cutting Schedule (CS)	.22	37
PK Treatment (PK)	1.13	50
CS x PK	.25	43
Variety (V)	.05	83
CS x V	.08	42
PK x V	.15	39
CS x PK x V	.22	21

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

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

	3-cut Schedule			4-cut Schedule			
Variable	1st	2nd	3rd	1st	2nd	3rd	4th
	- - - - - - - Signif. Level (%)[1] - - - - - - -						
PK Treatment (PK)	68	12	51	33	80	48	98
Variety (V)	60	94	94	6	51	84	76
PK x V	72	52	81	25	40	1	27

[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.

	3-cut Schedule			4-cut Schedule			
Variable	1st	2nd	3rd	1st	2nd	3rd	4th
	- - - - - - - Signif. Level (%)[1] - - - - - - -						
PK Treatment (PK)	14	98	40	90	90	96	> 99
Variety (V)	42	15	51	38	11	31	27
PK x V	79	65	74	10	19	45	86

[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 1984.

Variable	Soil Tests (lbs/acre)					
	Bray P		Olsen P		Exch. K	
	0-2"	2-8"	0-2"	2-8"	0-2"	2-8"
	- - - - - - - Probability[1] (%) - - - - - - -					
Cutting Schedule (CS)	87	21	87	83	29	29
PK Treatment (PK)	> 99	79	> 99	68	> 99	50
CS x PK	17	92	17	83	70	10

[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 to 2-inch soil zone (September 1984).

Fertilizer Rate			
P_2O_5	K_2O	Bray P	Olsen P
- lbs/acre -		- - - - lbs/acre - - - -	
0	200	13	10
50	200	27	22
100	200	53	49

Table 8. Effect of K rate on Answer only on soil test K of the 0 to 2-inch soil zone (September 1984).

Fertilizer Rate		
P_2O_5	K_2O	Exch. K
- lbs/acre -		lbs/acre
50	0	311
50	100	354
50	200	405
50	300	452
50	400	540

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

West Central Experiment Station - Morris
S. D. Evans

With the increase in reduced tillage systems, many new types of fertilizer placement devices have been developed. One of these is a knife which is mounted inside the double disk openers on minimum row crop tillage 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. This study was set up to examine the effect of two liquid fertilizers, 10-34-0 and 0-12-12, at two rates, 10 and 20 gal/acre, on corn growth and yield, when applied with this device.

Experimental Procedures

The study was set up on a Hidewood silty clay loam with a Bray P soil test of 15 lbs/acre and a K soil test of 288 lbs/acre. The liquid starters used were standard 10-34-0 and an 0-12-12 made from phosphoric acid (0-52-0) and pure KCl (0-0-62). The treatments were (1) 10-34-0 @ 10 gal/acre, (2) 10-34-0 @ 20 gal/acre, (3) 0-12-12 @ 10 gal/acre and (4) 0-12-12 @ 20 gal/acre. The variety was Pioneer 3906 planted at 24,300 seeds/acre on May 30-31. Nitrogen was applied sidedressed on July 9 to provide 120 lbs N/acre. Bladex was applied @ 2 1/2 lbs/acre on July 10 just as the corn was emerging. The treatments were replicated six times. Stand counts were taken on July 25 and height measurements were made on July 10. The plots were harvested on November 5 with a plot combine.

Results and Discussion

The stand counts (Table 1) were not significantly affected by treatment. The height measurements show an increase in height as the 10-34-0 rate was increased, but a drop in height when the 0-12-12 rate was increased. Yields show no significant effect of rates of 10-34-0 or between 10-34-0 and 0-12-12 at the low rate. With 0-12-12, the higher rate was significantly lower yielding than the low rate. Grain moisture on the 0-12-12 material @ 20 gal/acre was significantly higher than all other treatments.

The results of this study in 1984 show some detrimental effects of placing liquid 0-12-12 @ 20 gal/acre near the seed with this fertilizer knife. There was no effect on early stand. This type of device works well, but needs further research to determine rates and materials that may be safely used with it.

Table 1. Effect of 2 liquid starter fertilizers at 2 rates on corn at Morris in 1984.

Material	Rate	Stand (6-25-84)	Plant Height (7-10-84)	Grain Yield	Grain Moisture
	gal/acre	- plant/A -	- inches -	- Bu/A -	- % -
10-34-0	10	23,087	23.9	76.5	32.8
10-34-0	20	22,555	33.5	84.2	30.2
0-12-12	10	23,523	30.5	80.6	31.8
0-12-12	20	23,232	27.1	69.6	36.6
Signif. Level (%)		66	96.5	94.5	98
BLSD(.05)		-	4.4	11.9	9.3
C.V. (%)		4	11	11	10

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Problems with Irrigated Corn 1982, 1983, 1984

W. E. Fenster, Mike O'Leary and Greg Buzicky

The two experiments in the Staples area established in 1982, were again conducted in 1984 at both farms. These were located on the Staples experimental farm and on the Roth farm northeast of Staples. Both areas have sandy textured soils and are irrigated. The objective of these trials was to probe possible causes for apparent corn yield restrictions.

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

Treatments of the experiment are shown in Table 1 along with corn yield data and leaf tests. The Roth farm site was not in corn in 1983.

1982 results

Yield data in 1982 from the Roth farm indicated a significant response to nitrogen, and a significant benefit from the use of the inhibitor "N-Serve" but no benefit from boron even though plant analysis of the corn leaf at silking time showed below sufficient levels of boron. The Staples site showed no benefit from the inhibitor, the sulfur, the boron, or from split application of N in 1982.

1983 results

Data from the Staples farm in 1983 showed a significant response to nitrogen. The 80 pounds per acre N treatment (treatment 2) at the eight leaf stage plus inhibitor provided significantly higher yield than 160 pounds (treatment 3) of N per acre added preplant, at the Staples farm. With no inhibitor the treatment of 160 pounds in split applications added at eight leaf, 12 leaf and tasselling stages gave yields as high as any. The 200 pound N with inhibitor treatment gave no further yield increase over the 160 pound treatment with inhibitor. There was no significant increase in yield from magnesium or sulfur when used as starter with NPK fertilizer.

1984 results

In 1984 at the Staples farm there was a significant response to nitrogen. The 160 pounds of N preplant without inhibitor yielded no better than 80 pounds of N at the 8 leaf stage with inhibitor, as on other years the 200 pounds of N gave no higher yields than the 160 pounds treatment. There appeared to be a great benefit by adding N at the 8 leaf stage over the preplant treatment time, since the inhibitor on the 160 pounds treatment at preplant was no better than the 160 pounds preplant without inhibitor. There was no benefit from magnesium or sulfur at the Staples farm.

In 1984 at the Roth farm there was a significant nitrogen response. The 80 pounds of N per acre with inhibitor at the 8 leaf stage was significantly higher than 160 pounds of N preplant without inhibitor. The 200 pound treatment preplant without inhibitor was significantly lower than 200 pounds with the inhibitor but this treatment effect was significantly lower than 160 pounds per acre with inhibitor when N was applied at 8 leaf stage. Split applications of 160 pounds of N gave highest yields either with or without inhibitor. There was a significant drop in yield when sulfur was omitted (treatment 13 compared to treatment 12). There was no apparent magnesium benefit.

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

Table 1. Nutrient treatments on corn at various growth stages at the Staples and Roth irrigated farms. 1983, 1984.

Trt	Total[2/] #N/A	Broadcast Nitrogen: Amount and time of application: ppl[1/]	8 leaf[1/]	12 leaf	Tassel	Starter[2/]: N	P	K	S	Mg	1984 Roth	Yield Bu/A: 1983 Staples	1984 Staples
1	20	--	--	--	--	+	+	+	+	+	56	66	70
2	100		80+			+	+	+	+	+	133	124	130
3	180	160				+	+	+	+	+	100	91	122
4	180	160+				+	+	+	+	+	121	136	116
5	180		160+			+	+	+	+	+	152	149	131
6	180	80+	80			+	+	+	+	+	142	146	143
7	180		80	40	40	+	+	+	+	+	162	145	150
8	180		80+	40	40	+	+	+	+	+	156	137	142
9	220	200				+	+	+	+	+	101	139	145
10	220	200+				+	+	+	+	+	135	138	123
11	220		80	80	40	+	+	+	+	+	154	141	139
12	220		80+	80	40	+	+	+	+	+	158	141	147
13	220		80+	80	40	+	+	+	-	+	143	143	148
14	220		80+	80	40	+	+	+	+	-	153	147	135
15	220		80+	80	40	+	+	+	-	-	144	134	137
16	220		80+	80	40	-	-	-	-	-	142	132	139

Trts	CMIDRF (1984 1-12	12-16	Roth (1984) 1-12	12-16
Significant	**	ns	**	**
BLSD (.05)	16	--	15	9
C.V. %	9.3	7.3	8.8	3.9

1984 Soil test averages: Staples pH - 6.2, P - 59 lb/A, K - 252 lb/A, Mg - 233 lb/A, S - 4 ppm, Zn - 4 ppm.

Roth pH - 5.7, P - 115 lb/A, K - 242 lb/A, Mg - 145 lb/A, S - 1 ppm, Zn - 1 ppm.

1/ + associated with N rate indicates use of N-Serve (1/2 lb/A a.i.)

2/ 20 #N, 20 #P_2O_5, 40 #K_2O, 10# S and 10 #Mg applied per acre as starter if used. Both farms received 120 #K_2O over all plots.

Table 2. Plant analysis of corn of the 6th leaf. Staples (C) and Roth (R) farms 1984.

Treatment	N (%)		P (%)		K (%)		S (%)		Mg (%)		Zn (ppm)	
	R	C	R	C	R	C	R	C	R	C	R	C
12	3.0	3.1	.27	.27	2.75	2.81	.23	.22	.20	.23	6	6
13			.27	.26	2.78	2.74	.25	.22	.18	.24	6	6
14			.28	.27	2.80	2.84	.24	.21	.20	.21	5	6
15			.27	.29	2.69	2.75	.25	.21	.18	.23	6	7
16			.28	.28	2.78	2.81	.26	.22	.18	.23	5	5
Adequate levels			.25		1.75		.20		.16		6	

Table 3. Nitrogen content in 6th leaf at tasselling time from various nitrogen treatment rates and methods. Staples (CMIDRF) and Roth farms 1982, 1983, 1984.

Treatment		CMIDRF			Roth	
Treatment	N rate lb./A	1982	1983	1984	1982	1984
1	0	2.08	1.67	1.32	2.31	1.50
2	80	2.48	2.68	2.41	2.84	2.91
3	160	2.93	1.99	2.13	2.80	2.20
4	160+	3.06	2.74	2.67	3.15	2.53
5	160+	2.97	2.81	3.07	3.26	3.09
6	80+ + 80	3.29	2.70	2.89	2.96	2.87
7	80 + 40 + 40	3.03	3.04	2.90	2.98	2.88
10	200+	3.39	3.18	2.70	3.00	2.70
Adequate			2.70		2.70	

+means inhibitor added

CORN - SOYBEAN ROTATION

H. Meredith, Melvin Wiens and Greg Buzicky

A corn-soybean experiment initiated in 1981 at the Staples Station to evaluate corn yields under a regime of continuous corn and corn following soybeans continues.

Pioneer 3978 (85-day) and 3906 (95-day) relative maturity hybrids and clay soybeans are utilized as the test crops in the experiment.

Purpose of Study: This study was initiated following complaints from farmers and extension personnel of the inability to meet corn yield expectations under irrigation on the sand plain . It is recognized that consistently high yields result from the best combination of management and climate. Temperatures ranging from excessively low spring and early fall to high summer offer adequate opportunities for havoc. Rainfall, both too little and too much on these coarse textured soils creates severe management problems. Typically farmers are ill prepared to supply sufficient irrigation water during periods of severe heat stress. Excess precipitation, especially following irrigation, may result in removal of nitrate nitrogen and possibly other vital soluble nutrients as sulfur from the rooting zone.

This study attempts to apply the best cultural management practices coupled with emphasis on timely irrigation and nutrition adequacy.

Table 1. Yield and Corresponding Information.

Treatment	Bu/A	Harvest Population (x 1000)	% Moisture	Grain Yield T/A	Stover Yield T/A	Grain/Stover Ratio	Total Tons
(1) C-C 3978	116.4	26.7	29.2	2.70	2.42	1.11	5.12
(2) C-C 3906	112.7	31.4	37.5	2.79	3.37	.84	6.16
(5) SB-C 3978	124.0	27.1	28.6	2.82	2.70	1.05	5.52
(6) SB-C 3906	121.7	31.9	36.2	2.86	3.54	.81	6.40
(7) CC + Zn 3978*	117.6	26.5	29.2	2.63	2.42	1.08	5.05
BLSD (.05)	85	99	99	20	99	99	99
Sig level	--	.27	1.9	--	.42	.17	.74
C.V. %	5.3	6.2	4.2	10.8	9.8	11.3	8.4

*Received zinc in '81, '82, '83, and '84. All other plots received zinc only in '83.

CC Continuous corn
C-SB Corn-soybeans

Table 2. Fertilizer Applied to Corn Plots

	Broadcast	Row or Starter	Total
	- - - - - - - -	Lbs/A - - - - - -	
*N	180	10	190
P_2O_5		10	10
K_2O	225	20	245
S		10	10
Mg		5	5

*60#/A applied 6/15, 7/3, and 7/26

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

Table 3. Supplemental Information Corn

Date of Planting: 4/25
Herbicide: 2.5#AI/A Lasso 5/4/84
3/4 pt 2,4-D 6/2/84
Emergence Date: 5/16
Tassel Began: 7/19
Seeding Note Corn: 32,000 plants/A

Harvest: 10/4 corn
Irrigation: 13.5 in.
Rainfall (May-Sep): 12.5 in.
Row Width: 30 in.

Table 4. Additional Information on Nutrient Removal

Total Nutrients Removed (Grain + Forage)

	Lbs/A								
Treatment	N	P	K	Ca	Mg	MN	Zn	Cu	B
1	118.5	17.3	120.4	30.5	18.3	.37	.20	.036	.047
2	156.0	20.9	160.8	45.6	23.5	.53	.23	.034	.074
5	131.7	19.1	136.2	35.1	20.9	.44	.21	.025	.052
6	165.0	23.5	174.4	47.3	25.1	.57	.24	.033	.077
7	117.6	16.1	123.8	30.4	18.1	.37	.23	.025	.049
Sig level	99	99	99	99	99	99	96	99	99
BLSD (.05)	17.7	2.8	21.1	9.1	3.5	.10	.03	.004	.01
C.V. %	88.7	9.6	9.9	15.6	10.7	14.0	8.2	9.5	11.4

Table 5. Nutrient Content of Corn Grain

Treatment	N	P	K	Ca	Mg	Zn	Cu	B	Mn
	Percent					PPM			
1	1.21	.23	.44	.005	.10	20.8	1.1	2.4	4.0
2	1.48	.24	.43	.006	.12	20.8	1.4	3.5	5.6
5	1.27	.24	.46	.004	.11	21.2	.8	2.5	4.1
6	1.50	.27	.45	.006	.13	21.5	1.3	3.6	6.1
7	1.25	.22	.42	.004	.10	21.6	1.1	2.6	3.9
Sig level	99	99	83	99	99	.07	99	99	99
BLSD (.05)	.10	.02	--	.001	.008	--	.31	.19	.45
C.V. %	5.2	4.5	5.4	15.4	4.9	8.2	17.1	4.5	6.7

Table 6. Nutrient Content of Corn Stover

Treatment	N	P	K	Ca	Mg	Mn	Zn	Cu	B
	Lbs/A					PPM			
1	1.10	.104	2.00	.621	.263	71.1	18.2	4.11	7.03
2	1.09	.107	2.03	.664	.247	73.1	17.0	3.93	8.05
5	1.11	.103	2.05	.644	.272	76.5	16.5	3.92	6.94
6	1.13	.113	2.09	.658	.247	75.2	16.2	3.66	7.93
7	1.08	.096	2.10	.621	.263	72.0	23.5	4.10	7.19
Sig level	14	98	15	38	85	55	99	32	99
BLSD (.05)		.009					4.2		.58
C.V. %	6.8	5.4	7.1	7.7	6.1	6.1	14.2	12.1	5.0

Table 7. Leaf Tissue Analyses at Silking

Treatment	N	P	K	Ca	Mg	Mn	Zn	Cu	B
	- - - - - - - - -		Lbs/A	- - - - - - - - - -		- - - - - - - -	PPM	- - - - - - - -	
1	2.96	.287	2.72	.78	.26	77.2	23.6	4.97	5.41
2	3.02	.292	2.35	.84	.31	82.1	26.8	5.24	6.18
5	2.89	.286	2.78	.84	.28	81.0	23.2	4.61	5.43
6	3.10	.303	2.56	.86	.32	86.9	24.2	4.98	5.85
7	2.96	.286	2.76	.79	.27	73.3	28.6	5.10	5.56
Sig level	99	99	83	99	99	99	.07	99	99
BLSD (.05)	.10	.02		.001	.008	.45		.31	.19
C.V. %	5.2	4.5	5.4	15.4	4.9	6.7	8.2	17.1	4.5

Table 8. Leaf Sulfur and Nitrogen-Sulfur Ratios of Corn Leaf Samples at Silking, Staples

Treatment	N %	S %	N/S
Cont. corn (3978) 1/	2.96	.215	13.8
Cont. corn (3906)	3.02	.232	13.1
Rot. corn (3978) 2/	2.89	.220	13.2
Rot. corn (3906)	3.10	.236	13.2
High Zn (3978) 3/	2.96	.214	13.1
Sig level	88	97	78
BLSD (.05)	--	.017	--
C.V. %	3.4	4.5	4.4

1/ Continuous corn

2/ Corn-soybean rotation

3/ 10 pounds Zn broadcast

SOUTHERN EXPERIMENT STATION - WASECA

WEATHER DATA - 1984

Month	Period	Precipitation 1984	Precipitation Normal 1/	Avg. Air Temp. 1984	Avg. Air Temp. Normal 1/	Growing Degree Days 1984	Growing Degree Days Normal 1/
		----inches-----		-------°F-------			
January	1-31	0.35	0.84	11.4	10.0		
February	1-29	2.00	0.99	25.0	16.4		
March	1-31	2.79	1.99	22.1	27.6		
April	1-30	4.99	2.64	45.6	44.7		
May	1-10	0.75		45.8		30.0	
	11-20	0.66		59.5		113.5	
	21-31	1.56		58.4		116.0	
	Total	2.97	3.76	54.7	57.7	259.5	334
June	1-10	2.13		70.1		200.0	
	11-20	1.94		66.6		155.5	
	21-30	1.04		69.6		196.0	
	Total	5.11	4.48	68.9	67.1	561.5	518
July	1-10	1.60		67.8		182.5	
	11-20	1.63		67.9		185.5	
	21-31	0.20		71.0		229.0	
	Total	3.43	4.02	69.2	71.2	597.0	641
August	1-10	1.30		75.5		248.0	
	11-20	0.11		72.3		220.5	
	21-31	0.03		69.5		204.0	
	Total	1.44	3.99	72.3	68.8	672.5	579
September	1-30	2.42	3.36	57.1	59.8	309.5	311
October	1-31	4.63	2.08	50.0	48.9	0.0	38
November	1-30	2.21	1.43	32.5	32.5		
December	1-31	3.08	1.02	18.8	18.0		
Year	Jan-Dec	35.42	30.60	44.0	43.6	2400.0	2421
Growing Season	May-Sep	15.37	19.61	64.4	64.9	2400.0	2383

Notes:

1) 30-year normal from 1951-1980.
2) Highest temp. on Aug. 28 -- 96°.
3) Highest 24-hour precipitation on Apr. 30 -- 1.92".
4) Available soil moisture in 0-5' profile was 40% of field capacity in late August and was non-existent in the 0-2' layer.
5) Last spring frost -- May 8.
6) Frost on September 26.

ROTATION NITROGEN STUDY

Waseca, 1984

G. W. Randall, D. T. Walters, and M. P. Russelle

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

EXPERIMENTAL PROCEDURES

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

The corn-wheat + alfalfa sequence was dropped in 1981 in favor of a continuous corn system where all of the corn was removed as silage the preceding year. This gives us a comparison of the N needs between grain removal only compared to total above-ground biomass removal. In 1982, a C-C-Sb rotation was introduced to examine the N needs of second-year corn following soybeans.

In 1984, anhydrous ammonia was applied on April 19 to all corn plots. Wheat received 50 lb N/A as urea before planting. All plots were moldboard plowed in the fall of 1983. Because of high soil test P and K values, broadcast P and K or starter fertilizer was not used.

Each corn plot was split lengthwise and two corn hybrids (Pioneer 3732 and Pioneer 3906) were planted in 30" rows at 27700 ppA on May 12. Counter was applied to all corn plots at 1 lb/A to control rootworms. Butte wheat was planted on April 25. Hardin soybeans were planted on May 15.

Weeds were chemically controlled along with one cultivartion of the corn. A combination of 4 qt Lasso plus 3½ lb Bladex/A was applied preemergence to corn. Soybeans received 4 qt Lasso plus 6 qt Amiben/A applied preemergence.

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

After the 1983 harvest, soil samples were taken in the fall 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 in 1982. Soil samples were also taken from the 0-lb N treatments in the plots where soybeans, wheat, and corn following soybeans were the 1983 crops. Two cores were taken/plot, divided into 1-foot increments, composited/ rep, dried, crushed and analyzed for NO_3-N by the Soil Testing Laboratory.

RESULTS

Nitrate-N remaining in the soil profile after the 1983 crop which was available to the 1984 corn, is presented in Table 1. When no fertilizer N was applied in 1983 (except the blanket 50-lb rate to wheat) very little difference in residual NO_3-N appeared among the five crop sequences. For the second year in a row, levels were lowest following wheat. Approximately 50% of the residual NO_3-N was found in the top foot of the 5-foot profile with all five crop sequences. Very small amounts of NO_3-N were found below 2'. When 160 lb of N was applied to continuous corn (grain and silage) some residual N was found. About 30% of the carryover was located in the top foot with a uniform distribution throughout the rest of the 5-foot profile.

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

Table 1. Effect of crop and N rate applied to corn in the crop sequence on residual NO_3-N remaining in the 0-5' profile at the end of the 1983 growing season.

	1983 Crop				
Profile depth	Corn (grain)	Corn (silage)	Corn Fol. Soybeans	Soybeans	Wheat
feet	lb NO_3-N/foot				
			0 lb N/A		
0-1	33	37	31	35	28
1-2	13	13	12	17	10
2-3	9	8	5	13	7
3-4	8	7	7	7	6
4-5	8	13	11	11	9
Total (lb NO_3-N/5')	71	78	66	83	60
			160 lb N/A		
0-1	53	38			
1-2	28	24			
2-3	27	34			
3-4	27	33			
4-5	20	25			
Total (lb NO_3-N/5')	155	154			

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

Grain yield

Corn yields were suboptimal in 1984 due to the moisture stress conditions from late July through early September. As in previous years crop sequence had a substantial effect on corn yield. Yields following soybeans or wheat were significantly higher (15 to 28 bu/A) than when following corn (either for grain, silage, or first year corn after soybeans) when averaged over N rates and hybrids. Yields were economically maximized with the 120-lb N rate when averaged over crop sequences and hybrids. As in 1983, there was no difference in grain yield between P3906 and P3732 when averaged over sequences and N rates.

Closer examination of the interactions reveals additional information. Surprisingly, the sequence x N rate interaction was not significant when averaged across hybrids (P = 76% level) even though the yield response to the 200-lb rate over the 0-lb rate was 46.3, 60.3, 59.2, 64.1 and 49.1 bu/A for the CC (grain), CC (silage), C-Sb, C-Wht, and second year corn after soybeans sequences, respectively. The sequence x hybrid interaction showed slightly higher yields for P3906 when corn followed corn. However, when corn followed either soybeans or wheat, yields from P3732 were slightly better. In contrast to 1983, there was no N rate by hybrid interaction.

The three-factor interaction between sequence x N rate x hybrid (significant at the 92% level) shows that yields were generally higher with P3906 than with P3732 at the higher N rates when the sequence was CC (grain) or CC (silage). When corn followed either wheat or first year corn after soybeans, there generally was no difference between P3906 and P3732 as N rate was increased. However, when corn followed soybeans yields from P3732 were higher than P3906 at N rates greater than 80 lb/A.

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. Perhaps the NO_3-N differences among the sequences were too small, the absolute amounts too little, and/or losses between the fall of 1983 and summer of 1984 too great.

In summary, corn yields (averaged over hybrids) from the 200-lb rate were 11, 26, 30 and 5 bu/A higher when following corn removed for silage, soybeans, wheat or first year corn after soybeans, respectively, compared to continuous corn. This attests to the advantage for crop rotation in a dry (stress) year and gives further proof that yield differences due to previous crop cannot be overcome by high N rates alone.

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, 1984.

Previous Crop	Hybrid	N-rate (lb/A) 0	40	80	120	160	200
		Yield (bu/A)					
Cont. Corn (grain)	3906	72.5	97.5	101.7	118.4	116.6	125.1
	3732	77.7	89.2	101.1	111.8	114.4	117.6
Cont. Corn (silage)	3906	78.8	94.3	117.4	127.1	121.0	127.9
	3732	74.6	96.4	112.4	122.1	113.9	123.8
Soybeans	3906	88.5	122.2	131.8	143.9	143.0	145.0
	3732	87.6	127.0	131.2	148.9	157.5	149.5
Wheat	3906	88.3	104.6	133.7	142.4	142.1	152.4
	3732	85.7	119.7	136.4	144.4	141.6	149.9
Corn after soybeans	3906	73.4	98.0	118.9	129.8	131.9	133.3
	3732	71.4	103.0	112.5	128.3	125.3	132.1
		Leaf N %)					
Cont. Corn (grain)	3906	1.84	1.99	2.33	2.58	2.79	2.95
	3732	1.70	1.90	2.14	2.45	2.67	2.96
Cont. Corn (silage)	3906	1.70	2.01	2.53	2.65	2.78	2.90
	3732	1.54	1.91	2.35	2.40	2.77	2.78
Soybeans	3906	1.70	2.16	2.71	2.71	2.96	3.01
	3732	1.55	2.33	2.60	2.79	2.84	2.92
Wheat	3906	1.82	2.08	2.54	2.76	2.83	2.91
	3732	1.69	2.10	2.51	2.79	2.87	2.91
Corn after soybeans	3906	1.61	1.84	2.29	2.65	2.67	2.90
	3732	1.50	1.84	2.35	2.63	2.67	2.79
		Grain N (%)					
Cont. Corn (grain)	3906	1.34	1.23	1.35	1.60	1.67	1.66
	3732	1.15	1.10	1.24	1.45	1.49	1.55
Cont. Corn (silage)	3906	1.25	1.27	1.41	1.50	1.52	1.67
	3732	1.03	1.09	1.22	1.31	1.41	1.53
Soybeans	3906	1.19	1.28	1.42	1.47	1.61	1.66
	3732	1.05	1.12	1.26	1.38	1.44	1.46
Wheat	3906	1.33	1.25	1.36	1.55	1.62	1.58
	3732	.98	1.06	1.22	1.38	1.40	1.43
Corn after soybeans	3906	1.27	1.15	1.40	1.53	1.61	1.64
	3732	1.11	1.11	1.13	1.36	1.46	1.52
		Grain N Removed (lb/A)					
Cont. Corn (grain)	3906	46.1	56.7	65.4	89.5	91.5	98.1
	3732	42.7	46.0	59.5	76.4	80.4	85.5
Cont. Corn (silage)	3906	46.6	56.9	78.1	90.6	87.7	101.0
	3732	36.3	49.9	64.8	76.2	75.7	89.4
Soybeans	3906	49.7	74.7	88.9	99.9	108.9	113.2
	3732	43.6	67.8	78.1	96.5	106.6	102.8
Wheat	3906	56.4	62.4	87.0	104.7	108.4	113.6
	3732	40.0	60.0	78.8	94.0	94.2	100.9
Corn after soybeans	3906	44.0	54.2	79.0	93.9	100.3	102.8
	3732	37.0	54.2	60.3	82.6	86.6	94.3
		Grain Moisture (%)					
Cont. Corn (grain)	3906	16.6	15.9	16.5	14.3	14.2	14.1
	3732	23.2	20.4	18.1	16.5	16.3	16.1
Cont. Corn (silage)	3906	16.9	15.9	15.3	15.3	13.7	14.3
	3732	22.6	19.4	18.6	18.0	15.5	16.0
Soybeans	3906	18.1	18.1	17.0	16.8	16.6	16.1
	3732	22.7	21.0	20.0	19.2	19.5	18.6
Wheat	3906	19.0	18.6	17.6	17.3	16.5	17.7
	3732	25.4	22.2	20.1	20.1	19.1	19.3
Corn after soybeans	3906	17.1	17.2	16.4	15.5	15.6	15.8
	3732	23.4	20.5	19.8	18.8	18.3	17.7

Table 3. Main factor and two-factor interaction averages for corn grain yield, moisture, N, and grain N removal and leaf N in 1984.

Source	Grain Yield	Grain Moisture	Grain N	Grain N removed	Leaf N
	bu/A	------- %	-------	lb/A	%
MAIN FACTORS					
Sequence					
Cont. corn (grain)	103.6	16.8	1.40	69.8	2.36
Cont. corn (silage)	113.1	18.0	1.36	74.1	2.31
Sb-C	131.1	18.6	1.36	85.9	2.52
Wht-C	128.4	19.4	1.35	83.4	2.48
Sb-C-C*	109.1	16.8	1.35	71.1	2.36
Signif. Level (%):	99	99	66	99	99
BLSD(.10) :	8.8	1.2	-	6.4	.08
BLSD(.05) :	10.3	1.4	-	7.5	.10
N Rate (lb/A)					
0	79.9	20.5	1.17	44.3	1.66
40	105.2	18.9	1.17	58.3	2.02
80	119.7	17.9	1.30	74.0	2.44
120	131.7	17.2	1.45	90.4	2.64
160	130.7	16.5	1.52	94.0	2.78
200	135.6	16.6	1.57	100.2	2.90
Signif. Level (%):	99	99	99	99	99
BLSD(.10) :	3.7	0.4	.04	3.2	.09
BLSD(.05) :	4.3	0.5	.05	3.7	.10
Hybrid					
P 3906	117.4	16.3	1.45	81.7	2.44
P 3732	116.9	19.5	1.28	72.0	2.38
Signif. Level (%):	46	99	99	99	99
INTERACTIONS					
Sequence x N Rate					
CC(g) 0	75.1	19.9	1.24	44.4	1.77
40	93.3	18.1	1.16	51.3	1.95
80	101.4	17.3	1.30	62.5	2.23
120	115.1	15.4	1.52	83.0	2.51
160	115.5	15.3	1.58	85.9	2.73
200	121.4	15.1	1.61	91.8	2.96
CC(s) 0	72.4	20.3	1.19	40.6	1.56
40	100.5	18.8	1.13	54.2	1.84
80	115.7	18.1	1.27	69.7	2.32
120	129.0	17.1	1.44	88.2	2.64
160	128.6	16.9	1.54	93.5	2.67
200	132.7	16.7	1.58	98.6	2.85
Sb-C 0	88.0	20.4	1.12	46.6	1.63
40	124.6	19.5	1.20	71.2	2.24
80	131.5	18.5	1.34	83.5	2.66
120	146.4	18.0	1.42	98.2	2.75
160	150.3	18.1	1.52	107.8	2.90
200	147.2	17.3	1.56	108.0	2.97
Wht-C 0	87.0	22.2	1.16	48.2	1.76
40	112.2	20.4	1.16	61.2	2.09
80	135.1	18.8	1.29	82.9	2.52
120	143.4	18.7	1.47	99.3	2.78
160	141.8	17.8	1.51	101.3	2.85
200	151.1	18.5	1.51	107.3	2.91

Table 3. (Continued)

Source		Yield	Grain Moisture	Grain N	Grain N removed	Leaf N
		bu/A	------ %	--------	lb/A	%
Sb-C-C*	0	76.7	19.8	1.14	41.5	1.62
	40	95.4	17.6	1.18	53.4	1.96
	80	114.9	16.9	1.32	71.5	2.44
	120	124.6	16.6	1.40	83.4	2.52
	160	117.4	14.6	1.46	81.7	2.78
	200	125.8	15.1	1.60	95.2	2.84
Signif. Level (%):		76	79	28	70	44
Sequence x Hybrid						
CC(g)	3906	105.3	15.3	1.47	74.6	2.41
	3732	102.0	18.4	1.33	65.1	2.30
CC(s)	3906	114.2	16.3	1.43	79.0	2.33
	3732	112.1	19.7	1.28	69.2	2.30
Sb-C	3906	129.1	17.1	1.44	89.2	2.54
	3732	133.6	20.2	1.29	82.6	2.51
Wht-C	3906	127.2	17.8	1.45	88.7	2.49
	3732	129.6	21.0	1.25	78.0	2.48
Sb-C-C*	3906	111.1	15.2	1.44	76.8	2.43
	3732	107.2	18.3	1.26	65.4	2.29
Signif. Level (%):		99	10	60	66	81
BLSD(.10)	:	2.9				
BLSD(.05)	:	3.4				
N rate x Hybrid						
0	3906	80.3	17.5	1.27	48.6	1.73
	3732	79.4	23.4	1.07	39.9	1.60
40	3906	103.3	17.1	1.24	61.0	2.02
	3732	107.1	20.7	1.10	55.6	2.02
80	3906	120.7	16.6	1.39	79.7	2.48
	3732	118.7	19.3	1.22	68.3	2.39
120	3906	132.3	15.8	1.53	95.7	2.67
	3732	131.1	18.5	1.37	85.2	2.61
160	3906	130.9	15.7	1.60	99.4	2.80
	3732	130.6	17.7	1.44	88.7	2.76
200	3906	136.7	15.6	1.64	105.7	2.93
	3732	134.6	17.5	1.50	94.6	2.87
Signif. Level (%):		76	99	53	78	50
BLSD(.10)	:		0.5			
BLSD(.05)	:		0.6			
Seq. x N rate x Hybrid						
Signif. Level (%):		92	20	37	51	6
CV(%)	:	5.6	6.4	6.8	8.9	7.2

* = Position in sequence for which measurements taken.

Grain moisture

The CC (grain) and second year corn after soybeans sequences, which had lower yields, also had lower grain moisture at harvest compared to the C-Sb and C-Wht sequences. Grain moisture was reduced significantly by each additional 40-lb increment of N through 160 lb/A when averaged over sequences and hybrids. P3906 consistently showed lower moisture levels at harvest. This was especially true at the 0-lb N rate when a 5.9 percentage point difference existed between the two hybrids. At the 200-lb rate, only a 1.9 point difference was shown between the two hybrids; thus, the significant N rate by hybrid interaction.

Grain N

When averaged over N rates and hybrids, grain N was not influenced by crop sequence. Grain N was increased significantly from 1.17% with 40 lb N/A to 1.57% with 200 lb/A when averaged over sequences and hybrids. P3906 averaged 1.45% N compared to 1.28% for P3732 when averaged over sequences and N rates. Protein levels at the optimum N rates averaged about 9.8 (1.56% N) and 8.8 (1.40% N) for the two hybrids, respectively. In contrast to 1983, a sequence x hybrid interaction was not present.

Grain N removed

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

N efficiency, as measured by grain N removed fertilizer N application rate, ranged from 24% to 31% at the 200-lb rate and from 32% to 43% at the 120-lb rate for the CC (g) and C-Sb sequences, respectively, when averaged over hybrids. When averaged over crop sequences there was no difference between P3906 and P3732 at either of these N rates.

Leaf N

N concentrations in the earleaf at silking were significantly higher when corn followed either soybeans or wheat compared to followiong corn when averaged over N rates and hybrids. When averaged over crop sequences and hybrids, leaf N was increased significantly by each increment of fertilizer N through 200 lb/A. Significantly more leaf N was found in P3906 than P3732 when averaged over sequences and N rates. No interactions were found.

Silage production

Measurements were taken from the CC (silage) 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 to 160 lb/A on fodder yield. Fodder yield of P3732 was significantly greater than P3906. The highly significant (P = 98%) interaction for fodder N concentration between N rate and hybrid indicates that fodder N in P3732 was increased to significantly higher levels by the higher fertilizer N rates compared to P3906. The highly significant interaction for fodder N uptake (P = 97%) also indicates that N contained in the fodder of P3732 was increased with increasing rate of N application whereas with P3906 it plateaued.

Silage yields were also increased significantly by N rates up to 160 lb/A and by the P3732 hybrid. No N rate x hybrid interaction existed. Total N removed in the silage was increased with increasing N rates up through 160 lb/A. There was no difference in total N uptake between the two hybrids and no N rate x hybrid interaction.

Soybean production

To determine if N from the 1983 application to corn influenced the 1984 soybean yields, soybeans from the 0 and 200-lb N treatments were harvested. The data in Table 5 indicate no effect from the previous year's N treatment on either soybean yield or seed moisture at harvest.

Nitrogen Uptake Investigation

Because highly significant interactions were found in 1983 between the grain yields of the two hybrids with N rates and sequences and between the grain N concentrations of the hybrids with the sequences, an additional investigation was conducted by Drs. Russelle and Walters in 1984. The purpose of this study was to determine the N uptake patterns of the two hybrids at three times during the season (12-leaf stage, blister stage (BL), and physiological maturity (PM)) as influenced by N rate and crop sequence.

Plants from three N rates (0, 80, and 160 lb N/A) were taken from all crop sequences, from both hybrids, and from three of the replications. In order to not interfere with the main objectives of the rotation study, only two carefully selected plants were taken from each plot at each growth stage. The plants were cut at the ground level, chopped, dried, and weighed for dry matter. At physiological maturity, the ears were separated, the grain shelled from the cob, and the cob returned and weighed with the stover. The dried plant parts were then ground and submitted for total Kjeldahl

Table 4. Silage production as influenced by N rate and hybrid in a silage corn rotation at Waseca, 1984.

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	1.47	.41	12.1	3.52	55.4
	3732	1.51	.38	11.7	3.51	51.4
40	3906	2.05	.39	15.8	4.70	72.7
	3732	2.49	.39	19.2	5.22	71.9
80	3906	2.33	.41	18.9	5.46	89.7
	3732	2.88	.40	23.3	6.17	97.8
120	3906	2.35	.40	18.8	5.53	102.9
	3732	2.57	.49	26.1	5.58	101.9
160	3906	2.67	.52	27.6	6.49	132.9
	3732	2.98	.61	36.1	6.52	129.7
200	3906	2.27	.48	21.9	5.69	116.5
	3732	2.68	.70	37.4	5.96	128.8
Individual Factors						
N rate (lb/A)						
0		1.49	.40	11.9	3.52	53.4
40		2.27	.39	17.5	4.96	72.3
80		2.60	.40	21.1	5.81	93.8
120		2.46	.45	22.4	5.56	102.4
160		2.83	.56	31.8	6.51	131.3
200		2.48	.59	29.6	5.83	122.6
Signif. Level (%): 1/		99	99	99	99	99
BLSD (.05) :		.34	.06	4.2	.54	10.4
Hybrid						
3906		2.19	.43	19.2	5.23	95.3
3732		2.52	.50	25.6	5.49	96.9
Signif. Level (%): 1/		99	99	99	95	44
N rate x Hybrid IA: 1/		29	98	97	54	29
CV (%) :		16.	17.	25.	9.0	9.6

1/ Probability level of significance

Table 5. Soybean yield and moisture as influenced by N applied to corn in 1983.

N rate	Seed Yield	Seed Moisture
(lb/A)	bu/A	%
0	55.6	9.4
200	54.2	9.3
Signif. Level (%):	73	37
CV (%) :	3.3	5.2

N analysis. All values shown in Table 6 were obtained by converting the N concentrations and DM accumulation on the 2-plant samples to an area basis by adjusting with the final plant population of each of the plots. Statistical analysis of the population data showed no significant differences in final plant population. Only data from the BL and PM stages are presented.

Nitrogen in the stover at the BL stage was not influenced by crop sequence or hybrid (Table 6). N rate and the interaction between N rate and hybrid were both highly significant. The significant interaction is shown by the lower N yields with P3732 at the low N rates but the higher N yield with P3732 at the high N rate. Interactions between crop sequence and N rate or hybrid were not significant.

Stover N yield at PM presented slightly different results. Significantly more N was found in the corn following soybeans and wheat than when following CC for grain or silage or first year corn after soybeans. N rate again increased stover N. Similar to the BL stage, there was no effect of hybrid on stover N at PM. All interactions were not significant.

Total N in the grain at PM was affected significantly by crop sequence, N rate, and hybrid (Table 6). These results are similar to those presented in Table 3. Highest amounts of grain N were found when corn followed either soybeans or wheat and with the P3906 hybrid.

To try and determine when P3906 accumulated more N than P3732, the investigators assumed that the difference in stover N between the BL and PM stage (always less stover N at PM compared to BL) must be due to translocation of this N to the grain during earfill. This N which had already been taken up by the plant at the BL stage was termed "OLD N" (Table 6). "OLD N" was not affected by crop sequence when averaged over N rate and hybrid and was not affected by hybrid when averaged over sequence and N rate. However, the highly significant N rate by hybrid interaction is very similar to that found with stover N at the BL stage. Again, it appears as though P3732 was capable of taking up more N than P3906 by the blister stage and that much of this was translocated to the grain.

By subtracting the translocated "OLD N" in the grain from the total N in the grain, we can calculate the amount of N that must have been taken up after the blister stage. This N, termed "NEW N" may have come from late-season absorption of N from the soil by the roots or from N which may have been stored in the roots at the BL stage. The "NEW N" was affected significantly by the crop sequence, N rate, and hybrid (Table 6). More "NEW N" was found when corn followed either soybeans or wheat. The apparent difference between CC for grain or for silage is not explainable at this time. As expected Higher N rates increased "NEW N" in the grain. A two-fold increase in "NEW N" occurred with P3906 compared to P3732 when averaged over sequence and N rate. The highly significant interaction between N rate and hybrid shows substantially more "NEW N" accumulated in the grain with P3906 at the high N rate compared to P3732.

Total N in the plants at PM was also affected by crop sequence, N rate, and hybrid. Highest total N uptake occurred with the corn-soybean and corn-wheat sequences, at the 160-lb N rate, and with the P3906 hybrid.

In summary, these data indicate that P3732 is capable of taking up more N from the soil before the blister stage with higher rates of N application than is P3906. A large portion of this N appears to be translocated to the developing grain. However, P3906 at these N rates showed a tremendous ability to take up late-season N (either from the soil or from the roots) and translocate it to the grain. This uptake of late-season N more than accounts for any apparent early-season N uptake shortcomings and results in high grain N concentrations, excellent yields and excellent stress tolerance. The mechanism or reason for this late season advantage is not known at this time and needs further research. Perhaps it could be due to a larger more active root system capable of taking up and translocating N late in the season or an exudate relationship in the rhizosphere which increases N availability to the plant. On the other hand the uptake of late-season N could be related to soil moisture. If the ET demand of P3906 is not as high as with P3732, there could be more moisture available for late season uptake of both water and N with P3906.

Table 6. N uptake as influenced by rotation, N rate and hybrid in 1984.

Source	Stover N Yield[1/] BL	Stover N Yield[1/] PM	Grain N Yield at PM Total	Grain N Yield at PM OLD[2/]	Grain N Yield at PM NEW[3/]	Total Plant N at PM
	kg N/ha					
MAIN FACTORS						
Sequence						
CC (grain)	114	39	104	75	30	144
CC (silage)	120	35	94	85	10	130
Sb-C	126	48	115	77	38	163
Wht-C	120	49	113	70	42	162
Sb-C-C*	116	35	97	81	16	132
Signif. Level (%):	61	99	97	67	97	99
N Rate (lb/A)						
0	77	27	70	50	20	97
80	122	39	106	83	23	145
160	158	58	138	100	38	196
Signif. Level (%):	99	99	99	99	98	99
Hybrid						
P 3906	119	41	113	78	35	154
P 3732	119	42	96	77	19	138
Signif. Level (%):	9	26	99	23	99	99
INTERACTIONS						
N Rate x Hybrid						
0 3906	81	28	78	54	24	106
0 3732	73	26	63	47	16	89
80 3906	130	39	113	91	22	152
80 3732	114	40	98	74	24	138
160 3906	147	57	148	89	58	204
160 3732	170	59	128	110	17	187
Signif. Level (%):	99	33	17	99	99	4
Sequence x N Rate						
Signif. Level (%):	85	73	94	97	97	89
Sequence x Hybrid						
Signif. Level (%):	12	56	6	38	19	13
CV (%):	15.	21	17.	22.	72.	16.

1/ BL = blister stage, PM = physiological maturity
2/ OLD N = N in stover at BL - 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 blister stage and/or translocated from the roots.
* Position in sequence for which measurements taken

NITROGEN LOSS TO TILE LINES AS AFFECTED BY TILLAGE

Waseca, 1984

G. W. Randall and D. T. Walters

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' x 50'. Each plot is enclosed with plastic sheeting to a 6' fepth. 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 croops. Residual N from N applied over the 7-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 and 1983. Percent surface residue was measured on April 18, 1984 and averaged 8 and 93% for the moldboard plow and no tillage systems, respectively.

On April 23, 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 10 at a population of 27700 plants/A with a John Deere Max-Emerge planter equipped with 2" fluted coulters. Starter fertilizer was not used because of the high soil tests. Counter was applied at 1 lb (ai)/A to control rootworms. Weeds were controlled with a preemergence application of Lasso (3½#) and atrazine (3#/A) applied May 12. Control was excellent.

Early plant growth was determined by harvesting the above ground portion of 10 plants/plot 42 days after planting. The leaf opposite and below the ear was taken from 10 randomly selected plants per plot at silking (Moldboard plow = July 23, No tillage = July 25) 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 February, 1984 and continued to flow intermittently until mid July. Conditions were extremely dry in late July, August and September and no tile flow was recorded during this period. Tile lines commenced flowing again in November for 8 days. When tile lines were flowing, flow rates were measured daily and samples taken on a Monday, Friday, Wednesday two-week rotation for NO_3-N 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 26, 1984.

RESULTS

Early plant growth with moldboard plow tillage was significantly greater than with no tillage (Table 1). This was probably due to cooler soil temperatures and slower emergence rates under no tillage. Leaf N was also signficantly greater with moldboard plow tillage. Final population was not affected by tillage. Corn silking was delayed 2 to 3 days with no tillage.

Silage and grain yields and grain N removal were significantly higher (P = 95% level) with moldboard plow tillage compared to no tillage (Table 1). This is in contrast to 1982 and 1983 when differences between the two systems were not found. Although silage N uptake and grain N tended to be higher with moldboard plow tillage, these differences were not statistically significant.

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 1984.

Tillage system	Early plant growth	Final population	Leaf N	Silage Yield	Silage N uptake	Grain Yield	Grain N	Grain N removal
	g/plant	x10^3	%	T DM/A	lb N/A	bu/A	%	lb N/A
Mb. Plow	11.0	24.6	2.73	6.22	128.8	118.3	1.57	87.7
No Tillage	7.3	25.3	2.30	5.65	120.5	106.1	1.49	74.9
Signif. Level(%):[1/]	99	77	98	99	84	99	79	98
CV (%)	: 7.6	2.7	5.5	1.8	5.1	7.2	4.6	5.0

[1/] Probability level of significance.

Precipitation for the February-June period was 4" above normal. Most of the tile flow shown in Table 2 occurred during that period. Total tile flow, flow-weighted NO_3-N concentration, and NO_3-N lost thru the tile lines were not different between the two tillage treatments. Average NO_3-N concentrations rose from about 8 mg/L in 1983 to slightly above 11 mg/L in 1984.

Table 2. Influence of tillage system on tile flow, NO_3-N concentration and NO_3-N loss at Waseca in 1984.

Tillage system	Tile flow	Nitrate-N Concentration[1/]	Nitrate-N Loss
	acre-inches	mg/L	
Mb. Plow	13.89	11.2	35.1
No Tillage	12.75	11.4	32.9

[1/] Flow-weighted

Soil moisture measurements were taken from the 0-5' profile in each plot via neutron attenuation at weekly intervals. Differences in available water between the two tillage systems were minimal throughout 1984 (Table 3). However, there appeared to be a slight but consistent advantage for the no-tillage system during the dry July-September period. In addition, the only tile lines which flowed in November were from the no-tillage system.

Table 3. Influence of tillage system on available moisture in the 0-5' soil profile for corn at Waseca in 1984.

Tillage	Date 5/31	6/7	6/14	6/21	6/28	7/6	7/12	7/19	7/26
	inches available moisture[1/]								
Moldboard plow	7.16	9.16	9.21	8.68	8.92	6.73	7.08	7.47	6.23
No tillage	7.48	9.07	9.03	8.67	8.70	6.86	7.10	7.61	6.83

	8/2	8/9	8/16	8/23	8/30	9/7	9/21
	inches available moisture						
	5.43	5.02	3.88	3.92	3.85	4.17	4.71
	5.50	5.53	4.00	4.00	3.86	4.25	5.01

[1/] Determined through the use of a neutron probe.

Residual NO_3-N in the 0-8' profile after harvest was substantially higher than in 1983 when approximately 80 lb/A remained in the 0-6' layer (Table 4). Differences between the tillage systems existed with an additional 90 lb/A found in the profile under moldboard plowing. Although it was not surprising to find greater quantities of NO_3-N with the plow system, it was suprising to see the relatively high concentrations of NO_3-N (about 10 ppm) in the 6-8' zone of both tillage systems.

Table 4. Influence of tillage systems on residual NO_3-N in the soil profile in October, 1984.

Profile depth	Tillage System	
	Mb. Plow	No Tillage
feet	------ NO_3-N (lb/A) -------	
0-1	42.8	32.6
1-2	52.7	33.1
2-3	82.5	52.1
3-4	56.3	46.2
4-5	45.7	37.7
5-6	39.0	32.2
6-7	42.6	39.1
7-8	41.2	40.2
Total (lb NO_3-N/A 0-8')	403	313

THREE YEAR SUMMARY

The cumulative totals for the 3-year period (1982-1984) are shown in Table 5. Corn yields over this period have averaged 6 bu/A better with moldboard plow tillage, although the difference between the two systems has widened each year. Approximately 8% 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 (45% vs 41% for plow vs no tillage, respectively). Total tile flow was almost identical between the two systems. Even though about 9% more NO_3-N was lost through the tile lines with no tillage, this small difference is considered to be insignificant when considering tile flow variability among the eight plots over this 3-year period.

Table 5. Cumulative effects of the two tillage systems over the 3-year period.

Parameter	Tillage System	
	Mb plow	No tillage
Fert. N applied (lb/A)	540	540
Corn grain removed (bu/A)	370	352
N removed in grain (lb/A)	242	223
Percent of applied N removed in grain (%)	45	41
Tile flow (acre inches)	35.5	36.9
Nitrate-N lost in tile (lb/A)	73.0	79.6

SOIL TEST COMPARISON STUDY

Waseca, 1984

G. W. Randall, D. T. Walters, and P. L. Kelly

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

PROCEDURES

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

Four samples consisting of approximately 35 cores each from a 0-7" depth were taken from each site. All samples were oven dried at 95°F, crushed and mixed thoroughly. The samples were then subdivided and sent to five laboratories which test the majority of the soil samples from Southern Minnesota. Soil analyses requested consisted of pH, OM, extractable P, 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 allows us to follow the buildup or decline of nutrients in the soil as affected by the recommendations of a particular laboratory over a continuous, long period of time.

Soybeans were initiated into this study in 1982 after nine years continuous corn at the very high testing site and after seven years at the medium-high testing site.

Fertilizer amounts based on the analyses and recommendations from the summer 1983 samples were applied November 1 to the appropriate plots and plowed down. The fertilizer recommendations were based on a yield goal of 55 bu/A of soybeans. Soybeans (Hardin) were planted at the rate of 4.5 beans/foot in 15" rows on May 15. Chemical weed control consisted of 4 qt. Lasso and 6 qt. Amiben/A applied preemergence to all plots.

On July 9 (R1 stage) leaf samples were taken from each plot by sampling fifteen random, most recently mature trifoliate leaves. Seed yield was determined on soybeans harvested from the center eight rows of each plot with a modified JD 3300 plot combine. Seed yields were converted to 13.5% moisture.

In August, 1984, 0-7" soil samples were taken from each treatment at each of the two sites and were sent to the laboratory of the respective treatment. The recommendations obtained from these samples will be used for the 1985 growing season.

RESULTS

Very high testing site

The soil test results and the accompanying recommended fertilizer program of each laboratory are shown in Table 1 for the very high testing site. While the numeric values of the five laboratories were sometimes similar, the interpretations (whether the soil tests high, low, medium, deficient, etc.) varied substantially. As a result P and K recommendations among the laboratories were substantially different. Various micronutrients, sulfur, and lime were recommended by the private labs. Two of the four labs recommended nitrogen for soybeans.

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

Table 1. Soil test results and the recommended fertilizer programs on the very high testing site at Waseca in 1984.

Test	Soil Test Results[1/] Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	6.0	6.0	6.0	6.5	5.8
pH (buffer)	6.7	6.8	6.6	6.9	6.3
Phosphorus	35 VH	23 L	22 VH	39 H	17 H
Potassium	194 H	154 L	120 MH	157 H	138 H
Organic matter (%)	4.3 H	2.8 A	3.8 M	3.5	M
Calcium	2050 M	1975 E	3500	4560 H	---
Magnesium	496 VH	375 E	500	686 M	---
Sulfur	5 L	6 L	7 M	14 H	7 MH
Iron	89 VH	73 E	12 S	5.6 VH	---
Manganese	30 VH	21 E	10 S	2.1 VH	---
Zinc	3.3 H	1.5 E	1.8 VH	2.2 H	1.3 H
Copper	1.2 M	.7 A	.6 S	---	---
Boron	1.1 M	.8 E	1.0 S	0.0 VL	---
ENR (lb/A)	92	---	---	80	---
C.E.C. (meq/100g)	17.5	16.4	22.3	30.3	---

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

Nutrient	Recommended Fertilizer Program[2/] Lab A	Lab B	Lab C	Lab D	Lab E (UM)
Nitrogen	25	30	0	0	0
Phosphorus (P_2O_5)	30	50	0	35	30
Potassium (K_2O)	80	147[3/]	50	78	40
Sulfur	15	10	20[4/]	--	--
Iron	--	--	--	.2[5/]	--
Manganese	--	--	--	.5[5/]	--
Zinc	--	--	--	.3[5/]	--
Lime (T/A)	1.5	.5	1.2	--	--

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.

4/ Sulfur to be applied on a trial basis only.

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

Seed yields were not affected significantly by the fertilizer treatments (Table 2). The maximum difference between treatments including the check amounted to only 1.5 bu/A.

Leaf P, Ca, Fe and B concentrations among the five laboratories were not significantly different ($P = .05$ level) (Table 3). Higher K recommendations by Labs A and B resulted in higher leaf K and lower leaf Mg than the other treatments. The Fe + Mn + Zn recommended by Lab D resulted in higher leaf Mn than other labs but Fe and Zn were unaffected. Leaf Cu was reduced by the fertilizer applications. Leaf nutrient concentrations except Cu appeared to be adequate for optimum plant growth.

Medium-high testing site

The soil test results and the accompanying recommended fertilizer program of each laboratory are shown in Table 4 for the medium-high testing site. While the numeric values of the five laboratories were sometimes similar the corresponding interpretations (whether the soil tests high, low, medium,

Table 2. Effect of fertilizer recommendations on soybean seed yield on the very high testing site at Waseca in 1984.

Lab	Fertilizer Recommendations lb/A[1/]	Grain Yield bu/A
A	25N + 30P + 80K + 15S	47.7
B	30N + 50P + 147K + 10S	48.5
C	50K	48.4
D	35P + 78K + .2 Fe + .5 Mn + .3 Zn	47.0
E (UM)	30P + 40K	47.4
Check		47.3
	Signif. Level (%):[2/]	16
	CV (%) :	4.8

1/ P and K expressed on oxide basis.

2/ Probability level of significance.

Table 3. Effect of fertilizer recommendations on soybean leaf nutrient concentrations on the very high testing site at Waseca in 1984.

Lab	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%				ppm				
A	.44	2.44	1.16	.44	141	56	46	8.3	50.0
B	.45	2.41	1.12	.43	134	55	45	7.3	48.1
C	.45	2.31	1.19	.47	136	55	46	8.2	50.2
D	.45	2.32	1.16	.45	134	60	43	7.5	49.1
E (UM)	.47	2.32	1.12	.47	131	54	42	8.2	48.1
Check	.46	2.28	1.16	.48	135	50	43	9.4	50.8
Signif. Level (%):	73	98	73	99	42	99	99	99	91
BLSD (.05) :		.11		.02		3	2	.5	
CV (%) :	5.6	3.5	5.1	3.8	6.8	4.8	4.3	5.3	3.8

deficient, etc.) varied substantially. As a result P and K recommendations among the laboratories were markedly different. Various micronutrients and sulfur were recommended by the four private labs. Nitrogen was recommended by two of the four private labs.

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

There was no significant difference among the five laboratories for leaf nutrients P, Ca and Fe (P = .05 level) (Table 6). As fertilizer K rates increased, leaf K increased and leaf Mg decreased. All K recommendations resulted in higher leaf K levels than the check. Leaf Cu was reduced by the fertilizer applications. The Fe + Mn + Zn recommended by lab D did not result in higher leaf concentrations of these micronutrients. Leaf nutrient concentrations appeared to be adequate for optimum growth except for Cu.

SUMMARY - 1984

There were substantial differences among the laboratories' fertilizer recommendations for soybeans at both sites. Two of the five laboratories recommended N. Phosphorus and K recommendations among the labs differed by over three-fold. One private lab recommended micronutrients while three recommended sulfur. With the exception of K and Mn at the very high testing site, the fertilizer rates recommended and applied did not influence the leaf nutrient concentrations. Soybean yields were not influenced significantly by the large differences in fertilizer amounts nor was there a significant difference between fertilizer treatments and the check for the very high testing site.

Table 4. Soil test results and the recommended fertilizer programs on the medium-high testing site at Waseca in 1984.

Test	Soil Test Results 1/ Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	6.9	7.0	6.6	6.3	6.5
pH (buffer)	---	---	7.0	6.7	---
Phosphorus	19 M	13 L	13 M	25 M	18 H
Potassium	215 H	165 L	125 H	183 H	138 H
Organic matter (%)	5.9 H	3.5 A	5.1 H	4.2	M
Calcium	3610 H	4026 E	6000	7125 VH	---
Magnesium	554 VH	554 E	700	797 M	---
Sulfur	5 L	4 L	5 L	14.0 H	5 LM
Iron	48 VH	26 E	12 S	5.6 VH	---
Manganese	22 H	14 E	10 S	2.1 VH	---
Zinc	2.1 M	1.4 E	2.1 VH	2.9 H	1.4 H
Copper	1.2 M	.9 M	1.1 S	---	---
Boron	1.3 H	1.3 E	1.1 S	0.0 VL	---
ENR (lb/A)	107	---	---	110	---
C.E.C. (meq/100g)	23.2	25.2	36.1	47.0	---

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

Nutrient	Recommended Fertilizer Program 2/ Lab A	Lab B	Lab C	Lab D	Lab E (UM)
Nitrogen	20	25 3/	0	0	0
Phosphorus (P_2O_5)	60	100 3/	38	50	30
Potassium (K_2O)	55	178 3/	48	80	40
Sulfur	15	15	20 4/	--	--
Iron	--	---	--	.2 5/	--
Manganese	--	---	--	.5 5/	--
Zinc	--	---	--	.3 5/	--

2/ All values indicate pounds of nutrient 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.

4/ Sulfur to be applied on a trial basis only.

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

Table 5. Effect of fertilizer recommendations on soybean seed yield on the medium-high testing site in 1984.

Lab	Fertilizer Recommendations lb/A 1/	Seed Yield bu/A
A	20 N + 60 P + 55 K + 15 S	49.9
B	25 N + 100 P + 178 K + 15 S	50.5
C	38 P + 48 K	49.9
D	50 P + 80 K + .2 Fe + .5 Mn + 3 Zn	50.4
E (UM)	30 P + 40 K	51.3
Check		46.1
	Signif. Level (%):	95
	BLSD (.05) :	3.9
	CV (%) :	5.6

1/ P and K expressed on oxide basis.

Table 6. Effect of fertilizer recommendations on soybean leaf nutrient concentrations on the medium-high testing site at Waseca in 1984.

Lab	Nutrient P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%				ppm				
A	.43	2.35	1.28	.45	124	65	41	6.8	52.0
B	.43	2.33	1.27	.44	127	67	37	7.1	50.3
C	.43	2.20	1.30	.48	127	63	39	7.5	53.8
D	.43	2.27	1.25	.45	122	68	39	6.9	53.2
E (UM)	.43	2.14	1.27	.48	126	62	37	7.5	54.1
Check	.42	1.83	1.32	.56	129	60	45	10.3	58.6
Signif. Level (%):	20	99	92	99	45	99	99	99	99
BLSD (.05) :		.09		.19		4	2	.9	1.7
CV (%) :	3.7	3.7	3.2	3.7	5.6	5.3	5.4	5.8	2.9

Table 7. Effect of fertilizer recommendations on yield, value, fertilizer cost and the resulting economic return on both the very high testing site and medium-high testing site at Waseca in 1984.

Lab	Very High Testing Site Yield	Value @6.00/bu	Fert. Cost[1/]	Return[2/]	Medium-High Testing Site Yield	Value @6.00/bu	Fert. Cost[1/]	Return[2/]
	bu/A	$/A			bu/A	$/A		
A	47.7	286	26	-24	49.9	299	29	- 7
B	48.5	291	38	-31	50.5	303	54	-28
C	48.4	290	6	0	49.9	299	15	7
D	47.0	282	25	-27	50.4	302	29	- 4
E (UM)	47.4	284	12	-12	51.3	308	12	19
Check	47.3	284	--	---	46.1	277	--	---

1/ Using April, 1984 prices for each nutrient expressed as dollars/lb as follows: N, .26; P_2O_5, 25; K_2O, .11; S, .20; Zn, .95.

2/ Return yield value @6.00/bu - fertilizer cost - value of check trt.

Table 8. Effect of fertilizer recommendations on total yield, total fertilizer cost and the resulting economics on both the very high and medium-high testing site at Waseca from 1980-1984.

Lab	Very High Testing Site 5-Year Total Crop Value[1/]	Fert. Cost	Return[2/]	Medium-High Testing Site 5-Year Total Crop Value[1/]	Fert. Cost	Return[2/]
	$/A			$/A		
A	1599	265	-100	1803	303	+ 94
B	1628	283	- 89	1792	353	+ 33
C	1665	189	+ 42	1803	223	+174
D	1658	311	- 87	1795	333	+ 56
E (UM)	1626	152	+ 40	1814	197	+211
Check	1434	0	----	1406	0	----

1/ 3.00, 2.40 and 3.00/bu used for corn in 1980, 1981, and 1983, respectively, and 5.50/bu and 6.00/bu used for soybeans in 1982 and 1984, respectively, for a five-year total crop value.

2/ Return over 5-year period = crop value - fertilizer cost - value of check treatment.

Economic returns from the fertilizer recommendations for soybeans in 1984 are given in Table 7. On the very high testing site fertilizer costs ranged from $6 with Lab C to $38/A with Lab B. Positive economic return to fertilizer programs was not obtained with any of the five labs. On the medium-high site fertilizer costs ranged from $12 (Lab E) to $54/A (Lab B). Positive economic return to the laboratories' fertilizer recommendations was only obtained with two labs (C and E). Net returns ranged from $19 to -$28/A.

Conclusions from the 1984 study can be summarized as follows:

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

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

FIVE-YEAR SUMMARY

Economic returns from the very high testing site showed little benefit to fertilization (Table 8). Net return from 1980-1984 period ranged from $40/A to $42/A with Labs C and E which had the lowest fertilizer costs, to -$100/A with Lab A. Recommendations from Lab D resulted in the highest fertilizer cost. Part of the low overall return on this site was due to fertilizer recommendations for a yield goal of 180 bu/A in 1980 while the yields obtained barely exceeded 100 bu/A due to drought-stress conditions.

On the medium-high site yield responses paid for the fertilizer recommendations by all five laboratories (Table 8). However, net return ranged from $33/A with Lab B, whose recommendation resulted in the highest fertilizer cost, to $211 with Lab E which recommended the least amount of fertilizer.

NITROGEN AND SULFUR APPLICATIONS TO CORN IN SOUTHERN MINNESOTA

1984

G. W. Randall, D. T. Walters, and P. L. Kelly

Corn yield response to varying N rates and application times in Southern Minnesota have been documented frequently. However, response by corn to sulfur (S) on these soils has not been frequently and consistently reported. Recently, ammonium sulfate as a source of both N and S has become more common as a fertilizer material in the northern Corn Belt. The purpose of this study was to evaluate preplant vs split applications of ammonium sulfate compared to preplant application of urea on corn production on two soils of Southern Minnesota.

EXPERIMENTAL PROCEDURES

Two sites which had been planted to corn in 1983 were selected for this study. One location was on a Seaton silt loam (Alfisol) on the Charles McNamara 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 soil 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.

Tillage at the Goodhue County site consisted of fall chisel plowing and then spring disking and field cultivating prior to planting. The site in Waseca County was fall moldboard plowed and spring field cultivated. Soil tests for the Goodhue and Waseca sites follow: pH = 7.3 and 6.5; Bray extractable P_1 = 101 and 46 lb/A (both Very High); exchangeable K = 237 and 465 lb/A (Medium High and Very High); and extractable SO_4-S = 7 and 8 ppm, respectively, for the two locations.

Eight N and S treatments were replicated four times at the Goodhue site and 6 times at the Waseca site in a randomized, complete-block design. Each plot measured 15' wide (6-30" rows) x 30' long in Goodhue County and 10' wide (4-30" rows) x 55' long in Waseca County.

Corn was planted with a John Deere Max-Emerge planter at a population of 27700 plants/acre at both sites. Pioneer 3901 was planted on May 16 in Goodhue County while Pioneer 3906 was planted on May 9 in Waseca County. Weeds were chemically controlled with Lasso + atrazine at Waseca and Lasso + Bladex at Goodhue. Counter was applied with the planter to control rootworms at both locations.

The preplant applications of both N sources were applied and incorporated by secondary tillage on May 10 and April 25 at the Goodhue and Waseca sites, respectively. The split application treatments were applied ½ preplant and ½ sidedressed at the 8-leaf stage on June 29 and June 19 at the Goodhue and Waseca locations, repsectively. Application rates of N and S for the Goodhue and Waseca locations are shown in Tables 1 and 4, respectively.

Ten randomly selected leaves opposite and below the ear were taken at silking for total 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 fodder and grain analyses were conducted on samples gathered at harvest. Chemical analyses were performed by the Research Analytical Laboratory, University of Minnesota.

RESULTS AND DISCUSSION

Goodhue County: Leaf N was increased significantly (P = 94% level) over the check by the urea and AS treatments (Table 1). Differences among the urea with and without S treatments and AS were not statistically significant for any of these parameters.

When examining the effect of N rate averaged over N source and time of application, leaf N and fodder yield were greater with the higher N rate (Table 1). Fodder N, silage yield, total N uptake and final population were not influenced by N rate. The N source-method of application, when averaged over N rates, had no effect on any of the above parameters. Moreover, there was no interaction between N rate and N source-time of application.

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Grain N concentration was significantly improved by the urea and AS treatments over the check (Table 2). Grain yield, N removed by the grain and ear moisture at harvest were not affected by the N and S treatments. Factorial examination of the main effects showed no effect of either N rate or N source-time of application on any of the grain yield parameters. In addition, no interaction between N rate and N source-application time was noted.

Leaf, grain, and fodder samples from the three high N rate treatments were additionally analyzed for total S. Results shown in Table 3 indicate no significant (90% level) effect of S applied to this low OM soil on leaf, grain and fodder S concentrations, total S uptake in the silage, and grain S removal (product of grain yield times grain S concentration). In contrast to 1983, N:S ratios were not reduced by the AS treatments. N:S ratios were 13.0, 10.1 and 14.8 with urea and 12.7, 10.1 and 15.3 with the PP application of AS for leaf, fodder and grain, respectively.

In summary, this experimental site did not provide much valuable data to evaluate the treatments. Only leaf N and grain N were improved by the N treatments. The highest N rate (134 lb/A) resulted in higher leaf N compared to the 67 lb/A rate but did not influence any of the other parameters. Even though yields were high, they were not increased over the check by any of the N and S treatments. Apparently, the residual NO_3-N (124 lb/A in the 0-5' profile) plus mineralizable N was sufficient to sustain the crop. In addition, SO_4-S (7 ppm), although not high for this low OM soil, plus mineralizable organic S must have been sufficient for optimum corn production.

Table 1. Influence of rate, source and time of application of N and S on leaf N, fodder N, fodder yield, silage yield, total N uptake and final population at GOODHUE in 1984.

N Rate	N Source[1/]	S Rate	S Source	Applcn method[2/]	Leaf N	Fodder N	Fodder yield	Silage yield	Total N uptake	Final population
lb/A		lb/A			%	%	---T DM/A ----		lb N/A	ppA x 10^3
Check					2.69	.62	3.20	7.52	139	24.5
67	Urea	-	-	PP	2.94	.67	3.13	7.68	154	24.4
67	Urea	79	Gypsum	PP	2.87	.67	3.05	7.56	153	24.1
67	AS	79	AS	PP	2.91	.67	2.81	7.28	150	24.8
67	AS	79	AS	Split	2.92	.73	3.08	7.67	159	24.2
134	Urea	-	-	PP	2.92	.73	3.38	7.85	160	23.8
134	AS	158	AS	PP	3.02	.66	3.01	7.35	151	23.2
134	AS	158	AS	Split	3.07	.72	3.29	7.62	158	23.1
Significance Level (%):[3/]					94	44	66	18	63	14
BLSD(.10) :					.26					
CV(%) :					5.1	12.	10.	6.8	7.9	7.7
Individual Factors										
N rate (lb/A)										
67					2.90	.69	2.98	7.50	154	24.4
134					3.00	.70	3.23	7.60	156	23.4
Significance Level (%):[3/]					97	49	92	36	45	84
N source-time of application										
Urea - PP					2.89	.70	3.21	7.70	157	23.9
AS - PP					2.96	.66	2.91	7.32	151	24.0
AS - Split					2.99	.73	3.18	7.65	158	23.7
Significance Level (%):[3/]					82	82	84	70	80	9
Interactions										
N rate x N source-time										
Significance Level (%):[3/]					35	58	9	19	33	27

1/ AS = ammonium sulfate
2/ PP = preplant, Split = ½ at PP and ½ at 8-leaf stage
3/ Probability level of significant difference among treatment means

Table 2. Influence of rate, source and time of application of N and S on ear moisture, grain yield, N and N removal at GOODHUE in 1984.

N Rate	N Source[1]	S Rate	S Source	Applcn method[2]	Ear moisture	Grain Yield	Grain N	Grain N removal
lb/A		lb/A			%	bu/A	%	lb/A
Check					41.2	158.0	1.32	99
67	Urea	-	-	PP	40.9	167.3	1.42	112
67	Urea	79	Gypsum	PP	41.1	165.7	1.44	113
67	AS	79	AS	PP	41.4	164.5	1.45	113
67	AS	79	AS	Split	40.9	166.6	1.45	114
134	Urea	-	-	PP	40.5	163.3	1.42	110
134	AS	158	AS	PP	41.2	157.4	1.50	112
134	AS	158	AS	Split	41.4	158.3	1.48	110
	Significance Level (%):[3]				44	11	97	56
	BLSD (.05)		:				.10	
	CV (%)		:		1.6	8.0	4.4	8.5
Individual factors								
N rate (lb/A)								
67					41.2	165.6	1.45	113
134					41.0	159.7	1.47	111
	Significance Level (%):[3]				35	75	57	58
N source - time of application								
Urea - PP					40.8	164.5	1.43	111
AS - PP					41.3	161.0	1.48	112
AS - Split					41.2	162.5	1.47	112
	Significance Level (%):[3]				72	15	72	15
Interactions								
N rate x N source-time								
	Significance Level (%):[3]				72	13	46	6

Table 3. Influence of N source and time of ammonium sulfate application on leaf S, grain S, fodder S, total S uptake and grain S removal at GOODHUE in 1984.

N Source[1]	Application method[2]	Leaf S	Grain S	Fodder S	Total S uptake	Grain S removal
		%	%	%	lb/A	lb/A
Urea	PP	.225	.096	.072	12.3	7.4
AS	PP	.237	.098	.065	11.2	7.3
AS	Split	.232	.098	.070	11.8	7.3
Signif. Level(%):		77	29	39	71	22
CV (%)	:	3.7	3.2	16.	8.1	4.6

1/ AS = ammonium sulfate; Both N sources applied at rate of 134 lb/A
2/ PP = preplant, Split = ½ at PP and ½ at 8-leaf stage
3/ Probability level of significant difference among the treatment means

Waseca County: Similar to 1983, results from the study in Waseca County were considerably different than from Goodhue County. This was primarily due to the dry conditions which began in mid-July and continued through early September. Rainfall totaled only 1.90" over the 8-week period from July 18 through September 11, with a highest 1-day occurrence of 0.48 inches.

Leaf N concentration, fodder and silage yield, and total N uptake in the silage were increased over the check by all of the urea and AS treatments (Table 4). Fodder N was increased over the check by only the 178-lb N/A treatments. At the low rate of N, leaf N and fodder yield were both increased by

Table 4. Influence of rate, source and time of application of N and S on leaf N, fodder N, fodder yield, silage yield, total N uptake and final population at WASECA in 1984.

N Rate	N Source[1/]	S Rate	S Source	Applcn method[2/]	Leaf N	Fodder N	Fodder yield	Silage yield	Total N uptake	Final population
lb/A		lb/A			%	%	--- T DM/A --		lb/A	ppA x 10^3
Check					1.37	.33	1.42	3.18	41.9	23.5
89	Urea	-	-	PP	2.23	.32	2.31	5.48	83.7	25.1
89	Urea	105	Gypsum	PP	2.53	.34	2.59	5.90	89.6	26.1
89	AS	105	AS	PP	2.44	.33	2.54	5.95	87.1	25.6
89	AS	105	AS	Split	2.43	.33	2.36	5.77	81.7	24.8
178	Urea	-	-	PP	2.76	.48	2.88	6.88	128.6	25.1
178	AS	210	AS	PP	2.91	.49	2.92	6.73	127.1	26.2
178	AS	210	AS	Split	2.80	.48	2.46	6.09	119.9	25.2
	Significance Level (%):				99	99	99	99	99	97
	BLSD (.05)		:		.18	.05	.25	.52	8.0	1.8
	CV (%)		:		7.2	12.	9.6	8.6	8.0	5.1
Individual Factors										
N Rate (lb/A)										
89					2.47	.34	2.50	5.87	86.1	25.5
178					2.82	.49	2.75	6.56	125.2	25.5
	Significance Level (%):				99	99	99	99	99	01
N source-time of application										
Urea - PP					2.65	.41	2.74	6.39	109.1	25.6
AS - PP					2.68	.41	2.73	6.34	107.1	25.9
AS - Split					2.62	.41	2.41	5.93	100.8	25.0
	Significance Level (%):				31	02	99	92	97	73
	BLSD (.05)		:				.22		6.3	
Interactions										
N rate x N source-time										
	Significance Level (%):				80	10	56	69	04	70

1/ AS = ammonium sulfate

2/ PP = preplant, Split = ½ at PP and ½ at 8-leaf stage

3/ Probability level of significant difference among treatment means

the urea + gypsum and AS treatments over the urea alone treatment. Silage yield was increased 0.42 to 0.47 T DM/A by the S treatments, but this difference was only significant at the 90% level (BLSD = 0.45). These effects were not found at the high rate of N. No explanation can be given for the slightly lower final population in the check treatment.

Examination of the main effect of N rate averaged over N source-time of application indicates that leaf and fodder N, fodder and silage yield, and total N uptake were increased significantly (99% level) by the high N rate (Table 4). The N source-time of application had an effect on fodder and silage yield, and total N uptake when averaged over N rates. Results from the PP application of urea and AS were almost identical. However, splitting the AS application into ½ at the 8-leaf stage produced significantly lower fodder and silage yield and total N uptake. Apparently the sidedress portion of the split application remained near the soil surface and was never moved down into the root system where it could have been utilized by the plants. A significant interaction between N rate and N source-time of application was not found for these parameters.

Grain yield, grain N and grain N removal were increased substantially and grain moisture reduced significantly by all of the urea and AS treatments compared to the check (Table 5). The urea + gypsum treatment and the PP appliled AS treatments did not improve yield, N concentration, moisture content and N removal of the grain over the standard urea treatments.

Factorial examination of the main effects showed a highly significant improvement in all of the grain parameters with the high N rate when averaged over N source-time of application (Table 5). Differences among the N source-time application treatments were only significant (P = 95% level) for grain N removal when averaged over N rates. Corn grain yield, moisture content, N concentration and N removal were almost identical with the PP urea and AS treatments. However, the split application of AS gave significantly lower grain N removal than the PP application of AS. Positional unavailability of the sidedress portion applied at the 8-leaf stage was thought to be the primary reason for the somewhat poorer performance of the split AS treatments.

Sulfur analysis conducted on the plant tissue from the 178-lb N treatments showed highly significant increases in leaf, fodder and grain S with both of the AS treatments compared to urea (Table 6). This resulted in significantly higher total S uptake and grain S removal with both AS applications. Ratios of N:S for leaf, fodder, and grain were reduced from 16.0, 11.7 and 15.3 with urea to 12.5, 54.4 and 11.9 with the PP application of AS, respectively. As in 1983, these results were somewhat surprising on this high organic matter soil which had a moderate extractable SO_4-S level (8 ppm).

In summary, grain and silage yields, N concentration in the plant parts, and N and S uptake were improved by the urea and AS treatments. The highest N rate (178 lb N/A) produced the highest yields and N concentrations and was judged to be an optimum N rate under the growing conditions in 1984. The split application of AS consistently did not improve yields and N uptake when compared to the PP aplication in early May. This was primarily due to positional unavailability of the mid-June N application which apparently was not moved down into the zone of root activity during the dry 8-week period in July, August and September. Significant and consistent differences between the urea treatment and the urea + gypsum and AS treatments occurred for leaf N, fodder yield and silage yield when a low rate of N was applied but did not occur for the grain yield parameters. Even though S concentrations in the plant parts were significantly improved, yield response to the added S was not obtained.

CONCLUSION

Under the good growing conditions at the Goodhue County location in 1984, corn yields, plant N and S concentrations, and plant N and S uptake were generally not affected by any of the N and S treatments. This was apparently due to sufficient residual NO_3-N and mineralizable organic N and S which sustained optimum corn growth. At Waseca where dry conditions limited corn yields, highly significant and consistent effects of the N and S treatments were found for 14 of the 15 parameters measured. Yields and plant N concentration and uptake were highest with the 178-lb N rate. Split application of the AS treatments did not improve yields or nutrient uptake; probably due to positional unavailability of the sidedress-applied material. Application of S as AS or with urea increased leaf N, leaf, fodder and grain S, fodder yield, and silage yield but did not improve grain yield when applied at the low rate.

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Table 5. Influence of rate, source and time of application of N and S on grain yield, moisture, N and N removal at WASECA in 1984.

N Rate	N Source[1]	S Rate	S Source	Applcn method[2]	Grain Yield	Grain Moisture	Grain N	Grain N removal
lb/A		lb/A			bu/A	------ %	-----	lb/A
Check					53.3	20.2	1.28	32.5
89	Urea	-	-	PP	103.8	18.8	1.39	68.6
89	Urea	105	Gypsum	PP	106.9	18.6	1.42	71.7
89	AS	105	AS	PP	105.6	18.6	1.41	70.3
89	AS	105	AS	Split	96.9	18.2	1.43	65.8
178	Urea	-	-	PP	122.8	18.1	1.73	100.5
178	AS	210	AS	PP	121.8	18.1	1.71	98.2
178	AS	210	AS	Split	121.7	17.7	1.66	95.7
	Significance Level (%):[3]				99	99	99	99
	BLSD (.05)		:		8.1	.9	.07	6.3
	CV (%)		:		7.4	4.4	4.7	7.9
Individual Factors								
N rate (lb/A)								
89					103.2	18.5	1.42	69.3
178					122.1	18.0	1.70	98.1
	Significance Level (%):[3]				99	97	99	99
N source-time of application								
Urea - PP					114.8	18.3	1.57	86.1
AS - PP					113.7	18.4	1.56	84.2
AS - Split					109.3	18.0	1.55	80.8
	Significance Level (%):[3]				87	72	36	95
	BLSD (.05)		:					4.6
Interactions								
N rate x N source-time								
	Significance Level (%):[3]				78	03	72	11

[1] AS = ammonium sulfate
[2] PP = preplant, Split = ½ at PP and ½ at 8-leaf stage
[3] Probability level of significant difference among treatment means

Table 6. Influence of N source and time of ammonium sulfate application on leaf S, grain S, fodder S, total S uptake and grain S removal at WASECA in 1984.

N source[1]	Application method[2]	Leaf S	Grain S	Fodder S	Total S uptake	Grain S removal
		%	%	%	lb/A	lb/A
Urea	PP	.172	.113	.041	8.9	6.6
AS	PP	.233	.144	.090	13.5	8.3
AS	Split	.246	.142	.091	12.6	8.1
Signif. Level (%):[3]		99	99	99	99	99
BLSD (.05)	:	.032	.008	.009	1.1	.5
CV (%)	:	12.	4.8	10.4	7.9	6.0

[1] AS = ammonium sulfate; Both N sources applied at rate of 178 lb N/A
[2] PP = preplant, Split = ½ at PP and ½ at 8-leaf stage
[3] Probability level of significant difference among treatment means

LONG-TERM CARRYOVER FROM HIGH RATES OF MANURE

Waseca, 1984

G. W. Randall and R. H. Anderson

Conditions sometime exist in livestock operations where acreage, time and/or labor may not be sufficient to permit the application of manure to land just prior to planting or at conventional rates. In addition, the monetary value of the nutrients contained in the manure in relation to prices for inorganic fertilizers sometimes is relatively low. As a result of these factors, heavy rates of manure have been applied or disposed of in localized areas; often close to the livestock facility.

With these conditions in mind an experiment was established to determine the maximum quantity of manure that can be applied and incorporated in a limited non-crop area. Primary objectives were to investigate: (a) the capacity of land to serve as a disposal medium for excessive rates of manure, (b) the accumulation and movement of nutrients in the soil profile and (c) the response of future crops to these high rates.

Experimental Procedures

During 1971, 1972 and 1973, beginning in mid-May and ending in mid-September, dairy cattle manure taken directly from the barn was applied to the surface of a Webster clay loam soil. Manure was applied to the same 0.5-acre area in both 1971 and 1972. In 1973, this area was split and manure was applied to one of the 0.25-acre areas. The manure was allowed to dry for 1 to 7 days before incorporating by disking, field cultivating or periodic plowing by either moldboard or chisel plow. Dry matter determined at 105 C and nutruent application rates were calculated by weighing each load of manure and by gathering random manure samples throughout the season for chemical analysis. Total N, organic N, inorganic N, total P and total K applied in the manure treatments are shown in Table 1.

To evaluate the carryover from the manure treatments a 0.25-acre section has received an annual application of N (approximately 150 lb N/A) as anhydrous ammonia each year. Supplemental P and K or starter fertilizers have not been used on the whole experimental site due to very high soil test levels.

Corn has been planted annually beginning in 1974. Excellent weed control has been obtained with preemergence herbicides. Corn root worms have been controlled with a rotation of Furadan and Counter. Soil samples have been taken in 1-foot increments to a depth of 10' each spring. Leaf nutrient concentrations at silking, fodder N and grain N have been determined annually. Corn silage and grain yields have been obtained by hand harvesting four replicated sections within each of the treatments each fall.

Results

The manure application rates and amount of nutrients applied in the manure are shown in Table 1. These extremely high manure rates resulted in approximately 10, 3 and 5 tons of N, P, and K/A, respectively, applied over the 3-year period with slightly less over the 2-year application period. Approximately 75% of the N was in the organic form with the remainder as NH_4-N.

Table 1. Nutrient amounts applied with the manure treatments in 1971-73.

	Period	
	1971-72	1971-73
Manure rate (T/A, dry basis)	200[1/]	345[2/]
Nutrients (lb/A)		
Total N	11800	20150
Org. N	8980	15320
NH_4-N	2820	4820
NO_3-N	3	5
P	3220	5840
K	6210	10780

[1/] 1040 T/A on a wet basis.
[2/] 1758 T/A on a wet basis

Soil and plant samples taken annually (data not shown) and corn yields show that there has been a long-term effect of these manure rates on corn production (Table 2). Yield differences among the treatments have not been significant (P = 90% level) in 6 of the 10 years. Significant yield advantages were obtained with at least one of the manure treatments in 1976 and 1978. Yields in 1979 showed an advantage for the fertilizer N and high rate of manure treatments. Although significant yield differences were found in 1982, no consistent advantage was seen for either manure or fertilizer.

Table 2. Corn grain yields from 1974-1983 as influenced by previous manure application rates at Waseca.

	Treatment					
	Manure		Fertilizer	Signif.	BLSD	
Year	345 T/A	200 T/A	150 lb N/A	level	.05	(.10)
	bu/A			%		
1974	117.1	119.9	117.0	NS		
1975	99.2	93.2	105.3	NS		
1976	98.7	88.0	86.4	99	7.5	
1977	148.0	158.0	161.8	84		
1978	152.9	148.3	138.0	96	11.7	
1979	179.6	161.4	183.5	99	11.8	
1980	103.1	111.0	111.1	33		
1981	183.3	177.3	177.3	54		
1982	148.3	165.2	158.9	93		(12.4)
1983	85.4	77.6	93.2	78		

Some of the data shown in Table 3 indicate that the residual effect of the manure may be waning in the 11th year of the study. Leaf and fodder concentrations and total N uptake were significantly lower for both of the manure treatments compared to the annual fertilizer N treatment. However, grain yields from the manure treatments were significantly higher than from the N treatment. Silage yields showed the same trend but were not significantly different.

Reasons for this apparent discrepancy can probably be attributed to the weather conditions in 1984. Conditions thru July were excellent for corn growth. At the end of July corn growing on the N treatment looked much better (larger, more vigorous and darker green) than on the manure treatments. Less than 1.5" of rain fell between the end of July and September 12. This dry period coupled with a few hot days provided a severe stress on the corn. This was especially true on the larger, more vigorous corn with higher ET needs. Consequently, final yields of grain and silage (primarily because of grain) were lower with the fertilizer treatment.

Table 3. Influence of manure and fertilizer application on corn production and N utilization at Waseca in 1984.

Treatment	Final popl'n	Leaf N	Fodder N	Silage Yield	Silage N Uptake	Grain Yield	Grain N	Grain N removal	Ear Moisture
	$ppA \times 10^{-3}$	%	%	T DM/A	lb N/A	bu/A	%	lb N/A	%
Manure-(345 T/A)	25.9	2.70	.55	6.32	114.3	114.6	1.47	79.8	39.6
" -(200 T/A)	29.1	2.25	.48	6.18	106.0	112.8	1.43	76.4	38.1
Fert. N (150 lb/A)	29.1	3.06	.87	5.80	125.0	96.3	1.53	70.3	37.4
Signif. Level (%):	99	99	99	75	99	98	61	79	87
BLSD (.05) :	1.1	.18	.18		10.9	13.3			
CV (%) :	2.4	4.1	16.	6.7	5.4	6.9	6.8	8.8	3.4

Nitrate-N concentrations within the 0-10' soil profile show substantially more NO_3-N in the top 2' with the fertilizer N treatment (Table 4). Much of this could have come from the nitrified anhydrous ammonia that was applied in late April. At depths below 2' very little difference in NO_3-N concentration was found among the manure and fertilizer treatments. Consequently, total nitrate-N accumulation in the top 10' was higher with the fertilizer treatment as shown by 332 and 454 lb NO_3-N in the top 5' and 10', respectively. Accumulation between 5' and 10' ranged from 99 to 122 lb NO_3-N/A and these differences among treatments were considered to be insignificant.

Table 4. Influence of past manure treatments and annual N applications of NO_3-N in the 0-10' soil profile at Waseca in June, 1984.

Profile depth	Treatment		
	345 T/A	200 T/A	150 lb N/A
feet	ppm		
0-1	2.9	8.8	55.1
1-2	4.2	5.6	11.2
2-3	3.8	4.7	5.4
3-4	3.9	5.4	5.5
4-5	4.4	6.0	6.0
5-6	4.6	5.6	5.7
6-7	5.0	5.4	6.6
7-8	4.8	5.6	7.3
8-9	5.1	4.9	5.6
9-10	5.3	4.6	5.2
lb NO_3-N in top			
0-5' =	77	122	332
5-10' =	99	104	122
0-10' =	176	226	454

Summary

High rates of manure resulted in large quantities of nutrients applied to a Webster clay loam soil in 1971-73. Carryover from these manure treatments without additional fertilizer applications sustained corn production from 1974-1983. Nitrogen uptake by the corn and soil NO_3-N levels in 1984 indicated that the carryover effect from the previous manure treatments has begun to wane. Corn yields, however, were significantly higher with the manure treatments. This was due to the adverse effects of the August weather conditions on the annually fertilized corn.

CONSERVATION TILLAGE STUDY

Waseca, 1984

G. W. Randall, D. T. Walters, 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.

EXPERIMENTAL PROCEDURES

To evaluate some of these conservation tillage 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.

Ridges for the ridge-plant treatment in 1984 were built in July, 1983. The fall moldboard and chisel tillage operations were also done in early November, 1983. Secondary tillage conducted on April 24 consisted of field cultivating the moldboard and chisel treatments and the spring disking. Ammonium nitrate was broadcast-applied at a rate of 150 lb N/A immediately before the secondary tillage. Ridges for the 1985 soybeans were built on June 28.

Corn (Pioneer 3732) was planted in 30" rows at a rate of 29,900 plants/A on May 10. All treatments 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 treatment. Ten gallons/A of 7-23-5 was used as the starter treatment.

Broadcast P and K were not applied for the 1984 corn crop because of very high soil tests. Soil tests on this site 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 2' wide and 5' long was placed between the 4th and 5th rows of each tillage plot during herbicide spraying to prevent the application of herbicide onto the soil surface. Weed counts (grass and broadleaf) were taken on June 5 from sprayed and unsprayed areas. All treatments except no tillage were cultivated on June 19. Weed control was excellent on all cultivated plots.

Planting depth was determined by cutting off the coleoptile at the soil surface from all the plants in a 3-meter length of row in each tillage plot 30 days after planting. The seeds were then excavated and the length of the coleoptile to the seed was measured. Early plant growth was determined by harvesting the above ground portion of 10 random plants per plot 33 days after planting. On June 25 soil samples were taken to a 9" depth from the ridge-planted plots which had starter fertilizer for the last ten years. These plots were sampled in 3 positions: directly down the center of the ridge, at 6" to the side of the ridge and midway between the ridges. Before compositing the 8 cores/plot they were separated into 0-2", 2-4" 4-6" and 6-9" increments. After drying at 100°F they were submitted to the University of Minnesota Soil Testing Lab for pH, Bray 1 extractable P and exchangeable K analyses.

Yields were taken by combine harvesting the center two rows from each plot. Grain moisture and N concentrations were determined on each of these samples.

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

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

RESULTS

Since the 2-way and 3-way interactions shown at the bottom of Table 1 are generally non-significant, the comparison of main effects (tillage, starter fertilizer, and previous Poast treatment) is appropriate.

Significant differences in plant height, final population, grain moisture and grain yield were found among the tillage treatments when averaged over starter fertilizer and previous Poast treatments (Table 1). Plant heights taken after silking showed somewhat shorter plants with the ridge-plant (RP) system. This 4 to 6" difference could have been due largely to the presence of the ridge around the base of the plant. Plant height was increased slightly with starter fertilizer but was not affected by the previous Poast treatment.

Final population of the no tillage (NT) plots ranged between 1000 to 1500 plants fewer than with the other treatments. Differences in final stand did not exist among the moldboard plow (MP), chisel plow (CP), RP, and spring disk (SD) treatments. Final population was not affected by starter fertilizer or the previous Poast treatments.

Grain moisture, an indication of maturity, was significantly higher with the NT treatment (Table 1). This was consistent with previous years when continuous corn was grown. Grain moisture for the MP, CP, RP and SD systems was not significantly different. Neither starter fertilizer nor the previous Poast treatments affected grain moisture.

Grain yields were highest with the MP and SD systems, intermediate with the CP and RP systems, and significantly lower with the NT system when averaged over starter fertilizer and previous Poast treatments (Table 1). The 4.4 bu/A response to starter fertilizer averaged across tillage systems was only significant at the 90% level. Even though a statistically significant interaction between tillage system and starter fertilizer did not exist (81% level), it did appear that the largest responses to starter fertilizer were obtained with the NT (11.9 bu/A) and RP (11.0 bu/A) treatments. Yield responses to starter fertilizer were less than 4 bu/A with the MP, CP and SD treatments. The previous Poast treatment did not influence corn yields.

Early plant growth was significantly greater for the MP, CP and SD tillage systems than for the RP and NT systems (Table 2). Plants in the NT system were only 50% as large as with the MP, CP and SD systems. Starter fertilizer also increased early plant weight by 20% when averaged across tillage systems. The interaction between tillage system and starter fertilizer was not significant (38% level). The correlation between EPG and grain yield was not significant when starter fertilizer was used ($r = +.299$) but was significant at the 97% level when no starter was used ($r = +.486$). A linear rather than a curvilinear relationship was best for each.

Grain N (protein) was not influenced by tillage or starter fertlizer (Table 2). However, N removal in the grain (product of grain N concentration and grain yield) was significantly affected by both tillage and starter fertilizer. This effect was due largely to the yield difference among the treatments.

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 > RP = SD > 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 both the RP and NT systems.

Planting depth averaged significantly deeper with the MP and CP systems compared to the NT system. This was consistent with previous years (Table 3). Planting depth was not different between the MP, CP and RP systems which is in contrast to previous years with continuous corn when the RP system usually showed a shallower planting depth. The variability in the seeding depth as measured by standard deviation and range in depths indicates least variability with the CP, MP and SD systems and greatest variability with the RP and NT systems. This is consistent with previous years. Seed placement ranged between 2.2" and 3.0" with the CP system and between 1.8" and 3.2" with the RP

Table 1. Influence of tillage methods, starter fertilizer and previous Poast herbicide treatment on corn production at Waseca in 1984.

Treatment						
Tillage	Starter fert.[1/]	Poast herb.[2/]	Plant height	Final population	Grain Moisture	Grain Yield
			cm	x 10^3	%	bu/A
No tillage	S	P	275	26.3	25.7	136.4
"	S	NP	271	25.7	28.0	138.0
"	NS	P	269	25.6	28.1	127.7
"	NS	NP	265	24.5	28.8	123.0
Fall plow, f. cult.	S	P	274	26.3	24.8	157.9
" "	S	NP	269	26.1	24.5	152.0
" "	NS	P	274	27.0	24.1	157.6
" "	NS	NP	271	26.5	24.0	165.7
Fall chisel, f. cult.	S	P	271	26.3	22.3	146.4
" "	S	NP	271	26.6	22.9	150.9
" "	NS	P	268	27.1	22.2	146.3
" "	NS	NP	272	27.2	22.7	143.1
Ridge plant	S	P	261	27.0	23.0	150.4
"	S	NP	260	26.9	23.1	145.9
"	NS	P	257	26.8	23.1	131.9
"	NS	NP	258	26.7	21.9	142.5
Spring disk	S	P	276	27.1	23.4	158.2
"	S	NP	276	26.1	23.9	154.3
"	NS	P	272	27.7	23.7	152.8
"	NS	NP	271	27.7	22.7	155.5
Individual Factors						
Tillage						
No tillage			270	25.5	27.7	131.3
Fall plow			272	26.5	24.4	158.3
Fall chisel			270	26.8	22.5	146.7
Ridge plant			259	26.8	22.8	142.6
Spring disk			274	27.2	23.4	155.2
Significance Level (%):			99	99	99	99
BLSD (.05) :			6	.8	2.0	10.7
Starter Fertilizer						
Starter			271	26.4	24.2	149.0
No starter			268	26.7	24.1	144.6
Significance Level (%):			99	63	6	90
Poast Herbicide						
Poast			270	26.7	24.0	146.6
No Poast			268	26.4	24.2	147.1
Significance Level (%):			85	85	12	8
Interactions						
Tillage x SF			91	86	83	81
Tillage x Poast			69	18	49	2
SF x Poast			71	2	92	66
Tillage x SF x Poast			32	13	53	66
CV (%)			1.3	4.3	8.3	8.0

1/ S = starter fertilizer used and NS = no starter fertilizer used.
2/ P = Poast herbicide used and NP = no Poast herbicide used in 1983.

Table 2. Influence of tillage methods and starter fertilizer on corn production at Waseca in 1984.

Treatment		Early	Grain		
Tillage	Starter fert.[1/]	plant growth	N	Protein	N Removal
		g/plant	------- % -------		lb/A
No tillage	S	5.4	1.40	8.7	84.4
No tillage	NS	3.8	1.48	9.2	95.5
Fall plow, f. cult.	S	11.0	1.43	8.9	106.4
Fall plow, f. cult.	NS	8.7	1.43	8.9	107.1
Fall chisel, f. cult.	S	10.1	1.46	9.1	100.6
Fall chisel, f. cult.	NS	8.9	1.51	9.4	104.4
Ridge plant	S	8.4	1.44	9.0	89.7
Ridge plant	NS	6.7	1.47	9.2	104.7
Spr. disk	S	9.5	1.50	9.3	107.7
Spr. disk	NS	8.9	1.45	9.1	108.5
Individual Factors					
Tillage					
No tillage		4.6	1.44	9.0	89.9
Fall plow		9.9	1.43	8.9	106.8
Fall chisel		9.5	1.48	9.3	102.5
Ridge plant		7.5	1.46	9.1	97.2
Spr. disk		9.2	1.47	9.2	108.1
Signif. Level (%):		99	42	42	99
BLSD (.05) :		1.2			7.0
Starter fertilizer					
Starter		8.9	1.47	9.2	104.0
No starter		7.4	1.44	9.0	97.8
Signif. Level (%):		99	74	74	98
Till x SF IA					
Signif. Level (%):		38	62	62	69
CV (%) :		14.	4.5	4.5	7.9

1/ S = starter fertilizer used and NS = no starter fertilizer

system. 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.

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 11th to the 25th day after planting. Emergence, as a percent of final stand, shown in Table 4 indicates most rapid emergence with the MP, CP, RP and SD systems. Plants emerged 2 to 3 days later with the NT system.

Leaf samples were taken from the leaf opposite and below the ear at silking. When averaged over starter fertilizer treatments, only leaf Fe was affected (P = ≥ 95% level) by tillage (Table 5). The reason for higher Fe concentrations with the RP system compared to the MP and CP systems is unexplainable and not consistent with previous years. When averaged over tillage systems, the starter fertilizer treatment showed slightly higher leaf K and Mg concentrations and lower Zn, Cu, and Mg concentrations. The highly significant interactions between tillage and starter fertilizer for Mn, Zn, and Cu was generally due to lower concentrations of these nutrients when starter fertilizer was used with moldboard tillage compared to the other tillage systems. Reasons for this phenonenon are not evident at this time. All nutrient concentrations in the leaves were considered to be adequate for optimum yields.

Table 3. Influence of tillage methods for corn following soybeans on surface residue and seeding depth at Waseca in 1984.

Treatment	Surface Residence: Before planting	After Planting: Across plot	After Planting: Within row	Planting Depth: Average	Planting Depth: S	Planting Depth: Range
	%			mm		
No tillage	93	70	61	65	9.0	51-80
Fall plow	2	3	3	74	6.6	60-90
Fall chisel	25	13	17	71	4.8	57-75
Ridge plant	61	41	32	69	8.7	45-82
Spr. disk	60	18	23	66	7.2	52-74
Signif. Level (%):	99	99	99	98		
BLSD (.05) :	12	11	13	6		
CV (%) :	17	18	30	5.0		

Table 4. Influence of tillage methods on the emergence progress of corn following soybeans at Waseca in 1984.

Treatment	Days Post Planting: 11	12	13	14	15	16	17	18	19	20	21	25
	% emerged											
No tillage	1	23	47	67	92	95	97	98	98	98	98	100
Fall plow	45	91	97	98	100							
Fall chisel	44	91	95	97	98	98	99	99	100			
Ridge plant	36	81	91	96	97	98	99	99	99	100		
Spring disk	44	93	96	98	100							

Weed counts (broadleaf and grass) were taken between the 4th and 5th rows from randomly placed 1 ft^2 sections/plot 24 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 6). Grasses were controlled extremely well in the MP, CP, RP and SD systems. It should be noted that the RP system had the fewest grass weeds when no herbicide was applied and showed no weeds after herbicide application. Grass control was inadequate 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.

Soil samples taken from the RP treatment after planting showed that regardless of the sampling position, pH, P and K levels were fairly uniform when compared within each depth (Table 7.) From this we can conclude that soil samples can be taken randomly from a ridge-planted system that is relatively flat <u>after</u> planting but <u>before</u> ridging.

Table 5. Influence of tillage methods and starter fertilizer on the leaf nutrient concentration in the corn earleaf at Waseca in 1984.

Treatment		Nutrient									
Tillage	Starter fert.	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%					ppm				
No tillage	S	2.72	.29	2.02	.45	.34	115	34	28	9.1	6.4
" "	NS	2.62	.28	1.90	.44	.33	108	30	26	8.5	6.5
Fall plow	S	2.80	.29	2.09	.47	.31	112	46	23	8.5	6.4
" "	NS	2.89	.28	2.10	.47	.33	115	57	31	9.8	6.8
Fall chisel	S	2.83	.29	2.00	.50	.40	112	48	26	8.7	6.2
" "	NS	2.91	.30	1.97	.47	.36	119	44	28	9.3	6.8
Ridge plant	S	2.84	.29	1.90	.49	.43	135	39	25	8.7	6.8
" "	NS	2.74	.30	1.82	.48	.39	126	37	27	8.8	6.8
Spring disk	S	2.92	.28	1.97	.47	.45	123	43	30	9.2	6.8
" "	NS	2.91	.29	1.94	.47	.39	117	45	30	9.5	6.9
Individual Factors											
Tillage											
No tillage		2.67	.29	1.96	.44	.34	111	32	27	8.8	6.5
Fall plow		2.84	.29	2.09	.47	.32	114	52	27	9.1	6.6
Fall chisel		2.87	.29	1.99	.48	.38	116	46	27	9.0	6.5
Ridge plant		2.79	.30	1.89	.49	.41	131	38	26	8.7	6.8
Spring disk		2.91	.29	1.96	.47	.42	120	44	30	9.3	6.9
Signif. Level (%):		89	2	51	47	92	97	93	40	19	24
BLSD (.05) :							13				
Starter fertilizer											
Starter		2.82	.29	2.00	.48	.39	119	42	27	8.8	6.5
No starter		2.81	.29	1.95	.47	.36	117	43	28	9.1	6.8
Signif. Level (%):		13	11	93	71	99	76	38	99	95	97
Interactions											
Tillage x SF											
Signif. Level (%):		31	19	50	13	88	92	99	99	98	62
CV (%) :		6.0	8.1	3.9	6.2	7.6	5.2	9.6	6.1	5.2	5.0

Table 6. Weed populations on June 5th as affected by tillage and herbicide for corn following soybeans as Waseca in 1984.

Treatment	Herbicide[1/]		No Herbicide	
	Grasses	Broadleaves	Grasses	Broadleaves
	plants/10 sq. ft.[2/]			
No tillage	85	1	1107	7
Fall plow	1	2	16	4
Fall chisel	3	1	123	4
Ridge plant	0	0	4	6
Spring disk	1	1	155	1

1/ 3 lb Lasso and 3 lb Bladex/A, preemergence

2/ Average over 4 replications

Table 7. Soil test pH, P and K after corn planting and before ridging after 10 years continuous ridge planting at Waseca.

Profile depth	Position of ridge sample[1/]		
	In row	6" to side of row	15" between row
inches	Soil pH		
0-2	6.5	6.4	6.2
2-4	6.7	6.8	6.6
4-6	7.0	7.1	6.8
6-9	7.1	7.1	6.7
	Soil P (ppm)		
0-2	54	49	39
2-4	26	28	25
4-6	12	16	19
6-9	9	10	14
	Soil K (ppm)		
0-2	277	287	286
2-4	183	191	203
4-6	149	163	166
6-9	139	143	157

1/ Average over 4 replications; 8 cores composited/replication

SUMMARY

After 8 years of continuous corn this experiment was changed in 1983 to evaluate five tillage systems in a long-term corn-soybean rotation. Yield results from this study in 1984 differ from previous studies where corn yields were generally not influenced by various tillage systems when following soybeans in a corn-soybean rotation as long as weeds were controlled. Over the 8-year period with continuous corn a substantial amount of corn residue had accumulated on the soil surface with NT. Even with one crop of soybeans in 1983, a large amount of residue still remained (93% surface coverage) at the beginning of the 1984 season. This accumulation of residue resulted in a 2-3 day delay in corn emergence, retarded early plant growth, and higher grass weed populations. These factors more than likely contributed to the 15% yield reduction with no tillage compared to the higher yielding tillage treatments. Starter fertilizer improved the NT and RP yields by about 11 bu/A with less than 4 bu/A responses with the other tillage systems. Yields were not influenced by the previous Poast treatments. Large differences in nutrient concentrations in the earleaf at silking were not found among the tillage treatments or between the starter fertilizer treatments. Soil samples taken in the ridge, 6" to the side of the ridge, or midway between the ridges did not show apparent pH, P or K differences within depths when taken after planting but before ridging.

Weed pressure without herbicides was lowest for the RP system; however, the herbicides provided excellent control with all tillage systems except NT. Only the NT and RP tillage systems had greater than 30% surface residue coverage after planting, and thus met the SCS definition of "conservation tillage".

SOYBEAN ROW WIDTH IN A RIDGE-PLANT TILLAGE SYSTEM

Waseca, 1984

G. W. Randall, D. T. Walters, and P. L. Kelly

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

Experimental Procedures

An area of Webster clay loam which was planted to corn in 30" rows and ridged in July, 1983, was the site for the study. A split-plot design consisting of three row width-ridge treatments (30" row on ridges, 30" row with ridge disked, and 10" row with ridge disked) and split into two varieties (Corsoy 79 and Hodgson 78) was used. Each individual plot measured 60' long by 10' wide and was replicated six times. A light 20" diameter blade tandem disk was used to disk the tops off of the ridges immediately prior to planting the flat treatments. A John Deere 7100 Max-Emerge with B & H ridge cleaners was used to plant the 30" ridge treatment and the 30" flat treatment. An Almaco experimental planter was used for the 10" rows. Soybeans were planted on May 16 at a rate of about 160,000 seeds/A. Starter fertilizer was not used because of high soil tests. Weeds were controlled chemically with Lasso + Amiben.

Emergence rates were taken from May 23 thru June 13 by counting plants in either two 30-inch rows or four 10 -inch rows per plot. Surface residue accumulation was measured with the line transect method. Plant height was taken September 21 when greater than 75% of the pods were brown. All yields were determined by combine harvesting the entire plot.

Results and Discussion

Emergence rate of the soybeans was affected by the row width-ridge treatments but was only slightly affected by soybean variety (Table 1). Planting in 30" rows either directly into the ridges or where the ridge tops had been disked resulted in soybean emergence 8 days after planting with 50% of the beans emerged by 10 days. Rate of emergence was slowest with the 10" rows planted on the disked ridges. The first plants emerged 8 days after planting, but emergence continued to lag two days behind the 30" rows with 50% of the plants emerged by 12 days. Emergence was slightly earlier with the Hodgson 78 variety.

The reason for this delayed emergence can be attributed to (1) disking which tends to dry the surface soil especially when little rain occurs during the first 5 days after planting and (2) the Almaco experimental planter did not place the seed as deep in 10" rows as when planted in 30" rows. Consequently, emergence was delayed significantly by the combination of drier surface soil and shallower planting. In all row width-ridge treatments, 95% of the seedlings had emerged 20 days following planting.

Date of canopy closure estimated subjectively showed a large difference between row width but essentially no difference between ridge treatment or soybean varieties. The date of closure was July 1 with the 10" rows while the 30" rows did not close until July 22.

Surface residue measurements taken prior to disking of the ridges indicated that 70% of the soil surface was covered by residue from the previous corn crop. After planting, surface residues covered approximately 16% of the soil surface with the ridges that had been disked lightly compared to 23% with the conventional ridge-plant system (Table 2).

Surface residue measurements taken post-harvest revealed no difference between varieties but slightly more residue with the 10" row width-ridge treatment (Table 2).

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

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

Treatment		Days after planting																
Row width-ridge	Variety	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	23	28
		% emerged																
30", ridge	Corsoy 79	0	10	34	45	49	63	83	89	89	89	90	92	94	94	97	98	100
30", ridge	Hodgson 78	0	21	42	58	60	69	85	87	87	89	89	92	92	93	95	97	100
30", flat	Corsoy 79	0	21	46	55	58	65	80	82	85	89	90	91	92	95	97	100	100
30", flat	Hodgson 78	0	25	45	59	60	68	80	84	84	88	89	93	94	95	97	98	100
10", flat	Corsoy 79	0	3	11	32	35	43	66	76	80	85	88	93	95	95	96	99	100
10", flat	Hodgson 78	0	5	16	26	49	59	66	79	80	87	88	93	94	95	95	98	100

Table 2. Influence of row width-ridge treatment and soybean variety on surface residues, plant height and seed yields.

Treatment		Surface residue		Plant height	Seed	Seed
Row width-ridge	Variety	after pltng.	after harvest	at maturity	moisture	Yield
		%	%	in.	%	bu/A
30", ridge	Corsoy 79	26	22	32	8.9	46.0
30", ridge	Hodgson 78	19	22	32	8.3	43.7
30", flat	Corsoy 79	16	23	31	8.7	45.3
30", flat	Hodgson 78	15	22	31	8.3	44.6
10", flat	Corsoy 79	21	24	33	9.0	49.0
10", flat	Hodgson 78	17	23	35	8.3	46.4
Individual Factors						
Row width-ridge						
30", ridge		23	22	32	8.6	44.9
30", flat		16	23	31	8.5	44.9
10", flat		19	24	34	8.6	47.7
Signif. Level (%):[1/]		99	94	99	80	99
BLSD (.05):		5		2		1.1
Variety						
Corsoy 79		21	23	32	8.8	46.7
Hodgson 78		17	23	33	8.3	44.9
Signif. Level (%):[1/]		93	86	35	99	99
Row width-ridge x variety interaction						
Signif. Level (%):[1/]		56	32	17	82	83
CV (%):		28.	6.4	8.5	1.7	2.8

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

Plant height measured at maturity indicated that the soybeans planted in the 10" row flat treatment were taller than the 30" row flat treatment. Unexpectedly, there was no plant height difference between the two varieties.

As expected, seed moisture differed significantly among the two varieties (Table 2). The earlier maturing Hodgson 78 was .5% drier at harvest than the later maturing Corsoy 79.

Soybean yields were also affected significantly by the treatments (Table 2). Yields from the 10" rows surpassed the 30" rows by about 3 bu/A. No significant difference occurred between the ridge-planted and flat planted treatments in 30" rows. The Corsoy 79 variety outyielded the Hodgson 78 variety by 1.8 bu/A. There was no interaction between variety and row width-ridge treatment.

Summary

Data from the third year of the three-year study indicated that light disking of ridges could be performed easily and satisfactorily to enable narrow row planting of soybeans in a ridge-plant corn-soybean sequence. Surface residue amounts can be maintained at satisfactory levels and yields increased withthe 10" row soybeans planted in this manner. This, of course, necessitates building the ridges for corn (if one desires to do so) after the soybean crop is harvested.

THREE YEAR SUMMARY

Table 3. Influence of row width-ridge treatment and soybean variety on 3-yr average surface residues and seed yields.

Treatment		Surface residue after planting	Seed yield
Row width-ridge	Variety	%	bu/A
30", ridge	Corsoy 79	27	43.7
30", ridge	Hodgson 78	25	45.3
30", flat	Corsoy 79	29	43.2
30", flat	Hodgson 78	32	43.2
10", flat	Corsoy 79	33	50.1
10", flat	Hodgson 78	30	49.1
Individual Factors			
Row width-ridge			
30", ridge		26	44.5
30", flat		30	43.2
10", flat		32	49.6
Variety			
Corsoy 79		30	45.7
Hodgson 78		29	45.9

Acknowledgement

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

Waseca. 1984

G. W. Randall, D. T. Walters and P. L. Kelly

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

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

The purpose of this study was to evaluate three times of building ridges in soybeans on soybean production.

EXPERIMENTAL PROCEDURES

The experimental site (Webster clay loam) was planted to corn in 30" rows and ridged in 1983. Two varieties of soybeans (Corsoy 79 and Hodgson 78) were planted with a John Deere 7100 Max-Emerge planter with B & H ridge cleaners in 30" rows on May 16 at a rate of 160,000 seeds/A. No starter fertilizer was used. Weeds were controlled chemically with Lasso and Amiben. The ridging treatments were superimposed over varieties at three stages of soybean growth (early bloom (R1), mid-bloom (R2.5), and post-harvest). A Hiniker cultivator was used to build the ridges. This split-plot design with ridge treatments as the main plot was replicated six times.

Plant height at maturity and the height of the lowest pod above the soil surface were measured from 5 randomly selected plants/plot just prior to harvest. Harvest loss was determined by counting the soybean seeds present in 10 random one-foot square areas/plot. All yields were obtained by harvesting with a modified JD3300 plot combine.

RESULTS AND DISCUSSION

In 1982 and 1983 problems arose in that some plants ridged at the R1 stage were knocked over by the dry, hard soil slabs of ridging. To alleviate this damage, a Hiniker cultivator in the non-ridge mode was used to breakup the soil two weeks prior to the 1984 ridging. The ridging operation at the R1 stage (July 9) did appear to ridge more smoothly than in the two previous years. Yet speed and depth of cultivation had to be carefully watched. At the mid-bloom stage (R2.5) on July 16th, the plants were bigger and did not appear to be quite as sensitive to cultivation speed. Ridge height at the end of the July treatments was estimated to be about 5 to 6" (amplitude). Soil moisture conditions were at field capacity in the 0-6" depth during each of these operations.

Plant height at maturity from the early bloom (R1) ridging treatment averaged 3" higher than the mid-bloom (R2.5) and 2" higher than the post-harvest ridging treatments (Table 1). Corsoy 79 soybeans were 5" taller than the Hodgson 78 variety. A time of ridging by variety interaction was found indicating a positive growth response with Corsoy 79 with the early bloom ridging treatment.

The height of the lowest pod above the soil surface was shortest with the R2.5 stage of ridging (Table 1). There was no significant difference between early bloom (R1) and post-harvest ridging treatments. The pod height of the Group I variety (Hodgson 78) was significantly lower than the Group II variety (Corsoy 79). A time of ridging x variety interaction indicates a greater pod height with Corsoy 79 with the early and mid-bloom ridging treatments compared to the post-harvest treatment when no difference between varieties was noted.

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

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

Treatment		Plant height at maturity	Height of lowest pod	Seed	
Ridging time [1]	Variety			Moisture	Yield
		inches	cm	%	bu/A
July 9	Corsoy 79	41	13.9	8.7	46.5
"	Hodgson 78	33	9.9	8.2	44.3
July 16	Corsoy 79	36	11.5	8.6	41.7
"	Hodgson 78	32	10.0	8.2	41.7
Post Harvest	Corsoy 79	37	11.5	8.6	45.6
" "	Hodgson 78	33	11.6	8.2	45.3
Individual Factors					
Ridging time					
July 9		37	11.9	8.5	45.4
July 16		34	10.7	8.4	41.7
Post Harvest		35	11.6	8.4	45.5
Signif. Level (%): [2]		99	92	68	99
BLSD (.05):		1			1.2
Variety					
Corsoy 79		38	12.3	8.7	44.6
Hodgson 78		33	10.5	8.2	43.8
Signif. Level (%): [2]		99	99	99	88
Ridge time x variety interaction					
Signif. Level (%): [2]		99	99	10	81
CV (%):		4.8	11.	1.2	3.5

[1] Corresponds to R1 (July 9) and R2.5 (July 16) stages.

[2] Probability of a significant difference among treatment means.

Soybean yields when averaged over the two varieties were significantly reduced about 4 bu/A by ridging at the R2.5 soybean stage (Table 1). It does appear that some of the yield reduction may have been partially the result of higher harvest losses. Harvest difficulty was encountered because of the lower pod height associated with the mid-bloom (R2.5) stage of ridging. Ridge cultivation at this time may have also pruned roots and/or increased soil water loss during the very dry late July and August months. Yield differences between the varieties were not obtained nor was there a significant interaction between time of ridging and variety.

Harvest losses were 0.4 bu/A greater with the mid-bloom (R2.5) stage of ridging than the early bloom (R1) and post-harvest ridging treatments (Table 2). Losses were greater for the Hodgson 78 variety; perhaps due to lower seed moisture and lower pod height.

Ridge heights were measured shortly after the fall post-harvest ridging operation was conducted. At that time the post-harvest ridges were approximately 1" higher than the ridges formed in July (Table 2). The percent surface covered by the residue after harvest was decreased to 42% with post-harvest ridging compared to approximately 77% with the July ridge treatments when measured by the line-intercept method. As expected, no difference in residue was observed between the varieties.

Table 2. Influence of time of ridging and soybean variety on harvest loss, ridge height and surface residue cover.

Treatment		Harvest	Post Harvest		Spring'84
Ridging time [1]	Variety	loss	Ridge ht.	Residue	ridge ht.
		bu/A	cm	%	cm
July 9	Corsoy 79	.5	14.1	76	13.2
"	Hodgson 78	1.2	14.5	77	12.6
July 16	Corsoy 79	1.0	13.2	77	11.9
"	Hodgson 78	1.4	13.7	77	11.8
Post-Harvest	Corsoy 79	.6	17.1	42	14.7
" "	Hodgson 78	1.0	17.1	42	14.0
Individual Factors					
Ridging time					
July 9		.8	14.3	77	12.9
July 16		1.2	13.4	77	11.8
Post-Harvest		.8	17.1	42	14.3
Signif. Level (%): [2]		99	99	99	99
BLSD (.05):		.2	.8	4	.7
Variety					
Corsoy 79		.7	14.8	65	13.3
Hodgson 78		1.2	15.1	65	12.8
Signif. Level (%): [2]		99	59	11	87
Ridge time x variety interaction					
Signif. Level (%): [2]		84	19	01	28
CV (%):		23.	6.9	8.4	6.4

[1] Corresponds to R1 (July 9) and R2.5 (July 16) stages.

[2] Probability of a significant difference among treatment means.

Ridge heights from the 1983 experiment were measured on April 17, 1984 and are shown in Table 2. Ridge heights ranged between 4½ and 5". Significant differences among the time of ridging treatments were apparent with the largest ridges resulting from the post-harvest treatment.

SUMMARY

Results from the third year of this study indicate that soybeans were depressed approximately 4.0 bu/A when ridging was done at the R2.5 stage compared to the R1 and post-harvest stages of ridging. Soil cultivation prior to the early bloom (R1) ridging treatment reduced damage from soil slabs hitting the plants. These data agree fairly well with the 1982 and 1983 data and suggest a consistent yield advantage for post-harvest ridging in the fall for the next year's crop.

THREE-YEAR SUMMARY

Table 3. Influence of time of ridging and soybean variety on the 3-yr average height of lowest pod and seed yield.

Treatment		Height of lowest pod	Seed Yield
Ridging time	Variety	cm	bu/A
R1	Corsoy 79	10.1	47.5
"	Hodgson 78	8.1	43.3
R2.5	Corsoy 79	9.7	44.7
"	Hodgson 78	8.2	42.3
Post Harvest	Corsoy 79	11.1	47.7
" "	Hodgson 78	10.7	45.4
Individual Factors			
Ridging time			
R1		9.1	45.4
R2		9.0	43.5
Post Harvest		10.9	46.6
Variety			
Corsoy 79		10.3	46.6
Hodgson 78		9.0	43.7

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NITROGEN FERTILIZATION FOR PROCESSING SWEET CORN ON A FINE-TEXTURED SOIL: INFLUENCE OF RATES, TIMING AND A NITRITICATION INHIBITOR -- 1984

C. J. Rosen, H. J. Buchite and J. B. Hebel

The majority of the acreage used for processing sweet corn in Minnesota is on nonirrigated fine-textured soils. Because of potential nitrogen losses due to denitrification and/or leaching the practice of sidedressing or use of nitrification inhibitors in a nitrogen management program have become issues of interest for many growers. The objectives of this study were to 1) determine optimum rates and timing of nitrogen fertilizer for sweet corn on fine-textured soils, and 2) evaluate the effectiveness of N-Serve, a nitrification inhibitor, for sweet corn production.

Experimental Procedures:

The experimental site was located at the Southern Experiment Station in Waseca, Minnesota on a Webster clay loam (4.0 % organic matter). Phosphorus and potassium were broadcast according to soil test recommendations the previous fall. Treatments included a control, 4 nitrogen rates (50, 100, 150, 200 lb N/A), 100 lb N/A plus N serve (0.5 lb ai/A), 150 lb N/A plus N-Serve (0.5 lb ai/A), 100 lb N/A split (1/2 preplant, 1/2 6-8 leaf stage), 150 lb N/A split (1/3 preplant, 1/3 6-8 leaf stage, 1/3 12 leaf stage). All preplant nitrogen was with anhydrous ammonia. For the split treatments, ammonium nitrate was used as the nitrogen source. Each treatment was replicated 4 times in a randomized complete block design. Two varieties, Code 5 (early maturing) and Jubilee (midseason maturing), were planted on 11 May 1984 at a population of approximately 22,000/A. Each plot consisted of 6 - 30 ft rows with 2.5 ft between the rows.

Whole plant samples collected at the 6-8 leaf stage (before any sidedress application) and leaf samples from opposite and above the ear collected at mid-silking were dried, ground and analyzed for total nitrogen content. Leaf samples from the 100 and 150 lb N/A treatment with and without inhibitor were analyzed for P, K, Ca, Mg, Fe, Mn, Zn, Cu, and B using an inductively coupled plasma emission spectrometer.

Total yield (ear and husk), husked yield, and stover yield were obtained by harvesting 2 - 15 ft rows within each plot. Subsamples of ears, husk and stover were taken to determine % moisture for nitrogen uptake calculations. The following quality measurements were also made: ear length, % moisture in kernels, and % usable ears (5.5 inches or greater with tip removed).

Code 5 was harvested 6 August 1984 and Jubilee was harvested 10 August 1984. Rainfall data reported from the Southern Experiment Station is as follows: May, 2.22"; June 5.11"; July 3.43"; August (until Jubilee harvest) 1.3". The total rainfall was 12.06".

Results:

Rainfall at Waseca was very localized. During the month of July very little rain fell on the experimental plot. Additionally, root growth was extremely shallow, which may have been due to soil compaction. All plants including those that received 200 lb N/A showed signs of scorching on the older leaves. Scorching was most severe on the low nitrogen plots.

Sweet corn repsonded to nitrogen applications up to 100 lb N/A (Tables 1 and 3). Yields from plants receiving the 150 and 200 lb N/A rates were significantly greater than those in the 0 and 50 lb N/A plots but not the 100 lb N/A plot. Split applications or the addition of N-Serve at either the 100 or 150 lb N/A rates did not offer any advantage in terms of yield increase over the corresponding preplant rates. For Code 5, plants that received the split application at 100 lb N/A yielded significantly less than the corresponding preplant and preplant plus N-Serve treatment. Ear length and % COC eligible were similar for all 100 lb N/A treatments or more regardless of whether applications were preplant, split, or with N-Serve.

Whole plant nitrogen concentrations at the 6-8 leaf stage were generally lowest for plants in the check plots and those receiving 50 lb N/A (Tables 2 and 4). Except for plants in the check plots, nitrogen concentrations in whole plants at the 6-8 leaf stage were poor predictors of leaf nitrogen status at silking. Leaf nitrogen at silking tended to be greater when N-serve was added compared to preplant without N-Serve and split applications. Even at the high N rate treatments, leaf concentrations were relatively low (< 3.0% for Jubilee). It is possible that environmental factors such as low rainfall and/or soil compaction restricted nitrogen availability. These factors make it

difficult to interpret leaf analysis data. Concentrations of nitrogen in ear, husk or stover were generally not sensitive indicators of plant nitrogen status. Total nitrogen uptake generally increased with increasing nitrogen rates. For Jubilee, there were no significant differences in nitrogen uptake for plants receiving preplant, split or N-Serve treatments. For Code 5, nitrogen uptake by plants receiving the sidedress application and preplant plus N-Serve at 100 lb N/A were significantly lower than preplant applications. At 150 lb N/A, N uptake was the same regardless of treatment.

Preplant applications plus N-Serve had no consistent significant effect on leaf elemental concentrations compared to preplant applications without N-serve (Tables 5 and 6).

General Comments:

Maximum yields and quality for processing sweet corn were obtained with a preplant application of 100 lb N/A. N-Serve and sidedress treatments did not significantly increase yields or quality compared to corresponding preplant treatments. These data are based on one year of research. Further experiments are warranted on these fine-textured soils in order to better understand sweet corn response to nitrogen fertilization and management.

Table 1. Effect of nitrogen rate, nitrification inhibitor and sidedress applications on Code 5 sweet corn yield and quality.

Treatment lb N/A	Yield (T/A) Green	Yield (T/A) Husked	Ear Length inches	% Moisture in Kernels	% COC Eligible
0	2.97	2.20	5.9	69.7	41.2
50	5.40	3.65	7.2	68.7	72.0
100	7.30	4.81	7.9	69.8	85.9
150	6.75	4.54	8.0	69.2	88.1
200	7.28	4.89	7.8	67.6	86.1
100+N-Serve	7.24	4.97	8.2	68.2	92.2
150+N-Serve	5.80	4.01	7.7	68.8	86.4
100 2 splits	4.79	3.48	7.2	69.3	80.1
150 3 splits	6.80	4.70	7.7	70.5	84.0
Significance	**	**	**	NS	**
BLSD (.05)	1.57	1.01	0.4	--	10.8

Table 2. Effect of nitrogen rate, nitrification inhibitor and sidedress applications on nitrogen concentrations in various plant tissues during the growing season and total nitrogen uptake (Code 5).

Treatment lb N/A	% N Whole Plant (6-8 Leaf)	% N Leaf Above Ear (Silking)	% 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
0	3.14	2.06	1.68	0.54	1.04	14.2	1.4	24.5	40.1
50	3.49	2.65	1.65	0.54	1.13	29.3	3.3	45.6	78.2
100	3.78	2.91	1.77	0.73	1.42	41.9	6.6	67.4	115.9
150	3.95	3.01	1.83	0.71	1.53	39.3	5.7	65.2	110.1
200	3.96	3.17	1.79	0.75	1.59	40.6	6.4	71.3	118.3
100+N-Serve	3.75	3.03	1.79	0.69	1.08	41.7	5.4	43.6	90.7
150+N-Serve	3.94	3.12	1.74	0.76	1.44	29.2	4.5	61.7	95.4
100 2 splits	3.47	2.73	1.72	0.72	1.29	26.4	4.0	44.4	74.8
150 3 splits	3.43	3.00	1.79	0.74	1.74	36.3	5.3	66.0	107.7
Significance	**	**	NS	**	**	**	**	**	**
BLSD (.05)	0.21	0.19	—	0.13	0.30	10.3	1.8	14.6	17.1

Table 3. Effect of nitrogren rate, nitrification inhibitor and sidedress applications on Jubilee sweet corn yield and quality.

Treatment lb N/A	Yield (T/A) Green	Yield (T/A) Husked	Ear Length inches	% Moisture in Kernels	% COC Eligible
0	4.17	2.73	6.7	80.1	37.0
50	6.75	4.60	7.4	78.8	76.3
100	8.10	5.13	7.3	78.9	74.3
150	7.79	5.12	7.4	77.9	79.4
200	8.31	5.48	7.3	77.9	78.8
100+N-Serve	7.09	4.73	7.4	77.3	80.6
150+N-Serve	8.16	5.23	7.5	78.8	82.6
100 2 splits	7.56	4.70	7.5	77.4	78.4
150 3 splits	8.07	5.27	7.5	79.1	76.8
Significance	**	**	**	NS	**
BLSD (.05)	1.46	0.86	0.3	--	11.2

Table 4. Effect of nitrogen rate, nitrification inhibitor and sidedress applications on nitrogen concentrations in various plant tissues during the growing season and total nitrogen uptake (Jubilee).

Treatment lb N/A	% N Whole Plant (6-8 Leaf)	% N Leaf Above Ear (Silking)	% 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
0	3.29	2.03	1.96	0.68	1.28	16.6	4.8	31.6	53.0
50	3.77	2.47	1.88	0.62	1.25	32.9	5.3	55.6	93.9
100	3.96	2.78	1.95	0.74	1.09	37.1	8.5	48.5	94.0
150	3.91	2.88	2.10	0.84	1.14	41.3	8.2	61.1	110.6
200	3.87	2.96	2.12	0.88	1.41	42.5	8.6	70.3	121.4
100+N-Serve	3.97	2.81	2.05	0.81	1.10	36.4	7.2	49.1	92.7
150+N-Serve	3.98	2.93	2.16	0.88	1.35	44.1	9.4	74.2	127.8
100 2 splits	3.55	2.64	1.96	0.71	1.13	37.2	8.3	64.2	91.7
150 3 splits	3.45	2.87	2.08	0.81	1.40	42.3	8.5	65.1	115.9
Significance	**	**	NS	NS	NS	**	NS	**	**
BLSD (.05)	0.26	0.19	--	--	--	9.6	--	15.7	17.7

Table 5. Influence of N-Serve and N rate on leaf elemental concentrations at mid-silking: Code 5.

Treatment lb N/A	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
100	2.91	0.32	2.39	0.68	0.28	125	103	24	5	6
150	3.01	0.31	2.39	0.66	0.24	128	110	23	6	6
100+N-Serve	3.03	0.32	2.33	0.66	0.27	132	101	23	5	6
150+N-Serve	3.12	0.31	2.42	0.61	0.24	130	114	24	7	7
N rate effect	NS	NS	NS	NS	*	NS	NS	NS	**	NS
N-Serve effect	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
N rate X N-Serve	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 6. Influence of N-Serve and N rate on leaf elemental concentrations at mid-silking: Jubilee.

Treatment lb N/A	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
100	2.78	0.29	2.47	0.58	0.27	114	117	37	7	10
150	2.88	0.29	2.45	0.59	0.27	116	123	38	7	10
100+N-Serve	2.81	0.30	2.39	0.58	0.28	109	105	35	6	8
150+N-Serve	2.93	0.30	2.42	0.61	0.27	106	123	39	6	9
N rate effect	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
N-Serve effect	NS	NS	NS	NS	NS	NS	NS	NS	*	NS
N rate X N-Serve	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

SULFUR, BORON, COPPER AND MAGNESIUM TRIALS ON A PROBLEM ALFALFA FIELD 1982, 1983, 1984

W. E. Fenster, M. O'Leary and G. Buzicky

Yields of irrigated alfalfa on sandy loam soils have been unsatisfactory at some locations in Stearns County. This led to the establishment of a trial with sulfur, boron and magnesium where phosphorus and potassium were maintained at very high levels. These trials were on the Eugene Heinen farm. The 1983 and 1984 plots were in the same place but different from the 1982 location.

Tables 1 through 4 show alfalfa yields, related soil tests and plant analysis resulting from sulfur, boron, copper, and magnesium treatments.

Since copper appeared to be low in the plant analysis in 1982 it was added as a variable along with magnesium, sulfur and boron in 1983 and 1984.

Yields were low in 1982 because no irrigation water was added during first growth. Yields in 1983 and 1984 were reasonably good. No effect on yield due to treatments have been observed any of the three years.

Plant analysis shows highly adequate levels of all nutrients except copper. Copper treatments have failed to bring this element to an adequate level according to plant analyses.

Although very high in boron, added boron is reflected in an even higher level in the plant. Magnesium and copper sometimes show an increase in plant tissue of these elements from treatment. The magnesium soil test is increased by added magnesium, from 210 lb/A to 290 lb/N and copper is increased from 8 ppm to 1.1 ppm from copper treatment.

Table 1 shows treatments, alfalfa yields and check plot soil tests. Tables 2, 3 and 4 show 1982, 1983 and 1984 plant analyses results.

Table 1. Alfalfa yields relationship to sulfur, boron, copper and magnesium treatments. Stearns County 1982, 1983.

	Treatment lbs/A			Alfalfa yields Tons/acre (15% moisture)			Soil Test (Check plot)			
Treatment	1982	1983	1984	1982	1983	1984		1982	1983	1984
Check				3.62	5.35	4.90	Text	SL	SL	SL
S	100	50	50	3.85	5.27	5.16	O.M.	M	M	M
B	3	3	3	3.71	5.11	5.10	pH	7.3	7.2	7.1
Mg	300	300	300	3.94	5.04	5.05	P lb/A	200+	200+	200+
Cu	---	6	6	---	5.47	4.99	K lb/A	443	410	298
Significance				ns	ns	ns	Mg lb/A	204	201	210
C.V.				4.4	4.4	7.2	S ppm	5	2	7
							Cu ppm	---	0.6	8
							B ppm	---	0.5	---
							Zn ppm	---	4.5	5.2

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

Table 2. Plant analysis of alfalfa for 3 individual cuttings according to sulfur, boron and magnesium treatments 1982.

		Tissue Analysis									
1st cut		%					ppm				
treatment	lbs/A*	S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
check		.41	.44	3.28	1.67	.25	119	55	30	3	43
S	100	.44	.44	3.40	1.63	.25	110	52	31	3	40
B	3		.43	3.17	1.75	.25	116	55	30	3	43
Mg	300		.43	3.19	1.81	.26	116	57	29	3	36
adequate levels		.30	.25	2.40	1.70	.30	30	30	30	10	30
significance		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.		--	2.0	5.5	1.7	9.5	5.3	9.4	3.7	9.7	18.6
2nd cut		S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
check		.32	.44	2.81	1.96	.29	115	69	32	5	47
S	100	.35	.47	2.75	2.05	.28	118	72	33	5	45
B	3		.45	2.80	2.04	.27	110	65	31	6	42
Mg	300		.47	2.72	2.04	.27	111	65	33	5	38
adequate levels		.30	.25	2.40	1.70	.30	30	30	20	10	30
significance		*	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.		--	3.6	2.2	2.5	7.7	6.4	14.4	4.2	4.1	17.7
3rd cut		S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
check		.33	.37	2.65	2.12	.26	104	75	26	4	55
S	100	.34	.37	2.49	2.25	.26	104	76	26	4	51
B	3		.35	2.58	2.14	.24	99	70	26	5	50
Mg	300		.36	2.61	2.26	.26	104	78	27	5	45
adequate levels		.30	.25	2.40	1.70	.30	30	30	20	10	30
significance		*	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.		--	3.1	3.0	3.6	9.3	4.3	11.6	5.8	9.7	20.6

* Treatment once annually

Table 3. Plant analysis of alfalfa for three individual cuttings related to S, B, Mg and Cu treatments 1983.

First Cut		S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
Trt.	lbs/A*	%					ppm				
Check		.34	.46	2.58	2.15	.24	144	72	35	4	36
S	50	.41	.46	2.62	2.22	.25	144	76	38	4	38
B	3		.47	2.59	2.13	.25	143	72	36	4	70
Mg	300		.46	2.62	2.24	.26	150	84	36	4	38
Cu	6		.47	2.62	2.12	.24	148	73	37	4	40
Adequate levels		.30	.25	.240	1.70	.30	30	30	20	10	30
Significance		*	ns	ns	ns	ns	ns	ns	ns	ns	**
BLSD (.05)			--	--	--	--	--	--	--	--	6
C.V.			3.1	6.5	3.6	3.9	9.0	10.9	5.4	9.8	8.8
Second Cut											
Check		.35	.41	3.00	1.60	.25	111	46	26	4	43
S	50	.41	.42	3.15	1.65	.26	103	45	28	4	42
B	3		.42	3.03	1.68	.25	110	51	27	4	62
Mg	300		.41	2.88	1.68	.27	111	50	28	4	44
Cu	6		.42	3.00	1.62	.26	110	46	28	4	46
Adequate levels		.30	.25	2.40	1.70	.30	30	30	20	10	30
Significance		ns	ns	ns	ns	ns	ns	ns	ns	ns	**
BLSD (.05)		--	--	--	--	--	--	--	--	--	3
C.V.			2.8	4.5	3.8	3.6	4.8	7.2	3.3	9.3	5.2
Third Cut											
Check		.30	.36	2.74	1.65	.20	64	35	22	4	40
S	50	.29	.38	2.72	1.70	.20	67	37	22	4	40
B	3		.38	2.76	1.68	.19	64	35	22	4	53
Mg	300		.38	2.81	1.68	.20	64	35	22	4	41
Cu	6		.38	2.79	1.67	.19	68	36	23	4	44
Adequate levels		.30	.25	2.40	1.70	.30	30	30	20	10	30
Significance		ns	ns	ns	ns	ns	**	ns	ns	ns	**
BLSD (.05)		--	--	--	--	--	3	--	--	--	2
C.V.			5.1	4.6	2.9	5.2	2.5	5.2	7.2	15.2	3.9

* Treatment once annually

Table 4. Plant analysis of alfalfa for three individual cuttings related to S, B, Mg and Cu treatments. 1984.

First Cut		S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
Treatment*	lbs/A	%					ppm				
check	---	.32	.47	2.91	2.06	.29	104	60	32	3	37
S	50	.43	.49	2.90	2.15	.29	95	55	36	3	36
B	3		.47	2.93	2.09	.30	111	63	33	3	61
Mg	300		.47	2.90	2.13	.34	116	62	33	3	40
Cu	6		.49	2.94	2.11	.30	115	65	36	4	38
Significance		**	**	ns	ns	**	ns	ns	*	*	**
BLSD (.04)			.01			.02			3	1	6
C.V.		--	2.1	4.9	7.2	4.4	9.3	12.1	5.2	14.7	9.9
Second Cut											
Treatment*	lbs/A										
check	---	.36	.40	2.96	1.84	.27	90	50	28	3	36
S	50	.40	.41	3.00	1.86	.26	88	53	29	3	38
B	3		.40	2.95	1.86	.27	90	55	28	3	60
Mg	300		.40	3.06	1.70	.28	86	44	27	3	35
Cu	6		.42	2.87	1.72	.26	93	55	29	4	38
Significance		ns	ns	ns	ns	ns	ns	ns	ns	ns	**
BLSD (.05)		--	--	--	--	--	--	--	--	--	5
C.V.		--	3.0	4.9	5.4	5.7	7.6	11.4	5.1	15.1	7.7
Third Cut											
Treatment*	lbs/A										
check	---	.33	.34	2.64	1.77	.19	105	40	21	3	42
S	50	.32	.34	2.57	1.80	.19	107	40	21	3	43
B	3		.34	2.53	1.83	.19	105	43	22	3	71
Mg	300		.33	2.61	1.66	.21	106	37	20	3	43
Cu	6		.32	2.48	1.76	.19	108	41	20	4	44
Significance		ns	ns	ns	ns	ns	ns	ns	ns	**	**
BLSD		--	--	--	--	--	--	--	--	.6	7
C.V.		--	5.4	3.9	6.9	7.7	5.5	9.3	4.5	13.0	10.9
adequate levels			.25	2.40	1.70	.30	30	30	20	10	30

* Treatment once annually

LIMING ACID SOILS FOR CAULIFLOWER PRODUCTION

C. J. Rosen, H. J. Buchite and R. C. Munter

Many of the coarse-textured soils in north central Minnesota tend to be acidic. This tendancy is accentuated in soils that have been farmed for a number of years without liming. In these situations, soil pH values of 5.0 and below are common. In recent years, interest in growing fresh market vegetable crops in north central Minnesota has increased. At these pH levels, nutritional imbalance in vegetable crops may occur. The objective of the present study was to determine the influence of various liming rates on cauliflower production and nutrition.

Materials and Methods:

In November 1983, 200 mesh dolomitic limestone was broadcast on and disked in a Hubbard loamy sand located in Princeton, MN. The treatments included a control and three rates of lime (0.75, 1.5 and 2.25 T/A). After an initial crop of broccoli was harvested, cauliflower transplants were planted on 12 July 1984 and fertilized with 50 lb/A N, 50 lb/A P_2O_5, 150 lb/A K_2O, 1/2 lb/A B, 30 lb/A S and 40 lb/A Mg. At planting, all fertilizer was banded 3 inches to the side and 5 inches below the transplants. There was an additional 50 lb N/A supplied through the irrigation system at four different times to provide a total of 250 lb N/A for the crop. Plant spacing was 15 inches within the row and 40 inches between row centers. A randomized complete block design was used with three replications. Soil samples were collected 25 September 1984. The most recently mature leaves were sampled 29, 48 and 62 days after transplanting. Nutrient composition of ashed samples was determined using an inductively coupled plasma (ICP) spectrometer. Because molybdenum availability is reduced under acid conditions, this element was also included in the ICP determinations.

Four center 15' rows of each plot were harvested on six dates from 12 September - 9 October 1984. Plants were cut and trimmed to a market ready stage before weighing. Measurements included total fresh weight, head diameter, and number of harvested heads per plot. To determine the nature of the response to lime rates, data were statistically analyzed using orthogonal comparisons.

Results and Discussion:

As expected, soil levels of Ca and Mg increased with increasing lime rates (Table 1). The soil pH increased from 5.3 in the check plot to 5.9 where 2.25 T/A lime was applied. Because of shallow incorporation by disking, soil chemical properties were affected only at the 0-6 inch depth. Subsoil (6-24 inch) pH levels were all less than 4.8 regardless of the liming rate.

There was a significant trend for increasing yield with increasing lime rate. Although head diamter and percent harvestable heads were not significantly affected by lime applications, there was a trend for an increase in these measurements with increasing lime rate. The greatest benefit of lime additions seemed to occur when the soil pH was raised to 5.7.

Tissue analysis did not appear to correlate well with liming treatments. Levels of leaf Ca and Mg were not significantly affected by dolomitic lime. Additionally, Ca concentrations, which generally increase in plant tissue with age, tended to decrease in cauliflower leaves with age. Levels of Ca in leaves at the third sampling date appeared to be in a low range. This low tissue Ca in later samples may be due to a relatively fast growth rate along with a limited capacity of the root system to absorb Ca. Throughout the field symptoms of tip-burn appeared on recently mature leaves. This symptom was not correlated with liming treatments. The exact causes of this tip-burn are not know but may be related to the low tissue Ca. In general, Mo levels in the leaf tissue tended to be lowest in untreated plots; however, a statistically significant effect was not detected. By the final tissue sampling date, Mo tissue levels were all in a range considered to be sufficient. A significant trend was observed with increasing tissue P with increasing lime rates. This suggests a greater availability of soil P with increasing pH.

In summary, lime applications appeared to have a significant effect on cauliflower yield. If soil pH is below 5.5, then a lime application would be beneficial.

Table 1. Influence of dolomitic lime on soil pH, calcium and magnesium. Samples taken 9 months after initial application.

Lime Treatments (Tons/A)	Ca (lb/A) 0-6	Ca (lb/A) 6-12	Ca (lb/A) 12-24	Mg (lb/A) 0-6	Mg (lb/A) 6-12	Mg (lb/A) 12-24	pH 0-6	pH 6-12	pH 12-24
0	396	175	506	160	47	72	5.3	4.5	4.6
0.75	439	197	378	184	80	72	5.3	4.4	4.5
1.50	500	186	462	220	48	68	5.7	4.5	4.6
2.25	613	225	584	279	58	88	5.9	4.5	4.7
Regression	Significance*								
Lin.	-	-	-	-	+	-	-	-	-
Quad.	++	-	-	++	-	-	++	-	-

* + = 10% level, ++ = 5% level

Table 2. Influence of dolomitic lime on cauliflower yield, head diameter and % harvestable heads.

Lime Treatments (Tons/A)	Yield (T/A)	Diameter (inches)	% Harvestable Heads
0	4.33	5.3	68.4
0.75	4.73	5.6	64.1
1.50	5.24	5.7	70.3
2.25	5.28	5.7	71.4
Regression	Significance*		
Lin.	-	-	-
Quad.	+	-	-

* + = 10% level, ++ = 5% level

Table 3. Nutrient concentrations in recently mature cauliflower leaves as affected by dolomitic lime.

Days After Planting	Lime Treatments (Tons/A)	P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B	Mo
		%				ppm						
29	0	0.28	3.59	1.99	1.00	38	82	219	21	4	24	0.4
	0.75	0.30	3.90	2.15	1.05	34	81	227	23	4	26	0.9
	1.50	0.31	3.97	2.09	1.13	33	85	233	22	5	30	0.7
	2.25	0.31	4.07	1.94	1.03	38	88	228	24	4	26	0.9
	Regression	Significance*										
	Lin.	-	-	-	-	-	-	-	-	-	-	-
	Quad.	++	-	-	-	-	++	-	-	-	-	-
48	0	0.41	2.71	0.96	0.46	24	82	237	34	27	47	1.16
	0.75	0.44	2.87	1.16	0.49	28	93	267	34	39	40	0.97
	1.50	0.50	2.95	0.85	0.47	22	81	235	37	21	46	0.82
	2.25	0.48	2.98	1.04	0.54	21	82	254	38	17	45	1.21
	Regression	Significance*										
	Lin.	-	-	-	-	-	-	-	-	-	-	-
	Quad.	+	-	-	-	-	-	-	-	-	-	-
68	0	0.41	2.64	0.75	0.37	23	71	191	35	40	29	1.18
	0.75	0.44	2.71	0.62	0.36	21	75	173	38	62	30	1.21
	1.50	0.40	2.50	0.62	0.38	21	71	180	33	64	29	1.60
	2.25	0.51	2.59	0.69	0.38	21	86	228	39	76	30	1.50
	Regression	Significance*										
	Lin.	-	-	-	-	-	-	-	-	-	-	-
	Quad.	-	-	-	-	-	-	-	-	-	-	-

* + = 10% level, ++ = 5% level

HIGH PHOSPHORUS AND POTASSIUM RATES IN A CORN-SOYBEAN ROTATION

Waseca, 1984

G. W. Randall, S. D. Evans, W. W. Nelson and D. T. Walters

EXPERIMENTAL PROCEDURES

Ten P and K treatments (Table 1) were applied at three branch experiment stations (Southern Experiment Station, Waseca; Southwest Experiment Station, Lamberton; and West Central Experiment Station, Morris) in Minnesota. A randomized, complete-block design with four replications was used. The 50-pound rates were estimated to be "maintenance" rates, and the 0, 100 and 150-pound rates provide the response curves for each element. Treatments 5 and 8 receive P and K, respectively, every third year for the duration of the experiment. Treatments 9 and 10, applied in the fall of 1973, did not receive P and K again until the fall of 1978 when the treatments were resumed at Waseca because P appeared to be limiting. These two treatments were resumed at Morris in 1979 for the same reason. All other treatments have been applied annually. In 1982, soybeans were planted at Morris and Waseca after 8 years of continuous corn to begin a long-term corn-soybean rotation phase of this experiment.

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

Trt. No.	Application Year (Fall) 1973,'76,'79,'82	1974,'75,'77,'78,80,'81,'83
	----------lb P_2O_5 + K_2O/A----------	
1	0 + 0	0 + 0
2	0 + 100	0 + 100
3	50 + 100	50 + 100
4	100 + 100	100 + 100
5	150 + 100	0 + 100
6	100 + 0	100 + 0
7	100 + 50	100 + 50
8	100 + 150	100 + 0
9 1/	150 2/ + 100	0 + 100 3/ 5/
10 1/	100 + 150 2/	100 + 0 4/ 6/

1/ Neither P nor K was applied in 1976.

2/ The 150-lb rate was not applied at Lamberton or Waseca in 1979 but was applied at Morris.

3/ 150 + 100 applied at Waseca in 1978.

4/ 100 + 150 applied at Waseca in 1978.

5/ 0 + 100 was applied at all locations from 1980 through 1983.

6/ 100 + 0 was applied at all locations from 1980 through 1983.

The P and K materials were broadcast on corn residue and plowed down at all locations in the fall of 1984. Phosphorus was applied as CSP (0-46-0) and K as muriate of potash (0-0-60). Starter fertilizer was not used.

Specific experimental procedures used for soybeans at each of the stations are presented in Table 2. Management practices providing for optimum yields were employed at each location.

At Lamberton each of the plots was split with the west half planted to soybeans and the east half to corn. Corn (Pioneer 3732) was planted in 30" rows at a population of 26000 plants/A on May 18. Weeds were controlled with a ppi application of Lasso (3 lb) and Bladex (1½ lb). Plant tissue samples were not taken. Corn was harvested October 21.

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Planting in 1984 was delayed by late snow at Lamberton and Waseca in April. Yields at Waseca were reduced by a hot and dry August. Grain yields at Lamberton were reduced somewhat probably due to an excessively wet June.

Table 2. Experimental procedures for soybeans on the high P and K rate study at the three branch stations in 1984.

Variable	Lamberton	Morris	Waseca
Planting date	5/19	5/24	5/15
Row spacing	30"	6"	15"
Planting rate	10 beans/foot	3 beans/foot	4½ beans/foot
Variety	Corsoy	Evans	Hardin
Herbicide	2½# Amiben + 3# Lasso/A (Bdct)	2½# Amiben + 3# Lasso/A (Bdct)	3½# Amiben + 3½# Lasso/A (Bdct)
Harvest date	10/1	10/1	9/20

RESULTS AND DISCUSSION

Soil samples taken at the end of the 1984 growing season indicate significant differences in Bray P1 and Olsen's extractable P at all locations (Table 3). There appeared to be a good linear response between extractable P and P application rate. Soil test P was always lowest with treatments 1 and 2, which received no P. Intermediate P levels were found with treatment 3 (50-lb P_2O_5 annually) and treatment 5 (150-lb P_2O_5 every third year). Highest soil test P values were associated with the annual 100-lb P_2O_5 treatments at all locations. Soil test P values at Waseca were quite similar to those obtained in 1983. Soil test P values at Morris, however, averaged approximately 25 percent lower than 1983 while at Lamberton soil P was approximately 20% higher than 1983.

Table 3. Soil test values as influenced by 11 year's application of P and K treatments at Lamberton, Morris and Waseca.[1/]

Treatment No.[2/]	pH			P							K		
	La	Mo	Wa	L_{10}	L_{50}	L_{0L}	M_{10}	M_{50}	M_{0L}	Wa	La	Mo	Wa
				lb/A									
1	5.6	7.8	6.4	57	117	36	7	23	5	24	347	337	227
2	5.7	7.8	6.4	45	92	32	7	23	6	17	464	478	295
3	6.3	7.8	6.2	65	130	52	39	93	34	47	445	442	305
4	5.6	7.7	6.4	118	197	76	72	154	66	89	413	433	326
5	5.9	7.8	6.4	84	156	56	31	74	28	53	446	411	322
6	5.7	7.6	6.6	128	216	79	72	161	63	85	342	331	255
7	5.6	7.9	6.4	114	206	76	55	148	54	79	395	365	263
8	5.8	7.6	6.4	107	192	77	74	163	71	80	373	365	269
9	6.1	7.7	6.6	57	111	38	19	49	15	26	426	359	310
10	5.7	7.8	6.5	104	185	69	15	44	12	79	371	337	292
Signif.Level(%):	94	96	78	99	99	99	99	99	99	99	99	99	99
BLSD (.05) :		.2		20	31	13	15	29	13	17	49	53	41
CV (%) :	5.4	2.7	2.5	17.	14.	16.	22.	18.	22.	18.	8.5	8.2	7.5

1/ Samples were taken in August, October and September for Lamberton, Morris and Waseca, respectively, before the 1984 treatments were applied.

2/ Treatments applied in fall of 1983 for 1984 crop.

Use of the 1:50 soil to Bray P1 solution ratio on the calcareous Aastad soil at Morris indicated slightly more than twice as much extractable P in the soil as with the 1:10 ratio at higher levels of application and about 3 times as much when no P was applied. Soil P values obtained with Olsen's $NaHCO_3$ test on the calcareous soil at Morris were slightly but consistently lower than values from the Bray P1 test (1:10 ratio).

The 1:50 soil to Bray P 1 solution ratio extracted slightly more than twice as much P when no P was applied at Lamberton while slightly less than twice as much P was extracted when the 100-lb P_2O_5 rate was applied. Soil P values obtained with the Olsen's $NaHCO_3$ test on the acid soil at Lamberton were about 30% lower than with the Bray P1 (1:10) extractant.

Soil test K was influenced by K applications at all locations in 1984 (Table 3). The response to annual K applications was not as pronounced as with P. Highest soil test K levels were associated with the annual application of 100-lb K_2O/A. Soil pH was not related to P and K treatments.

Analysis of the uppermost mature trifoliate leaf samples taken at the R2 (mid-to-late bloom stage) indicated significant effects of the P and K treatments on leaf P, K, Ca, Mg, Zn and Cu at Lamberton and on leaf K, Fe, Zn, Cu and B at Waseca (Table 4). Leaf K was improved significantly by the K treatments at both locations while leaf P was increased by the P treatments only at Lamberton. Leaf Ca and Mg were reduced by the K treatments at both locations while leaf B was reduced at Waseca. Leaf Zn and Cu were reduced by the P treatments at both locations.

Table 4. Effect of high P and K rates on the nutrient concentrations in the soybean leaves at the Lamberton and Waseca experimental sites in 1984.

Treatment No.	Treatment Description	Nutrient Concentration[1/] P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb P_2O_5+K_2O/A	%				ppm				
					Lamberton					
1	0 + 0	.40	2.13	1.24	.67	139	60	39	8.6	74
2	0 + 100	.39	2.64	1.14	.55	141	52	37	8.6	68
3	50 + 100	.41	2.63	1.19	.56	138	51	35	7.0	72
4	100 + 100	.42	2.51	1.14	.58	139	57	36	5.9	69
5	0 + 100	.39	2.48	1.15	.56	143	54	35	7.6	70
6	100 + 0	.45	2.18	1.23	.67	132	62	36	5.2	79
7	100 + 50	.42	2.49	1.17	.59	130	57	35	6.1	74
8	100 + 0	.44	2.41	1.21	.61	136	53	33	5.3	71
9	0 + 100	.38	2.56	1.15	.56	138	51	36	8.5	76
10	100 + 0	.43	2.37	1.22	.64	138	55	33	5.6	74
	Signif. Level (%):	99	99	96	99	37	79	95	99	82
	BLSD (.05) :	.02	.10	.09	.02			4	1.0	
	CV (%) :	3.1	3.2	4.4	2.5	6.3	11	6.8	10	7.5
					Waseca					
1	0 + 0	.45	1.79	1.32	.67	142	52	51	11.0	59
2	0 + 100	.47	2.30	1.17	.48	128	51	49	10.5	51
3	50 + 100	.46	2.23	1.22	.50	135	57	46	8.9	54
4	100 + 100	.49	2.37	1.17	.49	125	55	42	6.9	53
5	0 + 100	.46	2.25	1.20	.49	123	57	46	8.2	53
6	100 + 0	.49	1.88	1.33	.65	125	57	43	6.9	62
7	100 + 50	.50	2.10	1.18	.53	122	53	42	6.7	54
8	100 + 0	.50	2.05	1.19	.57	125	51	44	7.4	56
9	0 + 100	.44	2.20	1.24	.52	133	57	48	9.6	53
10	100 + 0	.50	1.96	1.21	.60	121	52	43	6.8	57
	Signif. Level (%):	82	99	92	99	99	71	99	99	99
	BLSD (.05) :		.21		.06	11		3	1.0	6
	CV (%) :	6.5	5.8	5.8	6.3	4.6	7.5	4.5	7.4	5.8

[1/] Uppermost, mature trifoliate at the R2 stage.

The influence of 11 years of P and K applications on soybean yields is shown in Table 5. Soybean yields were not affected by the P and K treatments at Lamberton and Waseca although a trend toward a P response was noted at Waseca. At Morris yields were improved significantly with the 50-lb P_2O_5 rate with no additional response to the 100-lb rate. A response to K was not obtained.

Table 5. Soybean yields at the three sites as influenced by high P and K rates in 1984.

Treatment No.	Description	Lamberton	Morris	Waseca
	lb P_2O_5+K_2O/A	bu/A		
1	0 + 0	39.8	38.3	44.2
2	0 + 100	43.1	36.3	44.3
3	50 + 100	45.8	44.6	47.1
4	100 + 100	41.0	45.3	47.5
5	0 + 100	43.5	43.2	49.5
6	100 + 0	41.7	46.1	46.9
7	100 + 50	42.9	46.8	47.8
8	100 + 0	45.4	45.0	48.0
9	0 + 100	42.4	45.1	44.9
10	100 + 0	40.5	45.4	44.2
	Signif. Level (%):	48	99	76
	BLSD (.05) :		4.2	
	CV (%) :	9.7	6.6	5.9

Small corn plant weight and height, final population, and corn yield were not influenced by the P or K treatments at Lamberton (Table 6).

Table 6. Early plant growth, plant population, and grain yield as influenced by high P and K rates at the Lamberton site in 1984.

Treatmemt No.	Description	Early plant Weight	Early plant Height	Final popl'n	Grain Yield
	lb P_2O_5+K_2O/A	g/dry plant	cm	ppA x 10^3	bu/A
1	0 + 0	36	56	22.3	132.8
2	0 + 100	56	56	23.7	138.9
3	50 + 100	40	58	23.7	131.4
4	100 + 100	64	64	23.3	140.6
5	0 + 100	60	56	22.2	122.0
6	100 + 0	59	58	23.6	134.1
7	100 + 50	38	58	22.6	130.0
8	100 + 0	49	59	23.6	144.6
9	0 + 100	40	52	22.5	136.8
10	100 + 0	57	59	23.6	137.2
	Signif. Level (%):	81	63	54	82
	CV (%) :	34	9.6	5.2	7.5

SUMMARY

These 1984 data are quite similar to past years in that yield responses to K have not been obtained at any of the sites. Yield responses to applied P have been very consistent at Morris, have occurred in some years at Waseca and have not occurred at Lamberton. Triennial applications of the 150-lb rates of P and K appear to be equal to annual applications at the 50-lb rate.

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PLACEMENT OF P AND K FOR CORN AND SOYBEAN PRODUCTION IN THE NORTH CENTRAL REGION

G. W. Rehm, S. D. Evans, W. W. Nelson, and G. W. Randall

Background and Objectives:

Until recently, farmers had few choices with respect to placement of P and/or K for corn and soybean production. They could either broadcast and incorporate the fertilizer before planting, apply it in a band to the side of and below the seed at planting (starter fertilizer) or use a combination of both of these methods.

Our thinking about placement of P and/or K has changed substantially in recent years. Two factors are primarily responsible for this change. One factor is the increased popularity of the adoption of conservation tillage production systems. Without some form of primary tillage, P and K (both immobile nutrients) remain relatively close to the soil surface if broadcast applications are used. This may or may not be a disadvantage for broadcast application. Secondly, research at Purdue University demonstrated that fertilizer banded on the soil surface and plowed under produced corn yields that were higher than yields produced by the broadcast application of similar rates.

Thus, new methods of fertilizer placement have been developed and promoted in recent years. Terms such as "deep banding" and "surface bands" have entered our vocabulary. With these new ideas, however, come new questions. These questions had not been answered in previous research dealing with fertilizer placement.

Therefore, this study was initiated to evaluate the effect of placement of P and K on corn and soybean production planted with two tillage systems where the soil test levels for P and K vary over a wide range.

Procedure Used:

This study was initiated at the Waseca, Lamberton and Morris experiment stations in the fall of 1983. Appropriate site characterization data are listed in Table 1.

The treatments used at the Waseca and Morris locations are listed in Table 2. Space limitations dictated that fewer treatments be used at the Lamberton location and the treatments used at this location are listed in Table 3.

Some explanation should be provided for treatments 29 through 36 at the Waseca and Morris locations. The term "Deep Band" describes the placement of the N-P-K suspension used at a depth of 10-12 inches. In treatments 29 and 30, the 10X rate was applied so that it would be in the middle (M) of future corn rows. In treatments 31 and 32, the "Deep Band" was placed so that it would be dirctly below the rows (BR) of future crops. The annual rate of P_2O_5 and K_2O will be applied in the middle of existing rows in a band at a depth of 6-8 inches in treatments 29 through 32. The appropriate starter wil also be used each year in treatments 29 through 32. In treatments 33 through 36, the deep band was applied so that it would be in the middle of future crop rows. No addition N-P-K suspension will be applied in treatments 33 through 36 but the appropriate starter will be used for the designated treatments.

The fall chisel operation was completed after the application of fertilizer. Depth of chiseling was 6-8 inches. A secondary tillage operation was used in the spring prior to planting in this tillage system. With the ridge-till system, all fertilizer was applied after the ridges had been established.

Accepted production practices conducive to attaining high yields were used at all locations.

Whole plant samples (6 plants/plot) were collected from all locations at 4 to 5 weeks after emergence. These whole plants were dried, weighed, ground and analyzed for P and K by ICP (Induction Coupled Plasma) procedures. Uptake of P and K by these young plants was computed from plant weight and concentration data. The ear leaf at silking was also collected at all locations. These samples were dried and analyzed for P and K by the standard ICP procedure. Grain yields were

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measured with plot combines at all locations and are corrected to a 15.5% moisture basis.

Standard analysis of variance procedures were used for separation of treatment means.

Results and Discussion:

The data collected in this study are summarized in various ways in this report. The data for all treatments, except those involving the use of the deep band, are presented in Tables 4, 5, 6, and 7. Very little emphasis will be placed on the 1984 data gathered from treatments involving the use of the deep band. There is a logical explanation for this. The implement used to apply the fertilizer at a depth of 10-12 inches (either between or below future corn rows) caused a great deal of soil disturbance. Soil disturbance in itself could have an impact on the measurements taken. Therefore, any differences observed for the deep band treatments could be due to either the fertilizer applied or the soil disturbance created in the application process. More attention will be given to a discussion of data from these treatments in future years.

The main effects of the four variables used in this study on the parameters measured are listed in Tables 8, 9, 10, and 11. There were no significant interactions at the Morris location. Some significant 2-way interactions between or among variables were recorded at the low fertility site at Waseca. Two such interactions are summarized in Tables 12 and 13.

The control and the starter only treatments cannot be included in the statistical analysis of the complete factorial. The effect of the starter only treatment can be compared to the control for both tillage systems by using "t" test. This comparison for the parameters measured is summarized in Table 15.

As mentioned, data collected from treatments involving the use of the deep band were not analiyzed statistically. For those interested, the early growth and yield data are summarized in Table 15.

Because of space limitations at the Lamberton location, the treatments used are not as extensive as at Waseca and Morris. In addition, two factors severely limited the collection of data from this location. To begin with, an erratic stand emerged from the ridge-till system. The variability was such that it limited the collection of meaningful data from this tillage system. In addition, there was excessive rainfall during the month of June. This excessive moisture severely restricted early growth and development of the corn. This was especially true for the low fertility site. Therefore, data were gathered from the chisel system at the high fertility site at Lamberton. The data gathered are summarized in Table 16.

Table 1. Selected soil properties for the experimental sites.

	Location and Fertility Level				
	Waseca		Lamberton		Morris
Soil property	High fertility	Low fertility	High fertility	Low fertility	High fertility
pH	6.6	6.0	5.8	6.0	7.5
P (Bray + Kurtz #1) lb./acre	48	15	33	14	39
K (1N $NH_4C_2H_3O_2$) lb./acre	433	270	305	222	259
organic matter, %	3.5	3.5+	3.0	3.0	3.5+
soil texture:	silty clay loam	silty clay loam	silty clay loam	silty clay loam	silt loam

Table 2. Treatments used at the Waseca and Morris locations.

Treatment	Factor			
Number	Tillage	Rate[2]	Placement	Starter Use[3]
1	Ridge	--	--	No
2	Chisel	--	--	No
3	Ridge	--	--	Yes
4	Chisel	--	--	Yes
5	Ridge	X	Broadcast	No
6	Chisel	X	Broadcast	No
7	Ridge	X	Broadcast	Yes
8	Chisel	X	Broadcast	Yes
9	Ridge	1.5X	Broadcast	No
10	Chisel	1.5X	Broadcast	No
11	Ridge	1.5X	Broadcast	Yes
12	Chisel	1.5X	Broadcast	Yes
13	Ridge	X	Dribble	No
14	Chisel	X	Dribble	No
15	Ridge	X	Dribble	Yes
16	Chisel	X	Dribble	Yes
17	Ridge	1.5X	Dribble	No
18	Chisel	1.5X	Dribble	No
19	Ridge	1.5X	Dribble	Yes
20	Chisel	1.5X	Dribble	Yes
21	Ridge	X	Band	No
22	Chisel	X	Band	No
23	Ridge	X	Band	Yes
24	Chisel	X	Band	Yes
25	Ridge	1.5X	Band	No
26	Chisel	1.5X	Band	No
27	Ridge	1.5X	Band	Yes
28	Chisel	1.5X	Band	Yes
29	Ridge	X + 10X[4]	Band + Deep Band (M)[5]	Yes
30	Chisel	X + 10X	Band + Deep Band (M)	Yes
31	Ridge[6]	X + 10X	Band + Deep Band (BR)	Yes
32	Chisel[6]	X + 10X	Band + Deep Band (BR)	Yes
33	Ridge	10X	Deep Band	No
34	Chisel	10X	Deep Band	No
35	Ridge	10X	Deep Band	Yes
36	Ridge	10X	Deep Band	Yes

[1]Treatments applied to both high and low fertility sites at Waseca; treatments applied to high fertility site at Morris

[2]X - 44 lb. P_2O_5 + 87 lb. K_2O/acre; 1.5 X = 66 lb. P_2O_5 + 130.5 lb. K_2O/acre

[3]Starter rate was 100 lb. 7-21-7/acre at Waseca; 110 lb. 10-34-0/acre at Morris

[4]5 X rate was substituted for the 10 X rate at Morris

[5]M = deep band applied in the middle of the row; BR = deep band applied below the row

[6]Treatment not used at Morris location because ridges were built prior to the application of fertilizer

Table 3. Treatments used at the Lamberton location.

Treatment Number	Tillage	Factor Placement[2]	Starter Use[1]
1	Ridge	---	--
2	Ridge	Dribble	No
3	Ridge	Dribble	Yes
4	Ridge	Broadcast	No
5	Ridge	Broadcast	Yes
6	Ridge	Band	No
7	Ridge	Band	Yes
8	Chisel	---	--
9	Chisel	Dribble	No
10	Chisel	Dribble	Yes
11	Chisel	Broadcast	No
12	Chisel	Broadcast	Yes
13	Chisel	Band	No
14	Chisel	Band	Yes
15	Plow	Broadcast	No

[1]Starter used was 100 lb. 7-21-7/acre

[2]The P_2O_5 and K_2O were applied at the X rate; X = 44 lb. P_2O_5 and 87 lb. K_2O/acre

Table 4. The effect of tillage system, rate and placement of fertilizer and starter use on early growth and yield of corn at Waseca and Morris. 1984.

Treatment[1]				Early Growth			Yield		
Tillage	Rate	Placement	Starter	W (HF)	W (LF)	M (HF)[2]	W (HF)	W (LF)	M (HF)
				weight of 6 plants, g			-------bu./acre-------		
R	--	--	No	10.5	5.1	8.3	149.6	74.9	118.8
C	--	--	No	8.4	3.4	7.6	151.1	74.2	125.0
R	--	--	Yes	13.5	7.0	12.2	154.3	81.5	127.9
C	--	--	Yes	10.0	4.4	10.2	156.5	82.2	122.8
R	X	BD	No	12.0	5.2	8.4	155.2	81.6	119.2
C	X	BD	No	10.6	4.6	10.0	154.5	99.1	123.8
R	X	BD	Yes	14.1	6.8	12.4	159.3	90.3	123.1
C	X	BD	Yes	12.6	6.4	12.1	157.9	99.3	127.8
R	1.5X	BD	NO	13.6	7.5	7.9	150.0	84.2	123.5
C	1.5X	BD	No	11.8	4.0	10.8	151.9	96.5	128.0
R	1.5X	BD	Yes	13.9	6.5	13.4	146.4	85.7	130.0
C	1.5X	BD	Yes	12.9	4.7	10.8	150.0	99.2	128.8
R	X	D	No	12.1	5.4	9.1	149.1	99.9	121.3
C	X	D	No	9.7	5.9	8.9	157.8	101.6	124.8
R	X	D	Yes	12.0	6.6	12.1	148.1	97.6	123.0
C	X	D	Yes	10.9	4.5	11.2	166.2	107.0	128.9
R	1.5X	D	No	13.4	5.2	9.2	152.2	97.4	126.1
C	1.5X	D	No	9.4	4.5	7.0	148.8	97.4	125.4
R	1.5X	D	Yes	11.0	6.2	10.9	153.6	98.2	126.6
C	1.5X	D	Yes	11.1	5.9	12.6	150.6	106.1	128.3
R	X	B	No	12.1	6.0	9.6	150.2	105.3	120.0
C	X	B	No	9.5	4.8	10.6	154.0	110.6	124.3
R	X	B	Yes	11.8	7.0	11.6	149.5	106.6	120.4
C	X	B	Yes	10.9	4.5	14.3	157.8	101.3	124.9
R	1.5X	B	No	12.0	5.4	7.6	159.2	105.9	121.1
C	1.5X	B	No	8.6	4.1	9.3	157.2	106.5	125.0
R	1.5X	B	Yes	12.0	5.8	14.2	157.0	110.8	125.8
C	1.5X	B	Yes	7.7	4.4	10.5	156.4	107.7	129.2
			CV (%):	29.6	34.7	27.5	6.0	12.8	4.6

[1]R = ridge-till, C = chisel; BD = broadcast, D = dribble, B = band at 6-8 inches deep between rows.

[2]W (HF) = Waseca, high fertility; W (LF) = Waseca, low fertility; M (HF) - Morris, high fertility

These designations will be used in subsequent tables.

Table 5. The effect of tillage system, rate and placement of fertilizer and starter use on P and K concentration in young corn plants and ear leaf tissue as well as P and K uptake by young corn plants at the Waseca high fertility site. 1984.

Treatment				Young Plants				Ear Leaf	
Tillage	Rate	Placement	Starter	P	K	P uptake	K uptake	P	K
				-----%-----		mg/6 plants		-----%-----	
R	--	--	No	.428	4.00	44.6	422	.274	4.00
C	--	--	No	.469	3.93	36.2	330	.287	3.93
R	--	--	Yes	.442	4.09	59.8	555	.277	4.09
C	--	--	Yes	.471	4.25	44.2	423	.276	4.25
R	X	BD	No	.477	4.08	53.0	500	.279	4.08
C	X	BD	No	.440	3.85	45.4	412	.263	3.85
R	X	BD	Yes	.465	4.42	65.1	614	.292	4.42
C	X	BD	Yes	.493	4.19	57.5	539	.272	4.19
R	1.5X	BD	No	.465	4.09	61.4	559	.277	4.09
C	1.5X	BD	No	.453	4.40	50.9	514	.275	4.40
R	1.5X	BD	Yes	.511	4.39	64.8	609	.291	4.39
C	1.5X	BD	Yes	.476	4.41	57.7	559	.295	4.41
R	X	D	No	.474	4.26	52.0	513	.277	4.26
C	X	D	No	.491	4.16	42.1	404	.291	4.16
R	X	D	Yes	.493	4.05	52.8	485	.265	4.05
C	X	D	Yes	.501	4.03	47.8	443	.282	4.03
R	1.5X	D	No	.448	4.12	58.3	555	.269	4.12
C	1.5X	D	No	.454	3.92	40.2	366	.267	3.92
R	1.5X	D	Yes	.467	4.14	49.1	456	.265	4.14
C	1.5X	D	Yes	.489	4.12	51.3	453	.257	4.12
R	X	B	No	.475	3.90	55.0	468	.277	3.90
C	X	B	No	.472	4.24	41.4	409	.269	4.24
R	X	B	Yes	.440	4.22	52.0	500	.272	4.22
C	X	B	Yes	.505	4.60	50.0	507	.303	4.60
R	1.5X	B	No	.428	3.95	54.0	484	.264	3.95
C	1.5X	B	No	.473	4.16	37.6	361	.275	4.16
R	1.5X	B	Yes	.447	4.46	52.9	545	.271	4.46
C	1.5X	B	Yes	.487	4.04	34.6	313	.275	4.04
			CV (%):	6.4	8.4	33.5	31.4	3.6	8.0

Table 6. The effect of tillage system, rate and placement of fertilizer and starter use on P and K concentration is young corn plants and ear leaf tissue as well as P and K uptake by young corn plants at the Waseca low fertility site. 1984.

Treatment				Young Plants				Ear Leaf	
Tillage	Rate	Placement	Starter	P	K	P uptake	K uptake	P	K
				-----%-----		-----mg/6 plants---		-----%-----	
R	--	--	No	.380	1.22	19.8	65	.207	.58
C	--	--	No	.348	1.33	12.3	48	.202	.66
R	--	--	Yes	.406	1.31	28.8	94	.231	.62
C	--	--	Yes	.368	1.48	16.3	69	.218	.64
R	X	BD	No	.376	1.26	19.6	65	.172	.63
C	X	BD	No	.343	1.84	16.2	87	.238	.83
R	X	BD	Yes	.408	1.45	27.9	100	.203	.68
C	X	BD	Yes	.358	2.09	24.0	149	.236	.77
R	1.5X	BD	No	.383	1.47	29.1	121	.214	.70
C	1.5X	BD	No	.359	1.71	21.7	128	.231	.86
R	1.5X	BD	Yes	.406	1.57	26.9	114	.216	.79
C	1.5X	BD	Yes	.341	2.06	17.3	85	.231	.92
R	X	D	No	.399	1.93	21.5	107	.177	.73
C	X	D	No	.357	2.09	18.5	116	.223	.92
R	X	D	Yes	.422	1.32	27.9	87	.214	.79
C	X	D	Yes	.375	1.80	17.0	99	.227	.86
R	1.5X	D	No	.388	1.35	20.3	75	.196	.74
C	1.5X	D	No	.335	2.02	14.5	71	.231	1.07
R	1.5X	D	Yes	.409	1.35	25.2	87	.205	.83
C	1.5X	D	Yes	.374	2.93	16.4	97	.253	1.06
R	X	B	No	.377	2.05	22.5	123	.189	.97
C	X	B	No	.374	2.39	15.2	93	.226	1.16
R	X	B	Yes	.392	2.20	27.9	164	.199	1.03
C	X	B	Yes	.365	2.20	22.8	182	.231	1.14
R	1.5X	B	No	.385	1.97	20.7	109	.218	1.12
C	1.5X	B	No	.385	2.61	16.2	112	.227	1.22
R	1.5X	B	Yes	.401	1.87	23.2	111	.226	1.21
C	1.5X	B	Yes	.375	2.03	16.6	90	.235	1.33
			CV (%):	6.8	27.5	37.9	55.2	6.9	12.4

Table 7. The effect of tillage system, rate and placement of fertilizer and starter use on P and K concentration in young corn plants and ear leaf tissue as well as P and K uptake by young corn plants at the Morris high fertility site. 1984.

Treatment				Young Plants				Ear Leaf	
Tillage	Rate	Placement	Starter	P	K	P uptake	K uptake	P	K
				-----%-----		-----mg/6 plants---		-----%-----	
R	--	--	No	.411	3.26	34.1	268	.249	2.09
C	--	--	No	.385	3.14	30.8	243	.239	2.02
R	--	--	Yes	.432	2.88	55.4	371	.259	1.82
C	--	--	Yes	.389	2.69	36.5	252	.247	1.92
R	X	BD	No	.413	3.31	34.8	280	.258	2.09
C	X	BD	No	.421	3.60	42.5	363	.253	2.05
R	X	BD	Yes	.408	3.09	50.1	387	.250	2.01
C	X	BD	Yes	.412	3.22	51.2	412	.253	1.94
R	1.5X	BD	No	.416	3.46	33.2	277	.252	2.06
C	1.5X	BD	No	.418	3.74	46.0	403	.240	2.10
R	1.5X	BD	Yes	.428	3.18	57.5	419	.246	2.00
C	1.5X	BD	Yes	.407	3.34	45.2	370	.244	1.88
R	X	D	No	.417	3.32	39.7	316	.243	2.11
C	X	D	No	.398	3.45	35.7	306	.259	2.12
R	X	D	Yes	.429	2.94	52.2	364	.249	1.90
C	X	D	Yes	.445	3.35	50.2	377	.254	2.03
R	1.5X	D	No	.419	3.36	38.6	314	.247	2.08
C	1.5X	D	No	.399	2.95	27.8	208	.245	1.91
R	1.5X	D	Yes	.412	2.78	44.9	308	.242	1.94
C	1.5X	D	Yes	.442	3.15	55.7	405	.248	1.85
R	X	B	No	.421	3.34	40.3	321	.264	2.17
C	X	B	No	.416	3.42	44.1	365	.257	2.02
R	X	B	Yes	.424	2.92	49.2	342	.255	1.94
C	X	B	Yes	.420	3.50	60.6	507	.254	2.12
R	1.5X	B	No	.405	3.29	30.8	252	.251	2.16
C	1.5X	B	No	.400	3.52	37.9	330	.250	2.16
R	1.5X	B	Yes	.433	3.09	61.4	438	.260	2.12
C	1.5X	B	Yes	.422	2.74	44.8	296	.255	1.98
			CV (%):	7.1	10.9	31.6	35.1	4.7	6.4

Tillage system had a significant effect on some parameters measured at both Waseca and Morris (Table 8). Early plant growth as well as uptake of both P and K by these plants was greater when the ridge-till system was used at the high fertility site at Waseca. This may have been due to the more rapid emergence and subsequent expansion of the root system for this planting system. It's important to note that tillage system had no effect on yield at this high fertility site.

For the low fertility site at Waseca, early plant growth was higher, P concentration in the young plants was greater, and consequently P uptake by young plants was higher when the ridge-till system was used. On the other hand, yield, K concentration in the young plants as well as both the P and K concentration in the ear leaf tissue was higher when the chisel plow system was used (Table 8).

Tillage system had a significant effect on only two of the parameters measured at Morris (Table 8). Both grain yield and K concentration in the young plant tissue were higher when the chisel system was used.

The rate of fertilizer applied had no effect on grain production at both sites at Waseca (Table 9). The 1.5X rate did significantly increase the concentration of both P and K in the ear leaf tissue at the low fertility site. This increase in nutrient concentration, however, was not related to a significant increase in yield.

At Morris, grain yield was statistically higher when the 1.5X rate was used. This result is somewhat surprising in view of the high or very high soil test levels for P and K at this site. There is no apparent explanation for the apparent reduction in K in the ear leaf when the high rate of fertilizer was applied (Table 9).

When averaged over the other factors included in the study, placement of the fertilizer had a significant effect on yield only at the low fertility site at Waseca (Table 10). Statistical analysis shows that yield from the band application at a depth of 6-8 inches between rows was higher than the yield from the dribble application which, in turn, produced higher yields than those produced from the broadcast application.

Early growth and P as well as K uptake by the young plants at the Waseca high fertility site was highest when the fertilizer was broadcast (Table 9). Treatment means reported are averages for both tillage systems used. Placement had no significant effect on early plant growth at both the Waseca low fertility and Morris sites. The lack of significant differences for these parameters at these two sites may be due, in part, to the variability in the data recorded. The CV's are fairly high for these measured parameters (Tables 6 and 7).

The K concentration in the ear leaf tissue was highest at 2 of 3 sites when the fertilizer was placed in a band between the rows. Placement had a similar effect on the P concentration in the ear leaf at Morris but no significant effect on this parameter at both Waseca sites. The data resulting from the analyses of ear leaf tissue indicate that the fertilizer applied in the band between rows was readily available to the corn root system later in the growing season.

The use of a starter fertilizer in combination with some other method of fertilizer application had a significant effect on yield at the Morris location only (Table 11). This positive effect on yield at this site was accompanied by a positive effect on early plant growth. Early plant growth and yields at the Waseca sites were not affected by starter use in combination with the application of fertilizer in some other way.

For the most part, the plant analysis data show a positive effect for starter use. The lower values for K in the young plants and ear leaf tissue resulting from the use of starter cannot be completely explained at this time. Plant dilution due to higher dry matter production may be one possible explanation.

The use of starter fertilizer only had a significant effect on yield for both tillage systems at the low fertility site at Waseca and when corn was planted with the ridge-till system at Morris (Table 12). The results from the Morris location support earlier observations that starter fertilizer should be a management component for ridge-till and no-till planting systems at all soil test levels.

As would be expected, the use of starter only had a positive effect on early plant growth at the Waseca low fertility site. Again, K concentration in the corn tissue from Morris was lower when starter was used. Plant dilution provides the best possible explanation at this time.

The preceeding discussion has focused on the data collected from the Waseca and Morris locations. Results collected from the Lamberton location in 1984 were limited but do show some effects from treatment applied (Table 16). Early season stress contributed to a substantial amount of variability in the data. This variability may have some treatment effects.

Table 8. Effect of tillage system on early growth and yield, P and K concentration in young corn plants and ear leaf tissue and P and K uptake by young plants. 1984.

Tillage System	Yield	Young Plants Weight	P	K	P uptake	K uptake	Ear Leaf P	K
	bu./acre	6 plants, g	-----%-----		---mg./6 plants----		-----%-----	
Waseca - high fertility:								
Ridge-till	152.5	12.5	.443	4.17	55.9	524	.273	1.94
Chisel	155.3	10.5	.437	4.17	46.4	440	.274	1.99
		**			**	**		
Waseca - low fertility:								
Ridge-till	97.0	6.1	.395	1.65	24.4	105	.202	.85
Chisel	102.7	4.9	.362	2.15	18.0	109	.232	1.01
	*	**	**	**	**		**	**
Morris - high fertility:								
Ridge-till	123.4	10.6	.419	3.17	44.4	335	.251	2.04
Chisel	126.6	10.7	.416	3.33	45.2	362	.251	2.01
	**			**				

**, *, + Treatment means are significantly different at the .01, .05, and .10 confidence levels respectively.

Table 9. Effect of rate of fertilizer applied on early growth and yield, P and K concentration in young corn plants and ear leaf tissue and P and K uptake by young plants. 1984.

Fertilizer Applied P_2O_5	K_2O	Yield	Young Plants Weight	P	K	P uptake	K uptake	Ear Leaf P	K
lb./acre		bu./acre	6 plants, g	-----%-----		----mg/6 plants-----		-----%-----	
Waseca - high fertility:									
44	87	155.0	11.5	.442	4.17	51.2	483	.273	1.96
66	131	152.7	11.5	.439	4.18	51.1	481	.274	1.98
Waseca - low fertility									
44	87	100.0	5.7	.379	1.89	21.8	109	.211	.88
66	131	99.6	5.4	.378	1.91	20.6	105	.223	.99
								**	**
Morris - high fertility									
44	87	123.5	10.9	.419	3.29	45.9	362	.254	2.04
66	131	126.5	10.4	.417	3.22	43.7	335	.248	2.02
		**						**	

**, *, + Treatment means are significantly different at the .01, .05, and .10 confidence levels respectively.

Table 10. Effect of fertilizer placement on early growth and yield, P and K concentration in young corn plants and ear leaf tissue as well as P and K uptake by young plants. 1984.

Fertilizer Placement	Yield	Young Plants Weight	P	K	P uptake	K uptake	Ear Leaf P	K
	bu./acre	6 plants, g	-----%-----		----mg/6 plants----		-----%-----	
Waseca - high fertility								
Broadcast	153.2	12.7	.441	4.23	57.0	538	.274	1.97
Dribble	153.2	11.2	.435	4.10	49.2	459	.271	1.94
Band	155.2	10.6	.445	4.20	47.2	448	.275	1.99
		*			+	*		
BLSD (.05)		1.8			2.1	80		
Waseca - low fertility:								
Broadcast	92.0	5.7	.372	1.68	21.8	100	.218	.77
Dribble	100.6	5.6	.382	1.85	21.5	106	.216	.87
Band	106.8	5.3	.381	2.17	20.3	115	.219	1.15
	**			**				**
BLSD (.05)	5.9			.25				.05
Morris - high fertility:								
Broadcast	125.6	10.7	.415	3.37	45.1	364	.249	2.01
Dribble	125.6	10.2	.420	3.16	43.1	325	.248	1.99
Band	123.8	10.9	.417	3.23	46.1	356	.256	2.08
				+			*	*
BLSD (.05)				.19			.006	.07

**, *, + Treatment means are significantly different from one another at the .01, .05, and .10 confidence levels respectively.

Table 11. The effect of use of a starter fertilizer in combination with one additional application of P_2O_5 and K_2O on early growth and yield, P and K uptake by young plants. 1984.

Starter Use	Yield	Young Plants Weight	P	K	P uptake	K uptake	Ear Leaf P	K
	bu./acre	6 plants, g	-----%-----		----mg/6 plants----		-----%-----	
Waseca - high fertility:								
No	153.3	11.2	.433	4.09	49.3	462	.271	1.97
Yes	154.4	11.8	.448	4.26	53.0	502	.275	1.97
			**	**			*	
Waseca - low fertility:								
No	98.8	5.2	.371	1.89	19.7	101	.212	.91
Yes	100.0	5.8	.385	1.91	22.8	114	.223	.95
			**		+		**	+
Morris - high fertility:								
No	123.6	9.1	.412	3.40	37.6	311	.251	2.08
Yes	126.4	12.2	.423	3.11	51.9	385	.251	1.97
	*	**	+	**	**	**		**

**, *, + Treatment means are significantly different at the .01, .05, and .10 confidence levels respectively.

Table 12. The effect of tillage system and rate of fertilizer applied on the P concentration in the ear leaf tissue from the low fertility site at Waseca. 1984.

Fertilizer Applied		Tillage System	
P_2O_5	K_2O	Ridge-till	Chisel
lb./acre		----------%P---------	
44	87	.192	.230
66	131	.212	.235

Table 13. The effect of tillage system and placement of fertilizer on the P concentration in young corn plants at the low fertility site at Waseca. 1984.

Fertilizer Placement	Tillage System	
	Ridge-till	Chisel
	----------%P---------	
Broadcast	.393	.350
Dribble	.404	.360
Band	.387	.375

Table 14. The effect of the use of a starter fertilizer only compared to the control on early growth and yield, P and K concentration in young corn plants and ear leaf tissue and P and K uptake by young plants. 1984.

		Young Plants					Ear Leaf	
Treatment	Yield	Weight	P	K	P uptake	K uptake	P	K
	bu./acre	6 plants, g	-----%-----				-----%-----	
Waseca - high fertility: ridge-till								
Control	149.6	10.6	.422	4.00	44.6	422	.274	1.35
Starter only	154.3	13.5	.444	4.09	59.8	555	.269	1.89
			+					+
Waseca - high fertility: chisel								
Control	151.1	8.4	.432	3.94	36.2	330	.268	1.92
Starter only	156.5	10.0	.440	4.25	44.2	423	.267	1.95
Waseca - low fertility: ridge till								
Control	74.9	5.2	.380	1.22	19.8	65	.207	.58
Starter only	81.5	7.0	.406	1.31	28.8	94	.231	.62
	*	**	**				**	**
Waseca - low fertility: chisel								
Control	74.2	3.4	.348	1.33	12.3	48	.202	.66
Starter only	82.2	4.4	.368	1.48	16.3	69	.218	.64
	*	**						
Morris - high fertility: ridge till								
Control	118.8	8.3	.411	3.26	34.1	268	.249	2.09
Starter only	127.9	12.2	.432	2.88	55.4	371	.259	1.82
	*			+				*
Morris - high fertility: chisel								
Control	125.0	7.6	.385	3.14	30.8	243	.239	2.02
Starter only	122.8	10.2	.389	2.69	36.5	252	.247	1.92
				*				

**, *, + Treatment means are significantly different at the .01, .05, and .10 confidence levels respectively.

Table 15. The effect of application of fertilizer in a deep band on early growth and yield of corn. 1984.

Location	Tillage System	Deep Band Placement	Annual Fertilizer Used	Starter Used	Early Growth Weight 6 plants, g	Yield bu./acre
Waseca (HF)	ridge-till	below row	Yes	Yes	11.2	154.6
"	chisel	"	"	"	10.6	156.7
"	ridge-till	between row	No	No	11.4	153.4
"	chisel	"	"	"	10.4	163.4
"	ridge-till	"	"	Yes	10.3	158.0
"	chisel	"	"	"	12.1	158.3
"						
Waseca (LF)	ridge-till	below row	Yes	Yes	7.1	128.9
"	chisel	"	"	"	5.0	115.7
"	ridge-till	between row	"	"	7.3	125.5
"	chisel	"	"	"	4.9	120.1
"	ridge-till	"	No	No	7.1	116.4
"	chisel	"	"	"	6.4	125.0
"	ridge-till	"	"	Yes	7.3	114.7
"	chisel	"	"	"	6.1	124.5
Morris (HF)	chisel	below row	Yes	Yes	12.2	129.1
"	ridge-till	between row	"	"	11.1	126.1
"	chisel	"	"	"	11.0	132.1
"	ridge-till	"	No	No	9.1	121.7
"	chisel	"	"	"	9.0	122.8
"	ridge-till	"	"	Yes	11.9	123.6
"	chisel	"	"	"	13.4	127.9

Table 16. Effect of fertilizer treatment on early growth, yield, P and K concentration of young corn plants and P and K uptake by young corn plants at the Lamberton location when the fall chisel tillage system was used. 1984.

Treatment[1]	Yield	Weight	P	K	P uptake	K uptake
	bu./acre	6 plants, g	------%------		----mg/6 plants----	
Control	78.1	29.0	.236	3.69	68.8	1078
Dribble	66.4	25.8	.229	3.83	59.5	992
Dribble & Starter	78.3	35.5	.254	3.95	89.9	1400
Broadcast	71.9	30.2	.226	3.82	69.5	1165
Broadcast & Starter	75.5	35.2	.240	3.94	84.5	1386
Band	74.3	25.1	.262	3.59	64.9	915
Band & Starter	81.0	35.8	.285	3.78	101.6	1358
		*			*	*
BLSD (.05)	--	8.1	--	--	26.6	393
CV (%)	18.7	16.0	11.8	6.6	21.2	19.6

Table 17. The effect of the use of a starter fertilizer in combination with another fertilizer application on early growth and yield, P and K concentration in young plants and uptake of P and K by young plants at the high fertility site at Lamberton. 1984.

Variable	With Starter	Without Starter	Significance Level
Yield, bu./acre	78.3	70.3	*
Weight of young plants, g/6 plants	35.5	27.0	**
P conc. young plants, %	.260	.239	**
K conc. young plants, %	3.89	3.75	+
P uptake, young plants, mg/6 plants	92.0	64.6	**
K uptake, young plants, mg/6 plants	1381	1024	**

**, *, + Means are significantly different at the .01, .05, and .10 confidence levels.

EFFECT OF POTASSIUM PLACEMENT ON CORN PRODUCTION IN HIGH YIELD ENVIRONMENTS IN SOUTHEAST MINNESOTA

George Rehm, John Moncrief, Mike O'Leary and Greg Buzicky

There's no doubt that conservation tillage production systems are appropriate for use in southeastern Minnesota. However, if these systems are to be adopted by farmers, there are many questions that need to be answered. Because the K concentration in these soils is inherently low, there are several questions that relate to K fertilization and K management. 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 Procedures:

This study was initiated in the spring of 1984 in a farmer's field in Wabasha County. The soil is classified as a Fayette silt loam and is characteristic of soils in the region.

Prior to treatment application, 56 soil samples were collected from the experimental area to provide some measure of site uniformity. The results of this analysis showed the site to be quite uniform. The average pH was 6.5. The Bray and Kurtz #1 test showed 72 lb. P/acre while the 1 N NH_4 $C_2H_3O_2$ extraction showed 219 lb. K/acre.

The existing vegetation, sweetclover, was killed with Roundup (2 qt./acre) in late April. Treatments were applied in mid-May and corn was planted on May 18 with a Buffalo-Till planter adapted for planting in a no-till situation. Treatments used are listed in Table 1.

A fluid fertilizer (0-0-15) was used for the knife treatments. The broadcast K was supplied as 0-0-60. For the spring chisel tillage system, both broadcast and knife applications of K were made prior to the chisel operation.

The liquid starter, 7-21-7, was used at 125 lb./acre to supply K in the starter. Where no K was applied in the starter,10-34-0 was used at a rate to supply the amount of P_2O_5 provided by the 7-21-7.

A rotary hoe was used to enhance emergence in the chisel plow system. The corn planted in the chisel plow system was also cultivated once during the growing season.

Plant samples were collected from each plot at 3 times during the growing season (4-5 weeks after emergence, ear leaf at silking, whole plant at physiological maturity). These samples were dried, ground, and analyzed for K by routine procedures. Potassium uptake was computed for small plants and whole plants at physiological maturity.

Results and Discussion:

Statistical analysis of the data collected showed no significant interactions among the 4 factors used in this study. Therefore, main effects are discussed in the following paragraphs and summarized in the tables that follow.

Grain yield, silage yield, early plant growth, and total uptake of K by young plants were higher when corn was planted in the no-till system (Table 3). These measured differences were significant at the 99% confidence level. The concentration of K in the ear leaf at silking and the mature plant was significantly higher when the corn was planted in the chisel system (Table 3). These observations are consistent with those from other studies involving tillage systems in Minnesota.

The yield differences due to tillage could be related somewhat to a difference in plant population. The plant population at harvest was slightly lower in the chisel system. Nevertheless, grain and dry matter yields were certainly not reduced by the no-till planting. This is encouraging for farmers in southeast Minnesota.

Rate of applied K had no significant effect on any of the variables measured in this study (Table
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this publication for information regarding application and use of this article.

4). Since there were no significant interactions, the values reported in this table are averaged over both tillage systems, both methods of placement, with and without the use of a starter fertilizer.

When averaged over rate applied, tillage system, and starter use, early plant growth as well and K uptake by these early plants was high when K was knifed between the rows rather than broadcast (Table 5). Although the row spacing was 38 inches, the young plants were apparently able to use the knifed in K more easily than the broadcast K. The fact that placement of K had no effect on K concentration in the older tissue indicates that the broadcast K was utilized later in the growing season.

Considering all other factors, grain yields were higher when the starter fertilizer was used (Table 6). Total dry matter yield at physiological maturity and early plant growth, however, were significantly lower when starter was used. These observations are not consistent with grain yields and there is no ready explanation for these measured effects at this time. The use of a starter fertilizer when additional K was applied had no effect on the other variables measured.

Two treatments were included in the study which did not fit the complete factorial. These were: 1) complete control and 2) use of 125 lb. 7-21-7 only as a starter fertilizer. These treatments were included in both tillage systems so the effect of the use of a starter without additional K could be measured by the "t" test.

In the chisel system, the use of the starter only increased grain yield but had no significant effect on the other variables measured (Table 7). Starter use without additional K had no significant effect on any of the variables measured in the study (Table 8). These results are not consistent with results from other studies involving starter fertilizer use in Minnesota and cannot be readily explained at this time.

Table 1. The effect of tillage system, rate and placement of K and starter fertilizer use on early growth and yield of corn. Wabasha County 1984.

Tillage System	K Applied	Placement	Starter K Used	Early Growth	Yield	
					Grain	Silage
	lb./acre			weight of 6 plants,g	bu./acre	ton D.M./acre
No-till	---	---	No	18.0	171.0	6.88
"	---	---	Yes	17.9	172.0	6.51
"	40	Bdcst	No	18.8	166.8	7.03
"	40	Bdcst	Yes	17.1	169.9	6.88
"	40	Knife	No	19.5	166.5	7.43
"	40	Knife	Yes	18.6	171.8	7.11
"	80	Bdcst	No	17.8	156.0	6.93
"	80	Bdcst	Yes	15.1	166.0	7.12
"	80	Knife	No	17.4	160.1	7.07
"	80	Knife	Yes	17.8	169.8	7.20
"	120	Bdcst	No	17.7	165.8	7.31
"	120	Bdcst	Yes	16.7	172.9	6.76
"	120	Knife	No	18.7	164.5	7.05
"	120	Knife	Yes	18.1	168.9	7.06
Chisel	---	---	No	18.0	144.7	7.27
"	---	---	Yes	15.2	151.0	6.84
"	40	Bdcst	No	15.1	168.7	6.36
"	40	Bdcst	Yes	15.0	164.4	6.15
"	40	Knife	No	16.6	158.5	7.11
"	40	Knife	Yes	17.5	161.1	6.41
"	80	Bdcst	No	16.5	158.8	6.81
"	80	Bdcst	Yes	16.0	159.1	6.43
"	80	Knife	No	18.2	161.0	6.79
"	80	Knife	Yes	15.3	165.7	6.38
"	120	Bdcst	No	15.9	155.2	6.93
"	120	Bdcst	Yes	15.0	154.7	6.82
"	120	Knife	No	17.7	159.6	7.20
"	120	Knife	Yes	15.5	159.7	6.54
		CV = (%)		11.5	5.7	7.2

Table 2. The effect of tillage system, rate and placement of fertilizer K and starter fertilizer on K concentration in corn tissue and K uptake at 2 growth stages. Wabasha County, 1984.

Tillage System	K Applied	Placement	Starter K Used	K Concentration: Young Plant	K Concentration: Ear Leaf	K Concentration: Mature Plant	K Uptake: Young Plant	K Uptake: Mature Plant
	lb./acre			--------- %K	----------		mg/6 plants	lb./acre
No-till	---	-----	No	4.19	1.91	1.11	738	147.0
"	---	-----	Yes	4.30	1.81	1.10	768	148.0
"	40	Bdcst	No	4.43	1.79	1.00	829	138.8
"	40	Bdcst	Yes	4.49	1.84	1.15	768	152.7
"	40	Knife	No	4.48	1.87	.99	862	147.8
"	40	Knife	Yes	4.74	1.78	1.00	875	142.0
"	80	Bdcst	No	4.69	1.88	1.15	823	159.5
"	80	Bdcst	Yes	4.54	1.89	1.13	682	160.4
"	80	Knife	No	4.33	1.73	1.07	754	150.7
"	80	Knife	Yes	4.54	1.87	1.02	803	147.4
"	120	Bdcst	No	4.24	1.75	1.04	752	150.9
"	120	Bdcst	Yes	4.52	1.91	1.08	754	146.0
"	120	Knife	No	4.54	1.82	1.09	838	153.2
"	120	Knife	Yes	4.78	1.96	1.02	860	142.5
Chisel	---	-----	No	4.52	2.09	1.12	810	162.0
"	---	-----	Yes	4.32	2.06	1.23	660	168.0
"	40	Bdcst	No	4.59	2.02	1.17	696	148.5
"	40	Bdcst	Yes	4.72	1.96	1.18	712	146.1
"	40	Knife	No	4.53	1.99	1.04	747	146.8
"	40	Knife	Yes	4.40	2.02	1.13	766	144.9
"	80	Bdcst	No	4.51	1.98	1.04	746	141.8
"	80	Bdcst	Yes	4.62	2.01	1.22	735	157.1
"	80	Knife	No	4.43	2.12	1.08	808	146.3
"	80	Knife	Yes	4.36	2.08	1.13	665	143.2
"	120	Bdcst	No	4.67	2.11	1.15	741	160.3
"	120	Bdcst	Yes	4.54	2.04	1.15	682	155.8
"	120	Knife	No	4.45	1.99	1.10	794	157.6
"	120	Knife	Yes	4.59	1.99	1.29	708	168.3
			CV: (%)	9.0	9.8	14.8	13.0	14.6

Table 3. Effect of tillage system used on early growth, K uptake, and yield of corn. Wabasha County, 1984.

Tillage System	Early Growth	K Concentration			Yield		K Uptake	
		Young plant	Ear leaf	Mature plant	Grain	Forage	Young plant	Maturity
	wt of 6 plants,g	----------%K----------			bu./acre	ton D.M./acre	mg/6 plants	lb./acre
No-till	17.8	4.53	1.84	1.06	166.6	7.08	800.0	149.3
Chisel	16.2	4.53	2.02	1.14	160.5	6.66	733.3	151.4
	**	**	**	**	**	**	**	

**, + Significant at the .01 and .10 confidence level respectively. This designation applies to all subsequent tables.

Table 4. Effect of rate of applied K on early growth, K uptake, and yield of corn. Wabasha County, 1984.

K Applied	Early Growth	K Concentration			Yield		K Uptake	
		Young plant	Ear leaf	Mature plant	Grain	Forage	Young plant	Maturity
lb./acre	wt of 6 plants,g	----------%K----------			bu./acre	ton D.M./acre	mg/6 plants	lb./acre
40	17.3	4.55	1.91	1.08	166.0	6.81	781.8	146.0
80	16.8	4.50	1.95	1.10	162.1	6.84	752.0	150.8
120	16.9	4.54	1.94	1.11	162.6	6.96	766.1	154.3

Table 5. Effect of placement of K fertilizer on early growth, K uptake and yield of corn. Wabasha County, 1984.

Placement	Early Growth	K Concentration			Yield		K Uptake	
		Young plant	Ear leaf	Mature plant	Grain	Forage	Young plant	Maturity
	wt of 6 plants,g	----------%K----------			bu./acre	ton D.M./acre	mg/6 plants	lb./acre
Broadcast	16.4	4.55	1.93	1.12	163.2	6.79	743.3	151.5
Knife-In	17.6	4.51	1.93	1.08	163.9	6.95	790.0	149.2
	**						**	

Table 6. Effect of the use of a starter fertilizer in combination with application of either broadcast or knifed-in K on growth, K uptake and yield of corn. Wabasha County, 1984.

Starter used	Early Growth	K Concentration			Yield		K Uptake	
		Young plant	Ear leaf	Mature plant	Grain	Forage	Young plant	Maturity
	wt of 6 plants,g	----------%K----------			bu./acre	ton D.M./acre	mg/6 plants	lb./acre
No	17.5	4.49	1.92	1.08	161.8	7.00	782.5	150.2
Yes	16.5	4.57	1.95	1.12	165.3	6.74	750.7	150.5
	**				+	**		

Table 7. Effect of the use of a starter fertilizer without the application of additional K on growth, K uptake, and yield of corn in the chisel system. Wabasha County, 1984.

Starter used	Early Growth	K Concentration			Yield		K Uptake	
		Young plant	Ear leaf	Mature plant	Grain	Forage	Young plant	Maturity
	wt of 6 plants,g	%K			bu./acre	ton D.M./acre	mg/6 plants	lb./acre
No	18.0	4.52	2.09	1.12	144.7	7.27	810.0	162.0
Yes	15.2	4.32	2.06	1.23	151.0	6.84	660.0	168.0

Table 8. Effect of the use of a starter fertilizer without the application of additional K on growth, K uptake, and yield of corn in the no-till system. Wabasha county, 1984.

Starter used	Early Growth	K Concentration			Yield		K Uptake	
		Young plant	Ear leaf	Mature plant	Grain	Forage	Young plant	Maturity
	wt of 6 plants,g	%K			bu./acre	ton D.M./acre	mg/6 plants	lb./acre
No	18.0	4.19	1.91	1.11	171.0	6.88	738.0	147.0
Yes	17.9	4.30	1.81	1.10	172.0	6.51	768.0	148.0

THE PRESENCE OF "APPARENT" ATRAZINE IN GROUNDWATER OF SOUTHEAST MINNESOTA

R.S. Adams, Jr., Sheila Grow* and E.C. Alexander, Jr.*

For the past two years the authors have been conducting studies in the Karst area of southeast Minnesota. One of the measurements made has been to monitor atrazine in the water at four locations. The specific site is in Fillmore County. Water samples were collected at Fairview Sink and Mystery Cave: two sites where surface waters disappear into sink holes. Over a distance of 4 and 3 miles, respectively, these streams merge, converge, and emerge in two springs, Moth and Grabau that rise into Forestville Creek. Dye traces require three days to travel from the point of disappearance to the point of resurfacing.

Table 1 shows the concentration of "apparent" atrazine in the samples collected at these four sites from May 30, 1983 until January 12, 1985. The data show surges or peaks of "apparent" atrazine on July 5, 1983, followed by a gradual decline in concentration; and peaks on August 27, 1983, November 12, 1983 and April 29, 1984. Each of the samples were taken within a few days following a rainfall of two to three days duration. After a peak passed the quantities measured seemed to return to some equilibrium concentration which slowly declined with the approach of winter.

Using discharge flow rates from Moth and Grabau Springs the total delivery of "apparent" atrazine is plotted in Figure 1. These amounts total to approximately 10 pounds of "apparent" atrazine discharged to Forestville Creek over the period of a year's time. The estimated use of atrazine in the immediate watershed is 12,000 pounds or about .083% of the total used was discharged in these springs.

Why the designation "apparent" atrazine? A Hewlitt Packard gas chromatograph equipped with NP/FID detector and capillary columns was used in the analysis of these samples. Three liters of water per sample were extracted for atrazine by passing through an XAD-2 Amberlite resin. The atrazine was eluted with anhydrous ether. The ether evaporated to dryness and the residues dissolved in 2 milliliters hexane for analyses. The samples were analyzed in groups of four samples. With each group a deionized water control was passed through the entire analytical procedure. In the data reported here 46 controls were found to contain zero atrazine, in three controls the concentration was less than 10 nanograms per liter "apparent" atrazine and two controls had concentrations between 10 and 30 nanograms per liter "apparent" atrazine. One control was drawn while the deionizer was being recharged and gave extremely high readings and had to be discarded. All data given are minus the control concentrations. These precautions were taken and these procedures are shown because the gas chromatograph is a very sensitive <u>quantitative</u> instrument but not a <u>qualitative</u> instrument. Confirmation analyses must be performed. Such analyses are not sensitive at the nanograms per liter concentration reported here unless very large volumes of water are extracted. Intensive confirmation analyses are planned for the summer of 1985.

The data reported here are consistent with data reported from northeastern Iowa and Nebraska. We feel that peaks of "apparent" atrazine concentration probably do represent at least in part "true" atrazine. For example, with the April 29, 1984 peak, which occurred only at Mystery Cave, a heavy rainfall occurred April 27, 1984. Several farmers in the watershed planted corn early, just prior to that rainfall event. Water entering the sinks would not have had time to reach the springs from the April 27, 1984 rainfall on the sampling date. However, the fact that equilibrium levels were approached suggests that "noise" or atrazine mimics or "look alikes" may account for part of these results. Furthermore, in approximately 50% of wells (remote from the use of atrazine) tested by this laboratory "apparent" atrazine was measured. These findings make intensive confirmation analyses imperative before these data are accepted as atrazine.

Table 1. "Apparent Atrazine found in samples from four water sites in Fillmore County in nanograms per liter.

Date	Fairview Sink	Mystery Cave	Moth Spring	Grabau Spring
5-30-83	273	214	64	136
6-6-83	194	216	110	82
6-12-83	220	146	56	132
6-19-83	78	123	119	80
6-26-83	150	72	97	130

* Graduate Research Assistant and Associate Professor, respectively, Department of Geology & Geophysics,

Table 1. Continued.

Date	Fairview Sink	Mystery Cave	Moth Spring	Grabau Spring
7-5-83	1306	1462	1494	1333
7-10-83	565	388	360	511
7-17-83	227	203	193	237
7-31-83	57	73	185	139
8-7-83	87	113	76	102
8-17-83	54	120	84	89
8-21-83	51	217	101	115
8-27-83	217	551	449	530
9-4-83	117	155	146	222
9-11-83	108	129	129	154
9-18-83	55	96	75	93
9-25-83	165	201	175	198
10-5-83	154	152	89	146
10-9-83	94	176	173	155
10-16-83	150	144	138	124
10-23-83	222	334	274	154
11-6-83	63	121	105	111
11-12-83	104	285	117	139
11-20-83	152	170	121	134
11-27-83	93	148	146	132
12-4-83	88	119	114	90
12-11-83	94	60	109	130
12-18-83	88	0	53	96
1-1-84	--	--	27	31
1-8-84	--	29	--	23
1-15-84	79	103	96	86
1-22-84	37	113	93	98
1-29-84	23	34	29	8
2-5-84	25	--	39	60
2-11-84	37	121	79	35
2-19-84	115	247	115	--
2-23-84	122	172	152	147
3-4-84	142	128	206	145
3-11-84	128	124	111	112
3-18-84	78	138	104	116
3-25-84	78	295	128	145
4-1-84	108	203	189	171
4-8-84	39	57	42	72
4-22-84	35	28	10	6
4-29-84	6	1628	29	81
5-5-84	78	180	136	140
5-13-84	90	122	106	99
5-20-84	55	150	111	96
8-18-84	48	122	162	169
9-9-84	79	117	233	219
10-6-84	11	42	54	71
11-11-84	128	55	102	114
12-7-84	90	85	82	83
1-12-85	--	97	125	116

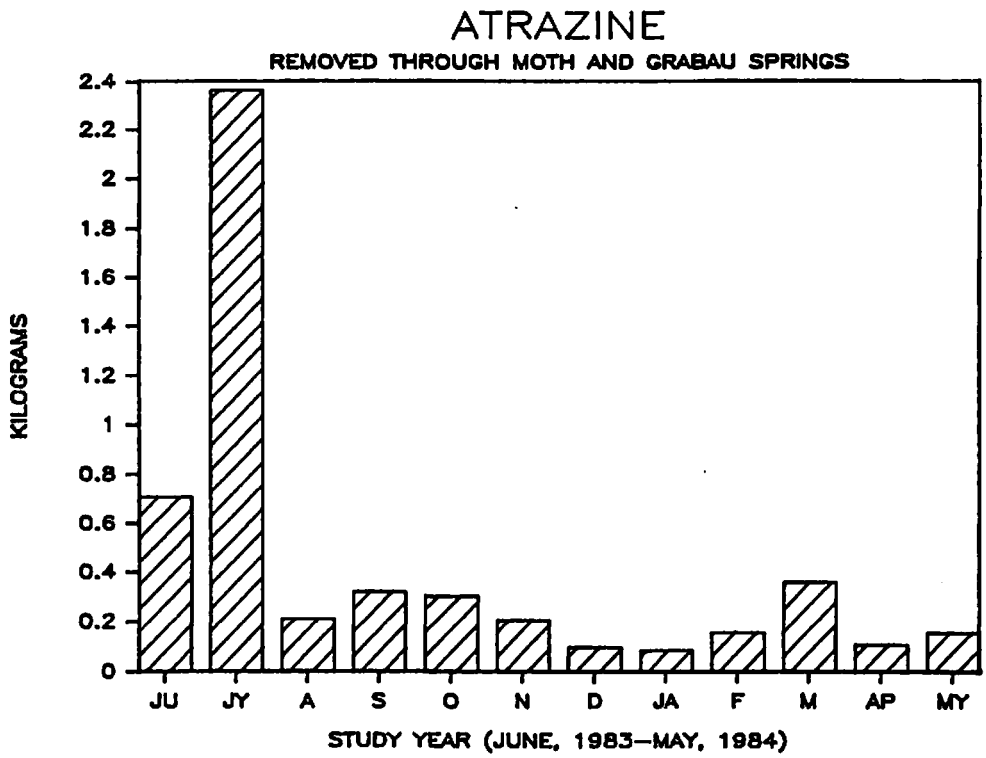

Figure 1. The discharge of "apparent" atrazine from springs in 1983-1984 study year.

CALCIUM AND MAGNESIUM AMENDMENT STUDIES ON POTATOES

C. J. Rosen and H. J. Buchite

Soil management practices for potato production differ from those used for most other agricultural crops in that liming of acid soils to a pH of 6.0 - 6.5 is avoided. The reason for not raising soil pH is due to the potential for increasing the incidence of common scab when the soil pH is above 5.2. Approximately 30% of potatoes grown in Minnesota are on irrigated coarse-textured soils. Because recommendations are not to lime, calcium and magnesium levels as well as soil pH are generally low. The potential for Al and Mn toxicity also exists due to the increase in solubilities of these elements with low soil pH. Yields of potatoes grown on many of these coarse-textured soils have generally declined over the past 10 years. Part of this problem may be due to lack of proper rotation coupled with an imbalanced soil fertility.

The objective of the present study was to determine the influence of Ca and Mg amendments on nutrition and production of potatoes grown on a soil with a history of continuous potatoes.

Materials and Methods:

The site was located in Cambridge, MN on an Anoka loamy sand. Potatoes had been grown on this site for the past 10 - 15 years. Treatments included:

1. Control
2. 0.4 T/A lime
3. 0.8 T/A lime
4. 1.2 T/A lime
5. 0.48 T/A gypsum + 0.56 T/A Epsom salts
6. 0.96 T/A gypsum + 1.12 T/A Epsom salts
7. 1.44 T/A gypsum + 1.68 T/A Epsom salts

All amendments were applied 8 November 1983 as a broadcast and disked in. The following spring the entire field was deep plowed to a depth of 8" - 10". The liming material used was a finely ground (200 mesh) dolomitic lime which enabled a relatively fast reaction with the soil. The gypsum/ Epsom salt combination was used to provide an equal amount of Ca and Mg as a non-lime source. Spacing used was 3' between row centers. Applications of N, P and K were made according to soil test recommendations. The cultivar used was 'Norland' planted on 23 April 1984. To monitor changes in soil pH, Ca and Mg levels, soil samples were collected on 7 November 1983, 4 April, 7 July, and 24 August 1984. Plant tissue samples consisting of the most recently matured whole leaf (blade and petiole) were collected 15 June, 6 July, and 24 July 1984 and subsequently analyzed for nutrient composition. Two center 15' rows of each plot were harvested on 28 August 1984 with the following measurements recorded: total yield, A-size, B-size and scab ratings. A randomized complete block design with 4 replications was used. Because this experiment was of a preliminary nature, non-orthogonal comparisons were used to determine the significance of trends observed throughout the experiment. This information will be used in the design of future experiments dealing with potatoes on acid soils.

Results and Discussion:

Soil Data -- Initial chemical properties of the soil before treatments were applied are provided in Table 1. Phosphorus levels were excessive while Ca and Mg levels were low. At the begining of the growing season fine dolomitic limestone increased soil pH slightly compared to a slight decrease with the gypsum and Epsom salts (Table 2). By the end of the season soil pH levels were low for all treatments. Soil Ca and Mg levels tended to be higher when amendments were added. As with pH, differences between the control and treated areas were minimal by the end of the season. Higher rates appear to be warranted in future studies.

Yield Data -- Regardless of source, there was a significant trend for plots receiving Ca and Mg to yield more A-size potatoes (Table 3). In general, potato yields were poor for the entire experiment regardless of treatment. This was probably due to die-back of the tops about two weeks earlier than expected. Symptoms of Verticillium wilt and Rhizoctonia were noted in the field. It appears that both of these factors, poor soil fertility and an increase in disease incidence are a consequence of continuous potatoes. In this study disease problems appeared to be the overriding factor. At the rates of amendments used, there was no effect on scab incidence.

Tissue Analysis -- Significant effects due to Ca and Mg amendments on leaf nutrient composition were apparent throughout the experiment (Tables 4 - 6). The most consistent reponses were high leaf Ca and Mg, and lower leaf K and Mn in the treated plots compared to the control plot. At the rates used, gypsum plus Epsom salts were more effective than dolomitic lime in depressing leaf Mn levels. It is conceivable that high tissue Mn coupled with low tissue Ca may increase susceptibility of these plants to disease.

The assistance of G. Buzicky, M. O'Leary and T. King during the course of this study is greatly appreciated.

Table 1. Initial soil chemical properties. Samples collected before treatment application. (Means of 4 samples.)

Soil Depth (inches)	pH	Buffer Index	P	K	Ca	Mg	O.M.	SO_4-S
			-------		lb/A	------	%	ppm
0-6	4.9	6.3	520	328	314	65	1.4	3
6-12	4.8	6.5	475	251	307	43	1.2	7
12-24	4.9	6.8	256	331	754	110	0.6	25

Table 2. Soil pH, calcium and magnesium levels during the course of the experiment. (Means of 2 replications.)

Soil Chemical Property	Treatment[1]	Date 4/84 Soil Depth (inches) 0-6	6-12	12-24	7/84 0-6	6-12	12-24	8/84 0-6	6-12	12-24
pH										
	1	4.8	4.7	4.9	4.2	4.5	4.6	4.5	4.3	4.5
	2	5.0	4.9	5.0	4.7	4.7	4.6	4.5	4.3	4.5
	3	5.0	4.8	5.1	4.5	4.8	4.6	4.5	4.6	4.5
	4	5.2	4.9	5.2	4.7	4.7	4.6	4.6	4.6	4.5
	5	4.7	4.7	4.7	4.5	4.6	4.6	4.7	4.4	4.6
	6	4.7	4.6	4.5	4.6	4.5	4.6	4.6	4.3	4.5
	7	4.6	4.5	4.6	4.6	4.5	4.6	4.6	4.3	4.5
Ca (lb/A)	1	184	189	530	169	147	484	178	195	409
	2	214	180	543	149	227	505	185	195	462
	3	221	204	553	203	219	595	184	266	463
	4	236	208	532	177	207	407	205	283	454
	5	184	179	491	185	246	561	173	233	500
	6	249	156	438	197	237	383	194	207	390
	7	444	163	470	197	266	420	168	308	428
Mg (lb/A)	1	52	46	100	37	31	99	47	56	104
	2	66	42	93	43	43	86	48	57	115
	3	72	51	96	40	58	107	41	93	111
	4	79	48	109	43	54	102	53	103	122
	5	75	77	146	47	65	152	59	73	165
	6	98	84	183	52	57	149	60	60	179
	7	85	102	239	48	49	156	60	71	166

[1]See Materials and Methods for treatment code.

Table 3. Total yield, A-size, B-size and scab rating as influenced by calcium and magnesium amendments.

Treatment[1]	B-size (cwt/A)	A-size (cwt/A)	Total (cwt/A)	Scab Rating[2]
1	51.8	38.7	90.5	1.75
2	51.4	63.9	115.7	1.58
3	47.3	70.7	118.1	1.48
4	66.1	62.4	128.5	1.65
5	61.6	67.0	128.6	1.67
6	44.0	73.6	117.7	1.68
7	49.9	88.1	137.9	1.75
CV (%)	22.9	35.4	25.3	13.7
Non-orthogonal Contrasts	Significance[3]			
Lin. Lime	-	-	-	-
Quad. Lime	-	-	-	-
Lin. G+E[4]	-	++	+	-
Quad. G+E	-	-	-	-
Lime vs G+E	-	-	-	-
Control vs lime+G+E	-	++	+	-

[1]See Materials and Method section for treatment code.
[2]Scale 0 - 5, 0 = no scab.
[3]++ = 5% level, + = 10% level.
[4]G+E = gypsum plus Epsom salts.

Table 4. Elemental concentrations in recently mature leaves 53 days after planting.

Treatment[1]	N	P	K	Ca	Mg	Fe	Al	Mn	Zn	Cu	B
	%					ppm					
1	5.20	0.63	6.74	0.33	0.30	235	219	614	39	5	46
2	5.40	0.64	6.55	0.37	0.33	239	214	547	41	5	41
3	5.29	0.70	7.52	0.42	0.38	239	211	506	48	7	42
4	5.13	0.64	6.83	0.36	0.38	224	196	502	40	6	41
5	5.01	0.64	6.70	0.44	0.36	250	192	436	44	6	40
6	5.39	0.69	6.63	0.40	0.36	252	188	380	49	7	40
7	5.36	0.68	6.71	0.40	0.38	250	180	373	52	5	39
CV(%)	2.8	6.4	7.3	13.1	11.8	11.2	9.4	10.3	13.1	34.5	11.3
Non-orthogonal Contrasts	Significance[2]										
Lin. Lime	-	-	-	++	++	-	-	++	-	-	-
Quad. Lime	++	-	-	-	-	-	-	-	+	-	-
Lin. G+E[3]	++	++	-	++	++	-	-	++	++	-	++
Quad. G+E	-	-	-	-	-	-	-	-	-	-	-
Lime vs G+E	-	-	-	-	-	-	-	++	+	-	-
Control vs Lime+G+E	-	-	-	++	++	-	-	++	++	-	++

[1]See Materials and Method section for treatment code.
[2]++ = 5% level, + = 10% level.
[3]G+E = gypsum plus Epsom salts.

Table 5. Elemental concentrations in recently mature leaves 74 days after planting.

Treament[1]	N	P	K	Ca	Mg	Fe	Al	Mn	Zn	Cu	B
	%					ppm					
1	4.26	0.41	7.86	0.74	0.44	540	365	1194	50	7	82
2	3.92	0.44	8.01	0.81	0.46	536	388	1144	43	6	93
3	4.07	0.39	7.61	0.85	0.47	387	320	883	37	5	64
4	4.05	0.41	7.45	0.96	0.53	476	354	943	39	8	84
5	4.32	0.42	7.73	0.77	0.47	519	384	918	49	6	80
6	4.26	0.42	7.21	0.81	0.46	560	375	850	47	6	73
7	4.34	0.41	6.76	0.85	0.47	585	320	821	49	5	69
CV(%)	6.3	7.6	8.2	11.5	13.6	21.6	16.0	9.0	14.5	28.6	27.1
Non-orthogonal Contrasts	Significance[2]										
Lin. Lime	-	-	-	++	++	-	-	++	++	-	-
Quad. Lime	-	-	-	-	-	-	-	-	-	+	-
Lin. G+E[3]	-	-	++	-	++	-	-	++	-	-	-
Quad. G+E	-	-	-	-	-	-	-	-	-	-	-
Lime vs G+E	++	-	+	+	-	-	-	++	++	-	-
Control vs Lime+G+E	-	-	-	+	++	-	-	++	-	-	-

[1]See Materials and Method section for treatment code.
[2]++ = 5% level, + = 10% level.
[3]G+E = gypsum plus Epsom salts.

Table 6. Elemental concentrations in recently mature leaves 92 days after planting.

Treatment[1]	N	P	K	Ca	Mg	Fe	Al	Mn	Zn	Cu	B
	%					ppm					
1	3.59	0.26	8.67	1.03	0.36	480	339	1702	54	107	107
2	3.72	0.27	8.33	1.07	0.47	435	282	1510	45	75	95
3	3.69	0.23	8.27	1.25	0.56	386	279	1307	43	84	69
4	3.70	0.25	8.35	1.29	0.55	393	324	1332	46	87	78
5	3.80	0.25	8.01	1.06	0.51	351	269	1299	43	66	95
6	3.78	0.25	7.90	1.17	0.53	475	294	1306	51	72	77
7	3.71	0.25	7.85	1.28	0.53	538	270	1230	60	66	75
CV(%)	4.8	12.3	5.1	8.8	12.5	27.9	16.3	8.2	20.2	27.6	21.0
Non-orthogonal Contrasts	Significance[2]										
Lin. Lime	-	-	-	++	++	-	-	++	-	-	++
Quad. Lime	-	-	-	-	-	-	++	+	-	-	-
Lin. G+E[3]	-	-	++	++	++	-	-	++	-	++	++
Quad. G+E	-	-	-	-	-	-	-	+	+	-	-
Lime vs G+E	-	-	++	-	-	-	-	+	-	-	-
Control vs Lime+G+E	-	-	++	++	++	-	+	++	-	++	++

[1]See Materials and Method section for treatment code.
[2]++ = 5% level, + = 10% level.
[3]G+E = gypsum plus Epsom salts.

COMPARISON OF THREE PHOSPHORUS SOIL TEST PROCEDURES TO CROP YIELDS AND PLANT ANALYSIS DATA

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M. O'Leary, G. Buzicky, and R. K. Severson

The objective of this study was to determine the relationship between crop yield and plant tissue phosphorus (P), and the amounts of phosphorus extracted by various soil testing methods. These experiments, to establish guidelines for making fertilizer recommendations from soil tests, have been conducted on private farms and at the Branch Experiment Stations since 1981.

EXPERIMENTAL PROCEDURE

Several field experiments were established on calcareous soils in western Minnesota in 1981 to evaluate three P soil tests and their relationship to crop response from P additions. The crops included spring wheat, barley, corn and soybeans. Information on location, soil type, crop and soil test levels of 1984 phosphorus trials is given in Table 1.

Table 1. Cooperator, county, soil type, crop, and soil test levels for 1984 phosphorus trials.

Cooperator:	Crookston Exp. Stn.	Morris Exp. Stn.	Dahl Farm
County:	W. Polk	Stevens	Norman
Soil Series:	Hegne	Doland	Vallers
Texture:	Sicl	Sil	Sil
Crop:	Wheat	Wheat	Barley
Soil pH:	8.0	7.8	8.3
Olsen P (lb/A):	15	6	12
Exch. K (lb/A):	314	263	302

The three soil tests compared were the Bray-1 method using 1:10 or 1:50 ratio of soil to extracting solution, and the Olsen sodium bicarbonate method. The Bray-1 method, used at a 1:10 soil/solution ratio, was adopted by the University of Minnesota Soil Testing Laboratory for routine analysis in 1954. This method is especially well suited for assessing P availability in acid to slightly alkaline soils. The reliability of the P soil test on calcareous soils was improved in 1975 by changing the soil/solution ratio from 1:10 to 1:50. In 1982, the Olsen method of extracting soil P was introduced for soils having pH over 7.4.

In the 1984 trials, only the 30 lb/A broadcast phosphate rate was applied, except at the Morris Station where the broadcast P effects were compared with and without the starter fertilizer.

RESULTS AND DISCUSSION

The yields of spring wheat for 1981, 1982, 1983, and 1984 are given in Tables 2 and 3, and Table 4 gives plant tissue and soil test results.

Wheat

Hegne sicl, Crookston Exp. Stn., Olsen P 15 lb/A (Fall 1983). Neither the yield nor the P concentration in plant tissue were affected by fertilization. Very high relative levels of P were indicated by the Bray-1 method (1:10 and 1:50) on this soil. Extractable P levels by all three methods were increased by broadcast fertilizer.

Wheatville sil, Crookston Exp. Stn., Olsen P 10 lb/A (Fall 1983). The yield was increased by 8 to 10 bu/A with 30 lb P_2O_5/A applied every year and from the carryover of 60 or 90 lb P_2O_5/A applied in 1982. On this soil which demonstrated relatively low P availability, tissue analysis and extractable P levels by three methods showed close relationship with the amounts of P applied.

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Doland sil, Morris Exp. Stn., Olsen P 6 lb/A (Fall 1983). Broadcast rates applied in 1983 and 1984 (30 lb P_2O_5/A) were reflected in increased percentage of P of plant tissue and higher soil test levels by all three methods. Increased yields were observed as a result of annual applications of phosphate fertilizer, either broadcast or banded, and from higher soil P levels, increased as a result of previous application of phosphate fertilizer.

Barley

Vallers sil, Dahl Farm, Olsen P 12 lb/A (Spring 1984). The yield was not determined because excessive rainfall in May and June resulted in heavy infestation with weeds and poor growth of barley. Gradual increases in plant tissue P and in extractable P by three methods resulted from broadcast phosphate applications.

Concentrations of eight plant nutrients in plant tissue are reported in Table 4. The concentration of zinc in tissue was decreased by fertilization with P in all experiments.

Table 2. Wheat yield at 13% moisture as affected by phosphorus fertilization in 1981, 1982, 1983 and 1984.

Treatment	Location									
Broadcast	Crookston Exp. Stn.						Morris Exp. Stn.			
P_2O_5	Hegne			Wheatville						
	1982	1983	1984	1982	1983	1984	1981	1982	1983	1984
Lb/acre	Bu/acre									
0	51	54	60	53	43	57	63	61	51	74
30	46	58	59	55	49	67	64	65	57	83
60	48	51	60	57	42	65	64	68	59	77
90	46	54	55	55	46	67	64	69	59	80
Significance	ns	+	ns	ns	ns	**	ns	*	**	+
BLSD (0.05)		5				7				
Starter	-	-	-	-	-	-	64	68	58	80
No Starter	-	-	-	-	-	-	64	64	54	77
Significance							ns	*	*	ns

Table 3. Wheat yield at 13% moisture as affected by broadcast and row applied phosphate fertilizer, Morris.

Treatment		Year			
Broadcast	Starter	1981	1982	1983[1/]	1984[1/]
P_2O_5 Lb/A		Bu/Acre			
0	-	63	56	44	68
0	+	64	67	57	80
30	-	62	64	56	81
30	+	65	67	58	85
60	-	65	68	58	77
60	+	63	68	59	75
90	-	64	69	58	80
90	+	64	68	59	79
Interaction					
Significance		*	*	**	*
C.V.%		2.5	5.7	3.9	3.2

1/ Only 30 Lb P_2O_5 rate applied in 1983 and 1984.

Table 4. Phosphorus concentration of entire wheat plant and barley plant at boot stage and relationship to P treatment and soil test.[1/]

Treatment	Location												
Broadcast	Crookston Exp. Stn.						Morris Exp. Stn.[2/]				Dahl Farm		
P_2O_5	Hegne Wheat			Wheatville Wheat			Wheat				Wheat	Barley	Barley
	1982	1983	1984	1982	1983	1984	1981	1982	1983	1984	1982	1983	1984
Lb/acre	Plant Tissue P %												
0	.30	.32	.28	.28	.30	.27	.16	.22	.27	.27	.27	.27	.20
30	.30	.33	.30	.26	.30	.29	.18	.26	.32	.32	.28	.31	.23
60	.30	.33	.29	.28	.32	.30	.18	.29	.32	.32	.29	.33	.24
90	.31	.34	.30	.28	.33	.32	.20	.31	.34	.34	.29	.36	.23
Significance	ns	*	ns	+	ns	**	ns	**	*	**	ns	*	**
BLSD (0.05)		.01				.01			.04			.06	.03
	Olsen P Lb/A												
0	20	16	15	15	10	10	11	6	5	6	17	14	12
30	-	22	21	-	10	12		13	9	10		15	16
60	-	24	27	-	16	25		15	12	11		19	21
90	-	30	34	-	18	26		23	15	16		21	34
	Bray-1 1:10 P Lb/A												
0	54	34	32	16	10	9	15	10	7	8	23	12	8
30	-	45	43	-	13	12		18	12	10	-	16	15
60	-	46	53	-	22	27		23	17	13	-	22	18
90	-	52	58	-	28	38		33	19	19	-	22	26
	Bray-1 1:50 P Lb/A												
0	84	81	71	60	54	45	21	12	38	30	57	45	62
30	-	96	86	-	54	48		23	34	34	-	46	70
60	-	101	104	-	72	84		25	42	40	-	64	86
90	-	111	112	-	70	82		33	48	55	-	66	102

1/ 1982 Crookston and Dahl trials were sampled in spring of 1982 prior to treatment, Morris trial was sampled in fall 1981.

1983 Crookston and Morris trials were sampled in fall of 1982, Dahl trial was sampled in spring of 1983. All 1984 trials were sampled in fall of 1983.

All soil test results are means of four replications.

2/ Plant and soil samples of Morris trial were collected from no starter plots.

Table 5. Plant nutrient concentration of wheat and barley at the boot stage, 1984.

Treatment Broadcast P_2O_5	Plant Nutrient							
	K	Ca	Mg	Fe	Mn	Zn	Cu	B
Lb/A	----------%----------			----------ppm----------				
	Crookston Exp. Stn., Hegne, Wheat - whole plant at boot stage							
0	3.31	.33	.25	93	51	23	4	4
30	3.12	.30	.26	108	51	21	3	3
60	3.16	.31	.24	84	51	19	3	3
90	3.15	.29	.22	88	49	18	3	3
Significance						**		
BLSD (0.05)						4		
	Crookston Exp. Stn., Wheatville, Wheat - whole plant at boot stage							
0	3.63	.33	.26	100	59	31	5	4
30	3.62	.34	.28	89	61	27	5	4
60	3.39	.35	.30	171	63	29	6	4
90	3.37	.34	.26	147	58	27	4	4
Significance						*		
BLSD (0.05)						3		
	Morris Exp. Stn., Doland, Wheat - whole plant at boot stage							
0	3.49	.32	.24	85	42	25	4	4
30	3.51	.37	.26	97	43	20	4	4
60	3.54	.39	.26	89	42	19	3	4
90	3.53	.40	.26	86	40	18	3	4
Significance						**		
BLSD (0.05)						2		
	Dahl Farm, Vallers, Barley - whole plant at boot stage							
0	2.19	.45	.25	48	41	15	3	4.1
30	2.03	.45	.22	28	41	13	2	3.5
60	1.97	.38	.25	28	30	12	2	3.4
90	1.71	.44	.23	26	34	10	2	3.3
Significance				**		**	**	**
BLSD (0.05)				15		3	1	.6

All indicated P rates were broadcast in 1982; the 30 lb rate was also applied in 1983 and 1984.

MICRONUTRIENTS AND RELATIONSHIP TO MICRONUTRIENT SOIL TESTS. 1981 Through 1984.

W. E. Fenster and G. W. Rehm

Even though micronutrients for agriculture have been in use for a long time, little or no research has been done to relate soil tests of these elements to their response in the field. Sulfur and magnesium, even though not micronutrients, were also included as a variable.

The micronutrient study was initiated on corn in 1981. Three of the original 6 locations were discontinued for various reasons in 1982 and the three that were continued were planted to soybeans, in 1983 one of these was planted to snap beans, the other two were in corn. In 1984 the Goodhue plot was discontinued. Corn was grown at Dakota Co. site and soybeans at the Martin Co. plot.

The "missing element" technique was used whereby a series of plots each having one of the nutrients omitted were compared to a treatment with all elements included. This design prevented other nutrients from being limiting factors if there was possible interaction. Only one rate of each element was used. Since most of the added nutrients were in the sulfate form the sulfur comparisons were established by themselves on an adjacent area. A boron trial, in addition to being included in the main experiment, was established on an adjacent area in order to have four levels of boron compared. Nitrogen, phosphorus and potassium were applied at or above adequate amounts. All plots were replicated four times.

Yields and Plant Analysis

Tables 1 through 5 show the 1981, 1982, 1983 and 1984 results. No significant yield increases were obtained but it is apparent that nutrient content in the leaves for some elements are increased by treatments (Tables 1 and 3). Iron, manganese and copper analysis did not show increases from treatment but were usually in the high category.

Soil Testing

There has been fine cooperation of private laboratories in testing soils from these plots. The Harris Laboratory at Lincoln, Nebraska, the A & L Laboratories at Omaha, Nebraska and Minnesota Valley Testing at New Ulm, Minnesota, have run soil analysis from all plots which will in final summary contribute a large volume of useful data.

Soil tests taken in the fall of 1983 show relationships to treatment for magnesium, zinc, copper and at high rates for boron. No effect from treatment was observed by sulfur, iron and manganese tests. The one pound boron treatment that was included in a factorial with the other nutrients only on occasion showed some sensitivity to this treatment but the treatments up to four pounds of boron show the positive effect (tables 5a and 5b). These tables also show the downward boron movement to the 2 foot depth during these 4 years. Generally the 4 labs show similar relationships between soil test and treatment.

The recommended treatments by the various labs are reduced or omitted compared to check plots. This indicates that the lab tests are sensitive to treatment and reflected in recommendations accordingly.

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

Table 1. Corn, soybean and snap bean yields, plant boron, and soil test boron from four levels of boron applications. 1981, 1982, 1983 and 1984.

Kingston Farm - Dakota Co. - irrigated
loamy sand

lbs B/A	Yield 1/ Bu/A		lb/A	Bu/A	ppm B 1/ leaf				Soil test - ppm hot H_2O			
	1981 Corn	1982 Soybeans	1983 Snap beans	1984 Corn	1981 Corn	1982 Soybeans	1983 Snap beans	1984 Corn	1981	1982	1983	1984 3)
0	155	36	12,440	159	7	43	21	9	0.25	0.2	0.2	
1	159	34	13,855	169	8	52	48	10		0.3	0.3	
2	147	32	12,472	162	12	67	72	13		0.5	0.8	
4 2/	160	27	13,728	165	18	112	60	8 2/		0.9	1.4	
significance	ns	**	ns	ns	**							
BLSD (.05)		4			3.5							
C.V.	5.0	82	33	6.2	21.9							

1/ Average of 4 replications, where statistics are shown.

2/ Four lb. rate not applied 1983 or 1984.

3/ See table 5.

Table 2. Yields[1/] in three counties comparing complete treatments of micronutrients plus Magnesium to plots using missing element techniques. 1981, 1982, 1983.

Treatment[2/] omitted (-) added (+)	Martin[3)] Yield[4)]				Dakota[3/] Yield[4/]			
	1981	1982	1983	1984	1981	1982	1983	1984
None	179	56	143	48	156	33	12,185	167
-Mg	181	51	144	46	160	35	14,814	158
-Zn	181	52	145	46	159	33	16,044	155
-Fe	182	53	148	48	151	34	15,036	161
-Mn	180	54	148	49	159	34	12,814	163
-B	178	52	148	46	152	34	14,596	167
-Cu	178	52	146	47	157	33	16,676	158
+ complete includes S	184	54	141	49	156	33	16,246	164
Significance	ns	ns	ns	ns	ns	ns	ns	ns
C.V.	4.9	5.0	6.7	7.3	5.6	7.8	27.2	7.1

1/ average of 4 replications.

2/ pounds per acre of nutrient added Mg=50, Zn=10, Fe=10, Mn=10, B=1, Cu=5 in 1981 and 1982, residual only in 1983, 1984.

3/ soils are irrigated sandy loam at Dakota Co., clay loam, non-irrigated in Martin Co.

4/ Martin Co., corn 1981, 1983; soybeans 1982, 1984.
Dakota Co. corn 1981, 1984; soybeans 1982; snap beans 1983.
Snap beans yields in pounds per acre.

Table 3. Plant analysis[1/] from micronutrient and magnesium treatments in trials at three counties. 1981, 1982, 1983.

Treatment[2/] omitted (-) added (+)	Martin[3)]								Dakota[3)]							
	(-)				(+)				(-)				(+)			
	81	82	83	84	81	82	83	84	81	82	83	84	81	82	83	84
Mg (%)	.58	.48	.45	.47	.58	.42	.53	.48	.27	.43	.52	.37	.27	.49	.50	.36
Zn ppm	21	42	14	38	24	48	20	44	29	45	25	20	34	47	27	25
Fe ppm	93	113	100	116	97	131	99	111	120	84	94	105	117	92	94	98
Mn ppm	56	61	46	87	61	97	57	58	76	63	54	76	77	58	60	63
B ppm	5	50	8	46	5	50	7	48	5	39	24	6	9	54	40	8
Cu ppm	3	10	3	9	3	11	3	10	10	10	8	8	10	10	8	9

1/ average of 2 replications from leaf opposite and below ear at silking time.

2/ symbol + is from treatment of all nutrients. Pounds of nutrients added Mg=50, Zn=10, Mn=10, B=1, Cu=5, in 1981 and 1982. Residual in 1983.

3/ irrigated sandy loam at Dakota Co. site, clay loam non-irrigated site in Martin Co.

4/ Martin Co. corn 1981, 1983; soybeans 1982, 1984.
Dakota Co. corn 1981, 1984; soybeans 1982; snap beans 1983.

Table 4. Yields, [1/] plant sulfur and soil test sulfur with and without sulfur treatments in two counties. 1981, 1982, 1983, and 1984.

Sulfur Treatment	Yield (bu/A)				Leaf test (% S)				U of M Soil Test (PPM S)			
	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984
						Martin Co.						
None	183	54	144	47	.23	.31	.20	.30	16	1	6	12
50#/A	180	53	152	48	.29	.31	.22	.32	--	--	5	11
Significance	ns	ns	ns	ns								
						Dakota [2/]						
None	151	33	15966	155	.24	.28	.21	.21	6	1	6	10
50#/A	154	34	14493	143	.25	.30	.21	.21	--	2	6	10
Significance	ns	ns	ns	*								

[1/] average of 4 replications, corn at both sites 1981, soybeans in 1982, corn in 1983 in Martin Co. and snap beans in Dakota Co.

[2/] irrigated sandy loam soil in Dakota Co., clay loam in Martin Co. (non irrigated).

Table 5a. Boron soil tests in one foot increments to 5 feet of depth. Kingston farm, Dakota Co. [1/] Fall 1983.

Depth, feet	Boron treatment, lb B/A 0	1	2	4
	lbs B/A ppm			
0 - 1	.3	.6	.8	.9
1 - 2	.2	.3	.4	.6
2 - 3	.1	.1	.2	.2
3 - 4	.1	.1	.1	.1
4 - 5	.1	.1	.1	.1

Table 5b. Boron soil test on Jokela farm. Goodhue Co., Fall 1983.

Depth, feet	Boron treatment, lb/A 0	1	2	4
	lbs B/A ppm			
0 - 1	.6	1.1	1.2	1.7
1 - 2	.4	.4	.4	.6
2 - 3	.3	.2	.3	.4
3 - 4	.2	.3	.3	.3
4 - 5	.2	.2	.1	.2

[1/] irrigated sandy loam, Kingston farm; silt loam soil, Jokela farm.

[2/] The 4 pounds rate was not applied in 1983 or 1984.

[3/] All B tests are averages of 2 reps.

Table 6a. Soil test means for micronutrients. University of Minnesota Lab. 1981, 1982, 1983 and 1984.

Treatment 1/ omitted (-) added (+)	Martin							Dakota						
	(ppm except Mg which is lbs/A)													
		(-)			(+)				(-)			(+)		
	1981	1982	1983	1984	1982	1983	1984	1981	1982	1983	1984	1982	1983	1984
Mg	881	990	1124	632	970	1096	1134	312	295	317	444	364	435	577
Zn	1.0	1.2	2.2	1.2	2.3	5.4	6.8	1.0	1.4	1.4	1.6	4.2	6.2	4.5
Fe	21	42	25	26	26	24	30	41	78	56	52	80	48	43
Mn	41	40	22	25	40	17	18	21	19	10	12	18	8	10
B	1.20	2.1	2.2	2.0	1.8	2.4	1.7	.25	2.2	0.4	0.8	2.4	0.9	0.8
Cu	1.28	1.8	1.7	1.8	2.5	3.0	3.7	0.48	0.6	0.9	0.5	3.1	3.4	2.1

1/ 1981 soil test results before treatment applied, 1982 from treatment plots in 1981 and 1983 from treatment plots in 1981 and 1982, 1984 from plots treated 1981, 1982 and 1983.

Table 6b. Soil test means for micronutrients. Minnesota Valley soil test lab. 1983 and 1984.

Treatment omitted (-) added (+)	Martin Co.				Dakota Co.			
	(ppm except Mg which is lbs/A)							
	(-)		(+)		(-)		(+)	
	1983	1984	1983	1984	1983	1984	1983	1984
Mg	1325	1350	1200	1675	400	500	525	625
Zn	2.1	2.0	4.0	6.7	1.8	2.2	4.0	4.8
Fe	8	18	8	12	8	12	8	12
Mn	2	10	2	8	2	10	2	10
B	3	3	4	3	1.4	0.5	2.4	0.8
Cu	0.4	1.9	0.4	3.6	0.4	1.5	0.4	2.5

Table 6c. Soil test means for micronutrients. Harris Lab. 1983 and 1984

Treatment omitted (-) added (+)	Martin Co.				Dakota Co.			
	(ppm)							
	(-)		(+)		(-)		(+)	
	1983	1984	1983	1984	1983	1984	1983	1984
Mg	629	585	567	567	143	164	227	206
Zn	2.0	1.2	4.7	6.6	1.4	1.5	5.8	4.8
Fe	22	21	20	26	43	41	36	35
Mn	14	15	12	13	9	14	7	11
B	1.9	1.5	2.0	1.6	0.5	0.8	0.7	0.8
Cu	1.5	1.3	2.6	3.0	0.8	0.6	3.3	2.2

Table 6d. Soil test means for micronutrients. A & L lab. Fall 1983 and 1984.

Treatment omitted (-) added (+)	Martin Co. (-) 1983	Martin Co. (-) 1984	Martin Co. (+) 1983	Martin Co. (+) 1984	Dakota Co. (-) 1983	Dakota Co. (-) 1984	Dakota Co. (+) 1983	Dakota Co. (+) 1984
	(ppm)							
Mg	549	592	525	582	171	193	223	212
Zn	1.7	1.2	4.7	6.7	1.8	1.8	5.2	5.2
Fe	19	23	19	27	46	46	49	46
Mn	15	13	11	12	10	13	7	12
B	2.8	1.5	3.0	1.4	0.9	0.8	0.8	0.8
Cu	1.4	1.4	2.4	3.0	1.5	0.8	2.9	2.2

CONCENTRATIONS OF P AND K IN THE RIDGE IN SELCTED RIDGE-TILL PLANTING SYSTEMS

George Rehm, Floyd Bellin, Jack Morris and Dave Hanson

Ridge-till planting systems for corn and soybean production have increased substantially in recent years. There is ample evidence that traditional management practices must be changed to match this conservation tillage production system. Many questions arise about soil sampling procedures needed for growers who use the ridge-till planting system. Before this question can be answered, it's important to know something about the concentration of plant nutrients in the ridge. Therefore, the purpose of the study was to monitor the concentration of P and K in the ridge in situations where ridge-till practices had been used for several years under widely different conditions in Minnesota.

Experimental Procedures

Ridge-till fields in 3 counties (Martin, Pope, and Dodge) were sampled in 1984. The sampling procedure varied with county.

Two fields were sampled in Martin County. One field was in corn in 1984 following a soybean crop in 1983. The second field was soybeans in 1984 following the 1983 corn crop. Row spacing was 30 inches in both fields. Soil cores were taken at 4, 8, and 15 inches from the row. These cores were sectioned into 0-3 and 3-6 inch increments.

These ridges were sampled at 4 times during the growing seson (early May, late May, late July, and late October). Samples were analyzed for pH, P, and K.

In Pope and Dodge Counties, soil cores were taken in the row, then at 3, 6, 9, 12, and 15 inches from the row. These cores were divided into 0-3, 3-6, 6-9, and 9-12 increments. Six cores were composited to form one sample. These samples were also analyzed for pH, P, and K by standard soil testing procedures.

Results and Discussion

The results from Martin County are summarized in Tables 1, 2, and 3. In general, the pH values were lower for the early May sampling date and increased during the growing season. There was no distinct change in pH with depths that were sampled.

Soil test values for P were quite variable--especially for the field that was in corn in 1984 (Table 2). Because of this variability it is difficult to make conclusions from the data taken from the field planted to corn in 1984. Except for the early May sampling, the P concentration in the soybean field was relatively uniform with respect to distance from the row and the depth sampled to 6 inches.

The potassium concentration was also quite variable with time of sampling and with depth. Therefore, no definite conclusions can be made from this data at the present time.

Results of the analysis of soil samples collected from the ridge-till field in Pope County are summarized in Table 4. The pH of the field was higher than 7.5. Therefore, both the Bray and Kurtz #1 and the Olsen procedures were used for P analysis.

As would be expected, the P concentration decreased with an increase in depth of sampling. This was true for cores taken at all distances from the row. Except for the 9-12 inch segment, the P concentration was fairly uniform up to 9 inches from the center of the ridge. The same general statements can be made for the concentration of K in the ridge.

This Pope County field had been in a ridge-till system for approximately 5 years. The grower routinely used a 9-18-9 liquid fertilizer applied at relatively low rates. Consequently, there were no small zones having high concentrations of P and K in the ridge.

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

The Dodge County field had been in a ridge-till system for 14 years. The standard fertilizer program consisted of a broadcast application of K with annual use of 10-34-0 applied with the seed at planting. The pH at this site was less than 7.0.

Using the Bray and Kurtz #1 P test values as a measure of P concentration in the center of the ridge was relatively high to a depth of 9 inches. This reflects the repeated use of 10-34-0 with the seed. The P concentration in the 9-12 inch segment was relatively uniform with distance from the center of the ridge.

Considering the other segments sampled, the P concentration was relatively uniform at 3, 6, 9, and 12 inches from the center of the ridge. In general, the P concentration at any depth was lower at 15 inches from the center of the ridge. The concentration of K was somewhat variable, but, in general, followed the same pattern as the P concentration.

The data generated from this study are, by no means, conclusive. They do indicate, however, that the concentration of P and K in the ridge where ridge-till planting systems have been used is relatively constant to a depth of 6 inches and at a distance of 8 to 9 inches from the center of the ridge. So, a preliminary suggestion for sampling a ridge-till system would be to take the sample to a depth of 6 inches at a distance of 6 to 8 inches from the center of the ridge. This sampling technique would avoid fertilizer bands created by repeated application of starter fertilizer.

Table 1. The pH in the ridge of 2 fields in Martin County. 1984.

		1984 Crop							
		Corn				Soybeans			
Sample depth	Distance from ridge center	Early May	Late May	Late July	Late October	Early May	Late May	Late July	Late October
in.	in.								
0-3	4	7.3	7.5	---	8.0	7.5	7.6	---	7.8
3-6	4	7.4	7.6	---	8.0	7.5	7.6	---	7.9
0-3	8	7.4	7.6	---	7.5	7.5	7.6	---	7.9
3-6	8	7.4	7.5	---	7.8	7.6	7.7	---	7.9
0-3	15	7.5	7.6	---	7.9	7.6	7.7	---	7.9
3-6	15	7.5	7.6	---	7.8	7.6	7.7	---	7.9

Table 2. Soil test P in the ridge of 2 fields in Martin County. 1984.

		1984 Crop							
		Corn				Soybeans			
Sample depth	Distance from ridge center	Early May	Late May	Late July	Late October	Early May	Late May	Late July	Late October
in.	in.	lb. P/acre (Olsen)							
0-3	4	32	41	44	64	29	14	16	12
3-6	4	25	45	33	56	14	14	14	10
0-3	8	32	47	39	82	20	22	14	15
3-6	8	21	32	35	53	8	20	13	17
0-3	15	19	46	36	66	37	27	17	17
3-6	15	17	40	35	71	14	25	18	13

Table 3. Soil test K in the ridge of 2 fields in Martin County. 1984.

		1984 Crop							
		Corn				Soybeans			
Sample depth	Distance from ridge center	Early May	Late May	Late July	Late October	Early May	Late May	Late July	Late October
In.	In.	lb. K/acre							
0-3	4	640	650	430	560	550	280	180	240
3-6	4	550	610	360	460	250	200	140	210
0-3	8	580	700	390	430	270	260	200	300
3-6	8	490	650	310	510	240	240	140	240
0-3	15	410	680	400	530	550	470	160	270
3-6	15	560	610	340	420	300	310	230	220

Table 4. Soil test values for P and K in a ridge planting system has been used for several years in Pope County.

	Distance From Row (in.)					
Depth	0	3	6	9	12	15
in.	lb. P/acre (Bray)					
0 - 3	75	71	73	71	68	62
3 - 6	56	63	59	55	39	31
6 - 9	56	56	66	47	48	36
9 - 12	21	25	28	21	18	14

	Distance From Row (in.)					
Depth	0	3	6	9	12	15
in.	lb. P/acre (Olsen)					
0 - 3	37	30	37	33	25	26
3 - 6	24	24	29	23	16	17
6 - 9	20	27	29	20	18	16
9 - 12	15	19	16	11	14	10

	Distance From Row (in.)					
Depth	0	3	6	9	12	15
in.	lb. K/acre					
0 - 3	495	455	470	440	390	360
3 - 6	205	250	220	255	180	185
6 - 9	310	255	275	280	300	235
9 - 12	160	175	175	170	180	175

Table 5. Soil test values for P and K in a ridge where ridge planting system has been used for several years in Dodge County.

Depth	Distance From Row (in.) 0	3	6	9	12	15
in.	lb. P/acre (Bray)					
0 - 3	213	164	180	147	155	180
3 - 6	162	87	73	90	90	75
6 - 9	117	107	74	91	80	55
9 - 12	48	47	37	36	40	26

Depth	Distance From Row (in.) 0	3	6	9	12	15
in.	lb. P/acre (Olsen)					
0 - 3	84	53	54	52	53	40
3 - 6	50	32	32	27	24	24
6 - 9	31	29	21	23	21	17
9 - 12	17	14	15	13	11	11

Depth	Distance From Row (in.) 0	3	6	9	12	15
in.	lb. K/acre					
0 - 3	605	585	545	570	530	570
3 - 6	250	265	240	290	255	250
6 - 9	305	185	250	265	285	275
9 - 12	185	165	160	160	190	195

EVALUATION OF FOLIAR FERTILIZERS FOR STRAWBERRY PRODUCTION

C. J. Rosen, E. E. Hoover, J. J. Luby and H. J. Buchite

The objectives of this experiment were to: 1) determine the influence of various rates and timings of foliar fertilizers (16-4-4, 9-18-9) on strawberry production; 2) increase the data base for strawberry leaf tissue analysis; and 3) determine nutrient removal by the strawberry crop.

Procedure:

Treatments were applied to a second year (first fruiting season) planting of 'Earliglow' strawberries on a Gotham loamy sand soil. A randomized complete block design was used with 5 replications. The planting system was a matted row with 4 feet between row centers. Each plot consisted of one 20 foot row. The treatments included:

1) control (soil applied previous season, U of M recommendations)
2) 1 gal/A 16-4-4 applied during flowering
3) 1 gal/A 16-4-4 applied during fruit maturation
4) 1 gal/A 16-4-4 split applied during flowering and fruit maturation
5) 2 gal/A 16-4-4 split applied during flowering and fruit maturation
6) 2 gal/A 16-4-4 soil applied during flowering and fruit maturation
7) 2 gal/A 9-18-9 split applied during flowering and fruit maturation
6) 4 gal/A 9-18-9 split applied during flowering and fruit maturation.

Treatments were applied 24 May 1984 and 8 June 1984. Except for treatment 6 which was soil applied, all others were applied with a CO_2 sprayer fitted with a fan type nozzle. The fertilizers were applied with 12 gal water/A at 40 psi. All treatments included WEX, a surfactant at the rate of 3 ml/gal.

Yield measurements were recorded for all treatments on the following harvest dates: 18, 21, 27 June and 7 July 1984. On 21 June, the most recently mature leaves were sampled for subsequent elemental analyses.

More detailed measurements were made for treatments 1, 5 and 8. A subsample of fruit was taken from these treatments to determine moisture content and number of berries per pound. Total N concentrations in lyophilized fruit tissue were determined conductimetrically and other elements were determined by ICP spectroscopy.

Results:

Neither of the foliar fertilizers, at the rates and timing used, significantly increased strawberry yields (Table 1). There was a significant decrease in yield when 2 gal/A 9-18-9 was split applied during flowering and fruit maturation. The reason for this yield decrease is not known. At higher rates of 9-18-9 (4 gal/A) applied at the same times, no yield de-crease was observed.

Elemental concentrations in leaves sampled on 21 June are presented in Table 2. Foliar fertilizers had no significant effect on leaf nutrient levels. It is possible that rates applied were too low to bring about a significant increase. Leaf burn was not observed from any of the treatments.

When the higher rates of 16-4-4 and 9-18-9 were compared with the control at the individual harvest dates, no significant differences in yield and number of berries per pound were observed (Tables 3 and 4).

Total nutrient removal by the strawberry crop is presented in Table 5. No differences due to foliar fertilizers were detected. In all cases, strawberry fruit appeared to remove relatively large amounts of potassium.

Table 1. Total yield of 'Earliglow' strawberries as influenced by foliar fertilizer (total from four harvest dates).

Treatment	Yield (T/A)
Control	8.07
1 gal/A 16-4-4 (fl)[1]	8.41
1 gal/A 16-4-4 (fr)[2]	8.76
1 gal/A 16-4-4 (fl + fr)	8.19
2 gal/A 16-4-4 (fl + fr)	7.97
2 gal/A 16-4-4 (soil)	8.60
2 gal/A 9-18-9 (fl + fr)	6.20
4 gal/A 9-18-9 (fl + fr)	8.36
Significance	**
BLSD (0.05)	1.34
CV (%)	11.6

[1]fl = applied during peak flowering
[2]fr = applied during fruit maturation

Table 2. Elemental concentrations in strawberry leaves (leaflets and petiole) sampled at peak harvest.

Treatment	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
Control	1.64	0.27	2.25	1.03	0.29	58	576	17	4	41
1 gal/A 16-4-4 (fl)[1]	1.70	0.28	2.36	0.95	0.29	52	625	18	4	39
1 gal/A 16-4-4 (fr)[2]	1.69	0.28	2.24	0.96	0.29	58	548	19	5	37
1 gal/A 16-4-4 (fl + fr)	1.66	0.28	2.28	0.96	0.29	53	639	19	5	40
2 gal/A 16-4-4 (fl + fr)	1.75	0.29	2.37	0.95	0.29	56	641	19	5	38
2 gal/A 16-4-4 (soil)	1.67	0.28	2.23	1.07	0.30	59	486	19	5	43
2 gal/A 9-18-9 (fl + fr)	1.65	0.30	2.43	0.88	0.29	55	631	20	5	37
4 gal/A 9-18-9 (fl + fr)	1.65	0.29	2.34	0.99	0.29	57	524	20	5	41
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	7.1	8.3	8.1	9.9	7.7	7.9	19.4	10.5	10.4	14.6

[1]fl = applied during peak flowering
[2]fr = applied during fruit maturation

Table 3. Strawberry yield at each harvest as influenced by 2 gal/A 16-4-4 and 4 gal/A 9-18-9.

Treatment	Harvest Date 6/18	6/21	6/27	7/3
	T/A			
Control	1.38	1.77	3.51	1.41
2 gal/A 16-4-4	1.47	1.92	3.42	1.16
4 gal/A 9-18-9	0.85	2.01	3.85	1.65
Significance	NS	NS	NS	NS
CV (%)	31.9	19.9	17.4	33.4

Table 4. Number of berries per pound at each harvest date as influenced by 2 gal/A 16-4-4 and 4 gal/A 9-18-9.

Treatment	Harvest Date 6/18	6/21	6/27	7/3
	berries /lb			
Control	20.8	28.2	41.6	81.8
2 gal/A 16-4-4	22.9	30.4	47.4	86.6
4 gal/A 9-18-9	20.2	29.7	43.2	73.8
Significance	NS	NS	NS	NS
CV (%)	14.4	12.7	18.6	16.3

Table 5. Total nutrient removal by strawberry fruits as influenced by 2 gal/A 16-4-4 and 4 gal/A 9-18-9 (total from four harvest dates)[1].

Treatment	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb/A					oz/A				
Control	13.9	4.2	35.3	4.3	3.0	1.17	4.42	0.34	0.15	0.39
2 gal/A 16-4-4	13.9	4.0	33.8	4.1	2.8	1.14	4.71	0.33	0.10	0.39
4 gal/A 9-18-9	14.3	4.3	35.6	4.5	3.1	1.19	4.67	0.35	0.14	0.41
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	12.0	11.6	11.2	16.1	15.1	20.8	27.3	27.3	31.9	12.2

[1]Yield for each treatment provided in Table 1.

FIELD TRIALS WITH "BASIC-H" 1983 and 1984

W. E. Fenster and G. W. Rehm

The effects of the wetting agent "Basic-H" were studied at several experimental farms and by growing various crops. This product is not marketed as a plant food but meant to improve water penetration and thus better water use efficiency.

Plots were established on fine textured, clay loam soils of high organic matter at Waseca, and Lamberton. The trials at the Morris station were on silt loam soils. The experiments conducted at Crookston were on high organic matter soils, the 1983 trial on a fine sandy loam, the 1984 trial on a loam soil. The trials at Becker were on very well drained loamy sands with low organic matter and were conducted under irrigation.

Under conditions of 1983 and 1984 no significant benefits were obtained by the use of the wetting agent except from one treatment on wheat at the Morris station.

Trials at the Waseca and Lamberton stations were conducted by G. W. Randall, W. W. Nelson respectively. The following tables present 1983 and 1984 results.

Table 1. Effects of Basic-H on corn yields, moisture at harvest and plant population at Waseca and Lamberton experiment stations 1983 and 1984.

	Yield (Bu/A)				Moist (%)				Pop. (x 1000)	
	Waseca		Lamberton		Waseca		Lamberton		Waseca	
	1983	1984	1983	1984	1983	1984	1983	1984	1983	1984
Control	56	68	62	94	21.6	21.5	23.2	31.5	27.1	26.6
Fertilizer (U of M recommendation)*	121	141	85	115	20.5	19.5	21.7	30.0	27.0	27.8
Fertilizer + Basic-H (1 gal./A)	111	141	87	116	20.4	19.3	22.1	31.5	27.6	28.2
Fertilizer + Basic-H (2 gal./A)	117	145	87	121	20.6	20.3	21.4	31.3	26.3	29.2
Basic-H only (1 gal./A)	53	58	54	95	21.8	22.6	23.1	31.8	26.8	26.1
Significance	**	**	**	**	**	**	ns	ns	ns	ns
BLSD (.05)	10	8	14	7	.6	2.5	--	--	--	--
C.V.	7.6	5.0	9.0	4.5	.8	7.3	4.2	2.9	4.9	6.8
*Fertilizer recommended	N		P_2O_5		K_2O					
Waseca lbs/A	175	170	50		150					
Lamberton lbs/A	150	150	60	60	60	60				

*This research partially funded by the Shaklee Corporation.

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In Table 1b results at Waseca of another wetting agent "Amway Spray Adjuvant" are shown.

Table 1b. Effects of Amway Spray Adjuvant on corn yield, moisture at harvest and plant population, Waseca, MN 1983 and 1984.

	Yield (Bu/A)		Moist (%)		Population (X 1000)	
	1983	1984	1983	1984	1983	1984
Control[1)]	56	68	21.6	21.5	27.1	26.6
Fertilizer (U of M recommendation)*	121	141	20.5	19.5	27.0	27.8
Fertilizer + Amway (1 gal./A)	115	142	20.4	18.7	27.2	28.7
Fertilizer + Amway (2 gal./A)	114	140	20.4	19.3	27.6	28.4
Amway only (1 gal./A)	50	71	21.8	22.2	26.6	26.5
Significance	**	**	**	**	ns	ns
BLSD (.05)	8.4	10	.8	2.6	--	--
C.V.	6.6	6.6	1.1	7.7	4.3	7.5
*Fertilizer recommended	N		P_2O_5		K_2O	
lbs./A	175	170	50	0	150	0

[1)] Soil test 1984, pH=6.8, P=30, K-345

Results from trials with "Basic-H" at the Morris station on wheat conducted by S. D. Evans and W. E. Fenster are shown in Table 2.

Table 2. Effects of Basic-H on wheat yields and moisture at harvest time. Morris, MN 1983 and 1984.

	Yield (Bu/A)		Moist (%)	
	1983	1984	1983	1984
Control[1)]	41	84	13.2	12.2
Fertilizer (U of M recommendation)*	55	75	12.2	12.6
Fertilizer + Basic-H (1 gal./A)	59	80	13.8	12.6
Fertilizer + Basic-H (2 gal./A)	56	81	13.9	12.6
Basic-H only (1 gal./A)	46	80	13.0	12.3
Significance	**	ns	ns	ns
BLSD (0.5)	4.5	--	--	--
C.V.	6.1	6.6	2.8	1.6

*Fertilizer recommended	N		P_2O_5	K_2O	
lbs/A	50	80	0 0	0	30

1) Soil test 1984, pH=7.2, P=46, K=278

Table 3. Effects of Basic-H on sunflower yield, annual oil content. Crookston, MN. 1983 and 1984.

	Seed Yield (lbs/A)				Oil %	
	1983	1984			1983	1984
Control	964	1743			37.5	42.6
Fertilizer (U of M recommendation)*	1180	1825			38.0	42.5
Fertilizer + Basic-H (1 gal/A)	1192	1949			37.4	42.5
Fertilizer + Basic-H (2 gal/A)	1169	1873			37.1	42.7
Basic-H only (1 gal/A)	996	1795			37.8	42.9
Significance	ns	ns			ns	ns
C. V.	11.4	8.9			3.4	1.5
*Fertilizer Recommendation	N		P_2O_5		K_2O	
lbs/A	90	18	50	46	100	0

1984 soil test - NO_3-N=86, P=13, K=260, O.M.+3.1%

Table 4. The effect of "Basic-H" on potato yield. Becker, MN. 1983 and 1984.

		Yield (Wt/A)		
		1983	1984	
Control		334	330	
Fertilizer (U of M recommendation)*		460	478	
Fertilizer + Basic-H (1 gal/A)		446	453	
Fertilizer + Basic-H (2 gal/A)		424	445	
Basic-H only (1 gal/A)		318	340	
Significance		**	**	
B.L.S. D. (.05)		98	37	
C. V.		11.0	6.3	
Fertilzer Applied	N	P_2O_5	K_2O	S
lbs/A - 1983	150[1/]	150	400	15
lbs/A - 1984	210[1/]	100	300	15

1984 soil test - pH=6.5, P=65, K=223, Mg=325, S=4, Zn=.8

[1/] 1983 N is applied in 3 different application times.
1984 N is applied in 4 different application times.

Field trials with "Reward" 1984

G. W. Rehm, W. E. Fenster, Sam Evans and John Lamb

Experiments with "Reward" were established on sunflowers at Crookston and on wheat at Morris, 1984. The product was used on plots where 75% of the recommended N was applied and compared to the 100% N applicaton. The Reward was foliar applied at the growth stage according to label instructions. Soils in these trials were Wheatville loam at Crookston and Tera silt loam at Morris. Reward contains no nutrients but is used on plants, soil or seeds to make more efficient use of nitrogen by the plant. The management practices at Morris were as follows: Era wheat was seeded at 1-1/3 bushels per acre on April 25. The fertilizer was broadcast and incorporated before planting. Harvest was in early August.

The management practices at Crookston were: Interstate 894 was the sunflower variety. The seeding rate was 21,550 seeds per acre. Planting was on May 30. The fertilizer was broadcast and incorporated before planting. Leaf application of Reward was made on July 6. The insecticide Pydrin at 1/3 pint per acre was applied July 20 for control of sunflower beetle and again on August 9 for control of the banded moth.

At Morris on wheat the 80 pounds of N per acre recommended was actually too high and caused reduction in yield due to lodging. The 75% N rate or 60 pounds of N resulted in a significantly higher wheat yield over the 80 pound rate. The addition of Reward at both 12 oz. and 24 oz. rate to the 75% N rate had no significant effect on yield.

At Crookston the recommended N rate for sunflowers was only 18 pounds of N per acre along with 46 pounds of P_2O_5. The 75% N treatment was therefore reduced to zero N since the difference between 13-1/2 and 18 pounds of N wouldn't be very meaningful. The treatments used had no significance on sunflower production at Crookston.

Results are shown in Table 1.

Table 1. The effects of "Reward" on sunflowers and wheat. 1984.

	Crookston Sunflowers		Morris Wheat		
Treatments	Yield lbs/A	oil %	Yield Bu/A	H_2O %	test Wt. lbs/bu
1. Check	1743	42.6	84	12.2	59.0
2. U.M. recommended	1825	42.5	75	12.6	58.9
3. *75% U.M. N rec. + 100% P and K	1787	42.9	84	12.1	60.0
4. *75% U.M. N rec. + 12 oz. Reward	1905	43.4	81	124	59
5. *75% U.M. N rec. + 24 oz. Reward	1791	41.0	81	126	60
Significance	ns	ns	**	ns	ns
BLSD (.05)	--	--	5.2	--	--
C.V.	10.5	3.0	4.0	2.5	2.8

*U.M. recommendation as follows: Sunflowers N=18 lbs/A, P_2O_5=46, K_2O=0
No. 3 treatment = 0, 46, 0

Wheat N=80 lbs/A, P_2O_5=0, K_2O=30
No. 3 treatment = 60 MO/A, P_2O_5=0, K_2O=30

Soil tests	pH	P	K	NO_3-N	O.M%
Sunflowers	7.8	13	260	86	3.1
Wheat	7.2	46	278	40	3.5+

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EFFECT OF SULFUR FERTILIZATION ON YIELD AND QUALITY OF ALFALFA AND CORN IN MINNESOTA

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The importance of S fertilizers for crop production on the sandy soils of Minnesota has been recognized for a number of years. To date most of the research has focused on the effect of S fertilizers on crop yield. Very little attention has been given to the effect of the use of S on the quality of the crops produced. Therefore, this study was designed to evaluate the effect of S additions to a fertilizer program on both yield and quality of corn and alfalfa on widely different soils in Minnesota.

Experimental Procedure:

Alfalfa studies--Studies with alfalfa were conducted at 2 locations (Staples, Winona County). Two sites were selected in Winona County. One site had no history of manure application in recent years. The second site had been manured heavily.

Gypsum was broadcast to the established stand at all sites in early April at rates to supply 0, 25, 50, 75, and 100 lb. S/acre. Adequate K_2O (supplied as 0-0-60) was also topdressed to all plots at this time.

The soil at the Staples site was classified as a Hubbard sandy loam. This site was irrigated as needed during the growing season. In Winona County, the soil was classified as a Fayette silt loam. Relevant soil properties for these experimental sites are listed in Table 1.

The first cutting was taken in late May at the Winona County site with subsequent cuttings at 30-35 day intervals. A total of 4 cuttings were taken from the manured site while excessive weed growth prevented a 4th cutting at the site which was not manured.

The first cutting at Staples was taken in early June with subsequent cuttings at 30-35 day intervals. A total of 3 cuttings were taken.

Whole plant samples were collected from each plot for each cutting. These samples were dried, ground and analyzed for S. In addition, forage quality was measured by using Near Infra Red (NIR) procedures.

Corn studies--Trials with corn were conducted at two locations (Staples, Goodhue County). The soil at the irrigated Staples site was classified as a Hubbard sandy loam. The soil at the Goodhue County site was classified as a Fayette silt loam. Appropriate soil properties for these two sites are summarized in Table 2.

For corn, 4 rates of N (0, 75, 150, 225 lb./acre) and 4 rates of S (0, 10, 20, 40 lb./acre) were combined in a complete factorial with 4 replications. Urea (46-0-0) was used as the N source while granular gypsum was used to supply the S. All plots received a broadcast application of 200 lb. 0-0-60/acre. At Staples, one half the N was applied before planting while the remainder was broadcast on the soil surface in early July. All fertilizer materials applied before planting were incorporated with a disk before planting.

Corn was planted in late April at Staples and early May at the Goodhue County location. Management practices appropriate for high yield production were used at both lcoations.

Samples of the leaves opposite and below the ear were collected from all plots at silking. These samples were dried, ground and analyzed for both N and S by standard laboratory procedures.

Total dry matter production (ear included) was measured at physiological maturity. Grain yields were recorded in October. Samples of chopped whole plant material taken at physiological maturity were collected from each plot. These samples will be analyzed for S by routine procedures and forage quality by NIR techniques.

Table 1. Selected soil properties (0-6 in.) for the alfalfa experimental sites. 1984.

Soil property	Site Description		
	Winona Co. manured	Winona Co. not-manured	Staples irrigated
pH	6.6	6.7	7.0
p (Bray + Kurtz #1) lb./acre	83	26	77
K (1N $NH_4C_2H_3O_2$) lb./acre	316	139	152
SO_4-S, ppm	8	7.5	5
organic, matter	low	low	medium
soil texture	silt loam	silt loam	sandy loam

Table 2. Selected soil properties (0-6 in.) for the corn experimental sites. 1984.

Soil Property	Location	
	Goodhue County	Staples
pH	6.6	7.1
P (Bray + Kurtz #1), lb./acre	56	91
K (1N $NH_4C_2H_3O_2$), lb./acre	231	178
SO_4-S, ppm	9	4
organic matter	1.6	medium
soil texture	silt loam	sandy loam

Results and Discussion: Alfalfa yields for the 3 sites are summarized in Table 3. The application of fertilizer S had no effect on yield at both Winona County sites. Although yields at both sites were lower than expected, there was no indication of any yield response due to the application of S.

The use of fertilizer S did increase yield of the 2nd and 3rd cuttings at the Staples location. The first cutting yields at this location were quite variable due to an unknown factor which caused the stunting of growth in some plots. This factor was not evident for the 2nd and 3rd cuttings. The application of 25 lb. S/acre was adequate to produce optimum yields in 1984. This observation is consistent with conclusions reached from other studies in the past.

At the time of this writing, plant samples collected from the Staples location had been analyzed for S while plant samples collected from the Winona County location had not been analyzed for S. As would be expected, the S concentration in the alfalfa tissue from Staples increased as rate of applied S increased. Except for the 3rd cutting, this increase was linear (Table 4). These results are consistent with conclusions reached from other studies in the past.

The effect of S fertilization on the quality of the forage produced was measured using NIR procedures. Results of this analysis are summarized in Tables 5, 6, 7, and 8. Rate of applied S had no significant effect on any of the forage quality parameters measured in 1984.

In 1984, corn grain yields at both locations were influenced by the application of both N and S (Table 9). Grain yield increased with rate of applied N at both locations with highest yields recorded from the use of 225 lb. N/acre. Grain yield was also significantly increased by the application of fertilizer S. At Goodhue County, the use of 10 lb. S/acre was adequate for maximum yield while 20 lb. S/acre was needed for maximum yield at the Staples site. It should be pointed out that this is the first reported response to S applied to a non-sandy soil in Minnesota.

Total dry matter yield measured at physiological maturity also increased as rate of N increased to 150 lb./acre. Additional N produced no additional dry matter (Table 10). In contrast to grain yield, application of fertilizer S had no significant effect on dry matter production measured at physiological maturity. Except for the problem of variability in this data, there is no ready explanation for this observation at this time.

There was no signfiicant NXS interaction for both grain and total dry matter yield at either location.

The results of the analysis of the ear leaf samples collected from the Staples location are summarized in Table 11. As would be expected the N concentration increased with rate of applied N while the use of S had no significant effect on the concentration of N in the ear leaf tissue.

The S concentration in the ear leaf tissue was increased by the application of both N and S. The concentration of S reached a maximum with the broadcast application of 20 lb. S|acre.

At the time of this writing, ear leaf samples collectedfrom the Goodhue County location had not been analyzed for N and S. In addition, there have been no measurements made of the quality of the samples collected at physiological maturity. The results of these analyses will be presented in future reports.

Table 3. Effect of rate of applied S on yield of alfalfa. 1984.

S Applied	Cutting 1	2	3	4	Total
lb./acre	---------- ton dry matter/acre ----------				
Winona Co. (manure):					
0	1.03	1.16	.90	.61	3.69
25	1.16	1.13	.97	.68	3.90
50	1.07	1.16	.85	.67	3.75
75	1.04	1.19	.92	.61	3.75
100	1.20	1.17	.84	.69	3.89
c.v.:%	7.2	11.5	14.9	11.1	6.4
Winona Co. (no manure):					
0	1.84	1.41	.90	---	4.15
25	1.90	1.28	.82	---	3.99
50	1.81	1.43	.85	---	4.08
75	1.96	1.32	.89	---	4.18
100	1.84	1.30	.88	---	4.02
c.v.:%	5.4	11.7	8.8		5.3
Staples:					
0	.92	1.36	.75	---	3.03
25	1.08	1.57	1.00	---	3.65
50	1.01	1.53	.94	---	3.48
75	1.04	1.52	1.01	---	3.57
100	1.06	1.47	.94	---	3.47
c.v.:%	8.3	13.5	8.8		8.2

Table 4. The effect of rate of applied S on the S concentration in alfalfa plants. Staples. 1984.

S Applied	Cutting 1	2	3
lb./acre	---------- % S ----------		
0	.227	.182	.193
25	.279	.268	.260
50	.310	.300	.287
75	.316	.308	.305
100	.328	.327	.297
cv: %	7.7	6.8	7.9
BLSD (.05)	.03	.03	.03

Table 5. Effect of rate of applied S on the percentage of crude protein in alfalfa tissue. 1984.

S Applied	Cutting 1	2	3	4
lb./acre	% protein			
Winona Co. (manure):				
0	24.9	22.0	25.8	26.9
25	25.7	21.6	25.5	26.8
50	25.2	22.9	25.7	26.3
75	25.7	21.9	26.2	26.8
100	25.8	21.6	26.0	26.9
cv: %	3.7	5.6	4.4	4.1
Winona Co. (no manure):				
0	24.4	21.4	26.3	----
25	24.2	21.6	25.9	----
50	24.0	21.1	26.4	----
75	24.1	21.6	25.7	----
100	24.2	22.1	25.6	----
cv: %	3.3	3.9	3.1	
Staples				
0	20.9	19.7	20.1	----
25	21.9	20.3	20.1	----
50	21.6	20.6	20.3	----
75	21.9	20.7	20.1	----
100	21.9	20.3	20.4	----
cv: %	2.4	5.6	2.9	----

Table 6. Effect of rate of applied S on the ADF (acid detergent extractable fiber) content of alfalfa tissue. 1984.

S Applied	Cutting 1	2	3	4
lb.|acre	---------- % protein ----------			
Winona Co. (manure):				
0	28.8	30.0	29.9	26.5
25	28.3	30.4	31.2	27.1
50	28.8	30.6	29.6	26.7
75	28.7	30.7	31.0	27.8
100	29.0	30.8	30.0	26.6
cv: %	2.9	2.6	4.3	2.4
Winona Co. (no manure):				
0	30.4	30.6	32.3	----
25	29.6	30.1	31.3	----
50	30.2	31.0	31.8	----
75	29.8	30.2	32.5	----
100	29.3	29.4	32.2	----
cv: %	3.0	3.8	2.8	
Staples:				
0	32.2	33.0	32.0	----
25	31.9	33.1	32.8	----
50	31.7	32.0	32.0	----
75	31.8	32.2	32.2	----
100	32.6	31.9	32.4	----
cv: %	2.6	3.0	2.1	

Table 7. Effect of rate of applied S on the NDF (neutral detergent extractable fiber) content of alfalfa tissue. 1984.

S Applied	Cutting 1	2	3	4
lb./acre	% NDF			
Winona Co. (manure):				
0	40.9	43.3	41.6	37.0
25	40.5	44.8	42.6	37.5
50	40.6	43.5	40.7	37.1
75	41.2	45.1	42.3	38.3
100	40.9	45.3	40.5	36.6
cv: %	4.7	4.1	3.9	3.5
Winona Co. (no manure):				
0	42.1	45.3	43.0	----
25	42.1	45.5	42.8	----
50	41.7	46.1	42.4	----
75	41.2	44.7	43.9	----
100	41.0	44.0	42.8	----
cv: %	3.6	3.2	2.9	
Staples:				
0	47.2	49.3	47.9	----
25	46.1	48.6	47.9	----
50	46.1	48.2	47.5	----
75	45.2	47.6	47.4	----
100	46.2	48.4	47.6	----
cv: %	3.1	2.9	1.9	

Table 8. Effect of rate of applied S on the TDN (total digestible nutrient) content of alfalfa tissue. 1984.

S Applied	Cutting 1	2	3	4
lb./acre	% TDN			
Winona Co. (manure):				
0	63.3	61.9	62.0	65.9
25	63.8	61.4	60.6	65.2
50	63.2	61.2	62.3	65.7
75	63.4	61.0	60.7	64.4
100	63.1	60.9	61.8	65.8
cv: %	1.5	1.4	2.5	1.2
Winona Co. (no manure):				
0	61.4	61.2	59.3	----
25	62.4	61.8	60.5	----
50	61.7	60.8	59.9	----
75	62.2	61.7	59.0	----
100	62.7	62.5	59.4	----
cv: %	1.6	2.1	1.7	
Staples:				
0	59.3	58.7	59.6	----
25	59.8	58.4	58.7	----
50	59.9	59.7	59.6	----
75	59.9	59.4	59.4	----
100	59.0	59.7	59.2	----
cv: %	1.6	2.0	1.3	

Table 9. The effect of rate of applied N and S on grain yield of corn. 1984.

S Applied		N Applied (lb./acre) 0	75	150	225	Ave.
Goodhue Co.:		bu./acre				
0		102.7	162.1	163.8	190.0	154.7
10		122.8	171.4	185.1	187.4	168.9
20		120.8	181.2	174.8	184.3	165.3
40		126.7	174.2	186.2	188.4	168.9
	Ave.	118.2	172.2	177.5	187.5	
	BLSD (.05) for N = 6.7			BLSD (.05) for S = 5.8		
Staples:		0	75	150	225	Ave.
0		63.3	128.0	145.3	152.8	122.4
10		78.6	143.0	152.7	155.1	132.4
20		92.0	145.5	154.8	158.7	137.8
40		81.5	129.1	149.1	154.6	128.6
	Ave.	78.9	136.4	150.5	155.2	
	BLSD (.05) for N = 9.9			BLSD (.05) for S = 12.9		

Table 10. The effect of rate of applied N and S on the total dry matter yield measured at physiological maturity. 1984.

S Applied		N Applied (lb./acre) 0	75	150	225	Ave.
Goodhue Co.		ton dry matter/acre				
0		4.9	7.3	7.6	7.2	6.8
10		4.8	7.0	7.5	7.3	6.7
20		5.8	6.6	7.2	6.4	6.5
40		5.7	6.9	7.6	7.7	7.0
	Ave.	5.3	7.0	7.5	7.2	
	BLSD (.05) for N = .5					
Staples:		0	75	150	225	Ave.
		ton dry matter/acre				
0		3.9	5.7	6.2	5.8	5.4
10		4.2	6.0	6.6	6.3	5.8
20		4.4	6.0	6.9	6.1	5.9
40		4.5	6.2	6.2	6.3	5.8
	Ave.	4.3	6.0	6.5	6.1	
	BLSD (.05) for N = .4					

Table 11. The effect of rate of applied N and S on the concentration of N and S in the ear leaf collected at silking from the Staples location. 1984.

S Applied	N Applied (lb./acre) 0	75	150	225	Ave.
	% N				
0	1.49	2.72	2.76	2.55	2.38
10	1.72	2.76	2.76	2.99	2.56
20	1.92	2.88	2.66	2.89	2.59
40	1.79	2.60	2.92	2.93	2.56
Ave.	1.73	2.74	2.77	2.84	

BLSD (.05) for N = .17

S Applied	N Applied (lb./acre) 0	75	150	225	Ave.
	% S				
0	.119	.187	.174	.162	.161
10	.147	.181	.199	.210	.184
20	.152	.203	.220	.216	.198
40	.147	.192	.218	.219	.194
Ave.	.141	.191	.203	.201	

BLSD (.05) for N = .014 BLSD (.05) for S = .014

PLACEMENT OF NITROGEN SOLUTIONS UNDER DIFFERING TILLAGE SYSTEMS

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The use of 28% N solution (UAN) for corn production has increased over the last several years in Minnesota. The popularity of this product stems at least partially because of its handling characteristics and its convenience as a carrier for herbicide applications. With the increasing emphasis on conservation tillage increased concerns are being expressed related to placement and/or management of UAN. These concerns are related to the potential volitalization losses or immobilization of N that may take place if applied to soils with high surface residues (conservation tillage). The objectives of these experiments were therefore to: (1) evaluate surface vs. injected applications of UAN under different tillage systems, and (2) with surface applications of UAN compare uniform broadcast applications to surface dribble applications under different tillage systems.

MATERIALS, METHODS, AND OBSERVATIONS

Experimental sites - In 1984 experiments were conducted at two locations. One location was in East Central (EC) Minnesota at the University of Minnesota Sand Plains Research Farm near Becker, Minnesota. The second location was in South Eastern (SE) Minnesota on a producers field in Goodhue County. The soils at the EC location are formed from glacial outwash and are deep, coarse textured, and contain medium to high levels of organic matter. The soils are classified as a Hubbard loamy sand (Udorthentic Haploboroll) and because of their coarse texture and low water holding capacity must be irrigated to attain high production levels. The soils at the SE location are loess derived silt loam soils classified as either Seaton (Typic Hapludalfs) or Mt. Carroll (Mollic Hapludalfs).

Experimental treatments - The treatment combinations at each location were a complete factorial arrangement of either four (EC) or three (SE) tillage treatments at three nitrogen (75, 150 and 300 # N/A), with three method of UAN application (broadcast, injected, or surface dribble). The 44 treatments established at the EC location consisted of four tillage systems (no till, ridge till, chisel, and moldboard plow) with all three methods of UAN application, plus two control treatments (zero N) for each tillage system. The two control treatments were included to determine the effect of the injection procedure across tillage systems. The 33 treatments established at the SE location were set up in an identical manner except that only three tillage systems were investigated. No moldboard plow treatment was included because this is no longer a recommended tillage practice in this area. All treatments were replicated four times utilizing a split-split plot design. The main plots were tillage with the first sub-plots being nitrogen rate and the second sub-plot being method of application. The smallest experimental sub-units were 14.7 ft. (4 rows) wide 50 ft. long.

Cultural practices - A summary of the management practices utilized at each location are summarized in Table 1.

Table 1. Management practices utilized at the Becker (EC) and Goodhue (SE) experimental locations.

Management Practice	EC (Becker)	Date	SE (Goodhue)	Date
Tillage	Moldboad plow & plowpacker	4/25		
	Chisel	4/26		5/28
	Ridge Till	6/24		6/29
	Culitivation	----		----
Planting Date[1]	No Till	5/2		
	Other Tillage	5/3		5/9
Corn Variety	Pionner 3906		Pionner 3906	
Seeding Rates	29,580 seeds/A		28,000 seeds/A	
Row spacing	30 inches		38 inches	
Fertilizer treatments application		5/9		5/11 & 14
Starter Fertilizer	150#/A 8-10-30		14gal/A 7-21-7	
Other Fertilizer	300#/A 0-0-22	4/3		
Insecticide	Lorsban 15g 7#/A	5/2 & 3	Counter 15g 6#/A	
	Lorsban 4e 7#/A	7/11		
	Lorsban 4e 7#/A	8/20		
Herbicide[2]	Atrazine 2#/A	5/11	Lasso 2.5#/A	5/9
	Dual AE 1.5 pint/A	5/11	Bladex 1.5#/A	5/9
	Round Up 1 qt./A	5/11	Atrazine 2#/A + oil	6/11
	Atrazine 2#/A + oil	5/29	Banvel 1/8 #/A	6/13
Irrigation	5.85 inches	July		
	5.65 inches	August		

1 At the EC location the ridge till treatments were planted with a Buffalo till planter (disc trash cleaners) and a white (12 inch fluted coulter). At the SE location a Hiniker planter was used for all treatments (trash discs were raised for no till and chisel treatments).

2 Excellent weed control was obtained at each location but giant foxtail was a problem on the no till plots at each location.

Surface residue cover - Tillage practices can have a considerable impact on the amount of crop residue remaining on the soil surface. The amount of residue on the surface may likewise influence many other parameters and processes including soil temperature, soil moisture, mineralization rate, nitrification rate, potential for surface volitalization of urea as well as leaching and/or denitrification processes. Surface residue cover observed in 1984 were as follows:

		1984 cover *	
Location	Tillage	In Row	Between Rows
Becker (EC) (6/27)	Moldboard	3.5 (4.6)	2.5 (3.5)
	Chisel	25.0 (13.7)	41.3 (17.4)
	Ridge till	16.7 (12.4)	32.0 (14.5)
	No till	64.0 (17.9)	73.0 (14.6)
Goodhue Co. (SE) (6/19)	Chisel	16.8 (11.0)	23.8 (11.1)
	Ridge till	10.0 (7.9)	31.8 (14.3)
	No till	77.8 (17.2)	65.5 (15.3)

* In the row = an 8 inch area centered over the row and between is the remainder. The number in parentheses is the standard deviation.

With moldboard tillage there was very little residue remaining on the soil surfaces. The chisel plow treatment left 15-40% surface cover with the EC (Becker) location having slightly more residue cover. The ridge till systems were generally comparable in residue cover to the chisel plow treatments although the ridge till treatments tended to accumulate a larger proportion of the residue between the rows. As would be expected the no till areas had the highest residue cover ranging from 65-75% of the soil surface.

Grain yields and N utilization - Leaf samples from opposite and below the ear at mid-silking were collected on July 24 at the EC location and on July 27 at the SE location. All leaf samples were dried, ground, and analyzed for Kjeldahl N. Total dry matter production was determined on Sept. 19 and 20 at the EC location and on Sept. 26, 27, and 28th at the SE location. At each location ears were separated from 40 ft. of row, field weights obtained, and subsamples collected for moisture analysis and N determination. Grain yields were adjusted to 15.5% moisture. Stover yields were obtained by removing the above ground plant material in the same 40 ft. row. Subsamples were also collected for moisture determination and N analysis.

RESULTS AND DISCUSSION - EC LOCATION - BECKER, MN

A summary of the crop yield components including grain, stover, and total N are included in Table 2. Parameters used to evaluate N utilization characteristics including concentrations and total N removal are included in Table 3. Treatment varaibles were evaluated utilizing analysis of variance. Treatment means are reported for individual treatments and statistically analyzed as factorial combinations in a split-split block design. Where appropriate a BLSD (.05) was computed to compare treatment means.

This location has a coarse textured soil with a low water holding capacity. With irrigation and proper N management these soils can be highly productive. The results obtained in 1984 at this location were excellent with treatment yields ranging from 41 bu/a to over 180 bu/a. The growing season, although excellent, was marked with a major rainfall event in mid June and a total monthly rainfall of over nine inches. It can be assumed that this precipitation resulted in substantial nitrate-N loss through leaching and probably had a profound effect on the yields obtained from the various treatments.

Nitrogen and management of UAN accounted for grain yield increases up to 140 bu/a (Table 3). Management of (placement) UAN across the different tillage systems was especially important in 1984 at this location. This can be demonstrated by examining the number of interactions that were obtained with UAN management across tillage systems (Tables 2 and 3, continued). A general view of the main effects would suggest that the highest yields were obtained when 300 #N/a was injected utilizing a moldboard plow system. All main effects (tillage, N rate, and placement) were important, but because of the significant interactions, placements and N rate did not react in a similar manner with all tillage systems and therefore require careful examination.

Grain yields were influenced by all main effects (tillage, N rate, placement) and each interacted with each other. The significant tillage by N rate interaction indicated that at the low N rate all tillage systems produced similar yields but at the higher N rates differences due to tillage were more apparent. In general no till was inferior to any of the other tillage systems at the higher N rates. The significant tillage by application method interaction indicated that the injection of UAN was superior to the other surface methods of application with all tillage systems except moldboard plow where methods of application were similar (one exception). This would suggest that if appreciable surface residue is present, injection of UAN would provide the best yield results.

Moisture content of the grain at harvest was influenced by all three main effects with no interaction. Grain produced from the no-till treatments had the highest moisture content followed by chisel and then ridge till and moldboard plow which were similar. The N rate and method of application that tended to have the highest yield (300 #N/a and injected) also tended to have a higher moisture content at harvest.

Stover and total yields tended to follow the same trend as that found with grain yield. The N rate by method of application interaction again supports the fact that injected applications gave the best results, but as the N rate increased (300 #N/a) results from the dribble application provided comparable results.

In general most of the results pertained to N concentrations, and N uptake followed the same trends as those that were observed with the various yield parameters.

GENERAL CONCLUSIONS (EC LOCATION)

The results from this location were excellent in 1984 and point out the importance of UAN placement with different tillage systems. In general, the injected placements were superior to either of the other surface applications when surface residue was present. The data collected this year also points out the complexity associated with N management and tillage on these types of soils. In many situations our concern with surface placement of UAN or other urea containing compounds would be associated with potential surface volitalization from the residue or immobiliation of N by the residue. The results from this experiment would suggest that other processes such as nitrification, leaching and/or denitrification should also be considered as factors that may interact with placement especially on soils which may be prone to leaching and/or denitrification problems.

RESULTS AND DISCUSSION - SE LOCATION - GOODHUE CO.

A summary of the crop yield components, and nitrogen utilization characteristics similar to the previous experiments are presented in Tables 4 and 5. The experimental design and treatments were identical in both experiments except only three tillage treatments were evaluated at this location.

Unlike the EC location, this experimental location consists primarily of a silt loam soil and yield reductions associated with N loss (leaching) were not evident at this location. This may partially explain why many of the treatment interaction obtained at the EC location were not observed at this location.

The yields obtained at this location in 1984 were well above average. Grain yields were increased up to the 150 #N/a application but not to the highest N rate. The chisel and ridge till treatments provided comparable grain yields while the grain yields associated with no till were significantly lower. Averaged over N rates and tillage treatments method of UAN application had no influence on grain yield. The relatively high P-value for the N rate by method of application interaction for grain yield, stover yield, and total dry matter yield would suggest that broadcast and dribble applications of UAN were inferior to injected application at the low N rates, but as N rates increased differences between methods of application were not observed. Reduced N availability or N loss may have occurred at all rates, but at the yield levels obtained the higher N rates masked the net effect and was therefore not reflected in the growth measurement.

Most of the N utilization data at this location tends to follow trends similar to the yield information. In general, however, N concentrations and N uptake tended to increase up through the highest rate of N application (300 #N/a). Likewise, even though no till was the lowest yielding, N concentrations in the plant tissue were normally highest with no till. Tillage did not influence total N removal, but total N found in the grain was lowest with no till and highest with chisel. This might suggest that the timing of N uptake by the crop may be effected by tillage. This may have

some influence on management in certain situations. The significant tillage by method interaction with leaf N suggested that injected application of UAN were superior on the no till and ridge till treatments while dribble was inferior to injected and broadcast treatments with the chisel tillage system.

GENERAL CONCLUSIONS

The results at this location in 1984 follow in a more traditional manner of what might be expected with UAN placement with different tillage systems. The injected applications, as would be expected, were generally better than the other methods. It is expected that the major reasons for reduced yields at this location with surface applications are related to surface volitalization and/or immobilization of N by the surface residue. By contrast the magnitude of yield reductions associated with placement at this location as compared to the EC location were much lower. This in turn brings out the complexity of N management and tillage systems on different soils. Although the final recommendation may be the same, the magnitude of the importance may be considerably different. Site specific recommendations based upon the major and dominant process in soils that may influence nitrogen management must be considered.

Table 2. Influence of nitrogen rates, tillage systems, and methods of 28% N application on grain yields and dry matter production on irrigated corn. Becker, MN - 1984.

Treatments			Grain		Dry Matter Production		
N-Rate	Tillage System	Method Applied	Yields	DM	Grain	Stover	Total
#/A			Bu/A	%	---------T/A----------		
Control	No Till	---------	45.5	62.9	1.07	0.98	2.06
Control-Knife	No Till	---------	44.5	60.7	1.05	1.04	2.09
Control	Ridge Till	---------	50.9	65.1	1.20	0.91	2.11
Control-Knife	Ridge Till	---------	52.4	65.2	1.24	0.94	2.18
Control	Chisel	---------	55.2	65.8	1.30	1.05	2.35
Control-Knife	Chisel	---------	59.5	68.0	1.40	1.16	2.57
Control	Moldboard	---------	47.9	63.1	1.13	0.92	2.06
Control-Knife	Moldboard	---------	55.9	63.2	1.32	1.11	2.44
75	No Till	Broadcast	41.0	61.8	0.97	1.05	2.02
75	No Till	Injected	76.1	60.2	1.80	1.86	3.66
75	No Till	Dribble	49.9	61.9	1.18	1.28	2.46
75	Ridge Till	Broadcast	57.7	68.9	1.36	1.07	2.43
75	Ridge Till	Injected	80.6	66.4	1.90	1.68	3.59
75	Ridge Till	Dribble	64.6	69.2	1.53	1.15	2.68
75	Chisel	Broadcast	65.6	66.3	1.55	1.77	3.32
75	Chisel	Injected	83.3	67.3	1.97	2.11	4.08
75	chisel	Dribble	76.0	67.3	1.79	1.81	3.61
75	Moldboard	Broadcast	65.9	67.3	1.56	1.47	3.03
75	Moldboard	Injected	61.8	65.2	1.46	1.44	2.90
75	Moldboard	Dribble	69.4	66.8	1.64	1.51	3.15
150	No Till	Broadcast	42.7	59.3	1.01	1.24	2.25
150	No Till	Injected	109.5	60.5	2.59	2.27	4.86
150	No Till	Dribble	50.7	61.1	1.20	1.35	2.55
150	Ridge Till	Broadcast	74.6	67.6	1.76	1.64	3.40
150	Ridge Till	Injected	128.5	66.3	3.04	2.28	5.32
150	Ridge Till	Dribble	83.0	67.7	1.96	1.81	3.78
150	Chisel	Broadcast	90.9	65.3	2.15	2.26	4.42
150	Chisel	Injected	142.6	64.4	3.37	2.78	6.16
150	Chisel	Dribble	101.3	67.0	2.39	2.31	4.71
150	Moldboard	Broadcast	137.2	68.1	3.24	2.72	5.97
150	Moldboard	Injected	135.7	67.0	3.21	2.61	5.82
150	Moldboard	Dribble	105.8	68.2	2.50	2.27	4.78
300	No Till	Broadcast	53.0	59.4	1.25	1.81	3.06
300	No Till	Injected	154.9	59.3	3.66	2.80	6.46
300	No Till	Dribble	137.9	60.5	3.26	2.64	5.91
300	Ridge Till	Broadcast	125.5	65.7	2.96	2.48	5.45
300	Ridge Till	Injected	176.8	64.9	4.18	2.90	7.09
300	Ridge Till	Dribble	165.4	66.0	3.91	2.96	6.88
300	Chisel	Broadcast	134.8	64.3	3.19	2.69	5.88
300	Chisel	Injected	181.8	63.7	4.30	3.44	7.74
300	Chisel	Dribble	160.2	64.4	3.79	3.28	7.07
300	Moldboard	Broadcast	155.2	66.4	3.67	2.82	6.50
300	Moldboard	Injected	170.6	65.1	4.03	3.02	7.06
300	Moldboard	Dribble	173.3	60.7	4.10	3.08	7.18

Table 2. Continued

Treatments Tillage System	Grain Yield	Grain DM	Dry Matter Production Grain	Stover	Total
	Bu/A	%	--------T/A----------		
Factorial Arrangement (Excludes Controls)					
Tillage					
No Till	79.5	60.5	1.88	1.81	3.69
Ridge Till	106.3	67.0	2.51	2.00	4.51
Chisel	115.2	65.1	2.72	2.49	5.22
Moldboard	119.4	66.9	2.82	2.33	5.15
P-Value (%)	99	99	99	99	99
BLSD (.05)		1.6			
N-Rate					
75	66.0	65.7	1.56	1.52	3.08
150	100.2	65.2	2.37	2.13	4.50
300	149.1	64.0	3.52	2.83	6.36
P-Value (%)	99	99	99	99	99
BLSD (.05)		0.9			
Method Applied					
Broadcast	87.0	65.0	2.05	1.92	3.98
Injected	125.2	64.2	2.96	2.43	5.39
Dribble	103.1	65.6	2.44	2.12	4.56
P-Value (%)	99	99	99	99	99
BLSD (.05)		0.8			
Tillage X N-Rate	99	76	99	85	98
Tillage X Method	99	18	99	99	99
N-Rate X Method	99	7	99	99	99
Tillage X N-Rate X Method	94	10	99	17	57

Table 3. Continued

Treatments Tillage System	N-Concentration Leaf	Stover	Grain	N-Removal Grain	Stover	Total
	----------%----------			----------#/A---------		
Factorial Arrangement (Excludes Controls)						
Tillage						
No Till	1.77	0.47	1.20	48.0	18.2	66.3
Ridge Till	1.91	0.48	1.26	65.6	20.3	85.9
Chisel	1.98	0.44	1.22	68.7	22.7	91.4
Moldboard	1.97	0.46	1.29	75.1	22.3	97.5
P-Value (%)	99	98	99	99	99	99
BLSD (.05)			0.04			
N-Rate						
75	1.36	0.42	1.16	36.2	12.9	49.2
150	1.79	0.44	1.20	58.0	19.2	77.2
300	2.58	0.53	1.37	98.9	30.5	129.4
P-Value (%)	99	99	99	99	99	99
BLSD (.05)						
Method						
Broadcast	1.61	0.43	1.17	49.1	16.7	65.8
Injected	2.31	0.51	1.29	79.7	25.7	105.5
Dribble	1.80	0.46	1.26	64.3	20.2	84.5
P-Value (%)	99	99	99	99	99	99
BLSD (.05)						
Tillage X Rate	99	49	26	97	80	93
Tillage X Method	99	99	43	99	99	99
N-Rate X Method	99	99	99	99	99	99
Tillage X N-Rate X Method	99	99	70	62	66	58

Table 3. Influence of nitrogen rates, tillage systems and methods of 28% N application, on leaf N, grain N and nitrogen removal by irrigated corn. Becker, MN - 1984

Treatments			N-Concentration			N-Removal		
N-Rate	Tillage System	Method Applied	Leaf	Stover	Grain	Grain	Stover	Total
#/A			----------%----------			---------#/A----------		
Control	No Till	---------	1.38	0.47	1.03	21.9	9.2	31.2
Control-Knife	No Till	---------	1.26	0.44	1.14	23.0	9.2	32.3
Control	Ridge Till	---------	1.35	0.40	1.19	28.7	7.5	36.3
Control-Knife	Ridge Till	---------	1.32	0.43	1.14	28.4	7.9	36.4
Control	Chisel	---------	1.22	0.45	1.19	31.3	9.5	40.9
Control-Knife	Chisel	---------	1.15	0.44	1.12	30.7	10.2	41.0
Control	Moldboard	---------	1.22	0.45	1.11	25.4	8.4	33.8
Control-Knife	Moldboard	---------	1.18	0.42	1.12	29.5	9.1	38.7
75	No Till	Broadcast	1.23	0.42	1.10	21.8	9.1	31.0
75	No Till	Injected	1.78	0.46	1.05	38.2	17.1	55.3
75	No Till	Dribble	1.30	0.39	1.14	26.8	10.0	36.9
75	Ridge Till	Broadcast	1.24	0.36	1.23	33.7	7.8	41.5
75	Ridge Till	Injected	1.65	0.46	1.10	42.3	15.7	58.1
75	Ridge Till	Dribble	1.17	0.46	1.27	39.0	10.9	49.9
75	Chisel	Broadcast	1.29	0.41	1.07	32.9	14.4	47.3
75	Chisel	Injected	1.54	0.40	1.17	46.1	16.9	63.1
75	Chisel	Dribble	1.25	0.42	1.15	41.2	15.6	56.8
75	Moldboard	Broadcast	1.18	0.41	1.23	38.3	12.7	50.4
75	Moldboard	Injected	1.43	0.44	1.16	34.0	13.0	47.0
75	Moldboard	Dribble	1.26	0.39	1.23	40.6	12.0	52.6
150	No Till	Broadcast	1.18	0.44	1.13	23.1	10.9	34.1
150	No Till	Injected	2.35	0.47	1.22	63.6	21.6	85.2
150	No Till	Dribble	1.31	0.44	1.07	25.9	12.0	38.0
150	Ridge Till	Broadcast	1.34	0.48	1.15	40.6	15.7	56.3
150	Ridge Till	Injected	2.51	0.48	1.25	76.5	21.8	98.4
150	Ridge Till	Dribble	1.52	0.39	1.26	49.7	14.2	64.0
150	Chisel	Broadcast	1.47	0.38	1.11	48.2	17.1	65.3
150	Chisel	Injected	2.43	0.48	1.36	92.3	26.8	119.2
150	Chisel	Dribble	1.69	0.42	1.11	53.5	19.6	73.1
150	Moldboard	Broadcast	2.04	0.47	1.19	77.6	26.0	103.6
150	Moldboard	Injected	2.26	0.47	1.28	83.7	24.9	108.6
150	Moldboard	Dribble	1.36	0.43	1.22	60.8	19.8	80.7
300	No Till	Broadcast	1.46	0.45	1.18	29.3	16.8	46.2
300	No Till	Injected	3.00	0.72	1.55	114.0	40.5	154.6
300	No Till	Dribble	2.36	0.49	1.35	89.1	25.8	115.0
300	Ridge Till	Broadcast	1.96	0.38	1.19	71.0	19.2	90.2
300	Ridge Till	Injected	2.91	0.68	1.49	125.7	40.3	166.0
300	Ridge Till	Dribble	2.90	0.62	1.42	111.8	37.0	148.8
300	Chisel	Broadcast	2.42	0.44	1.25	80.4	23.8	104.3
300	Chisel	Injected	2.93	0.53	1.36	116.8	37.0	153.8
300	Chisel	Dribble	2.81	0.50	1.41	107.3	32.8	140.1
300	Moldboard	Broadcast	2.49	0.47	1.24	92.2	27.1	119.4
300	Moldboard	Injected	2.99	0.54	1.52	123.1	32.9	156.1
300	Moldboard	Dribble	2.69	0.52	1.53	125.8	32.7	158.5

Table 4. Influence of nitrogen rates, tillage sytems and methods of 28% N application on grain yield and dry matter production on corn. Goodhue Co. MN - 1984

Treatments			Grain		Dry Matter Production		
N-Rate	Tillage System	Method Applied	Yields	DM	Grain	Stover	Total
#/A			Bu/A	%	----------T/A----------		
Control	No Till	--------	82.8	60.8	1.96	1.85	3.81
Control-Knife	No Till	---------	84.7	61.0	2.00	1.87	3.88
Control	Ridge Till	---------	70.8	65.0	1.67	1.59	3.26
Control-Knife	Ridge Till	---------	73.4	63.9	1.73	1.63	3.37
Control	Chisel	---------	91.3	66.1	2.16	1.61	3.77
Control-Knife	Chisel	---------	93.2	64.0	2.20	1.86	4.07
75	No Till	Broadcast	127.8	63.1	3.02	2.34	5.37
75	No Till	Injected	145.7	63.8	3.44	2.68	6.13
75	No Till	Dribble	140.9	63.2	3.33	2.65	5.98
75	Ridge Till	Broadcast	143.6	64.6	3.39	2.46	5.86
75	Ridge Till	Injected	152.4	63.6	3.60	2.78	6.39
75	Ridge Till	Dribble	145.9	65.1	3.45	2.65	6.11
75	Chisel	Broadcast	144.1	66.0	3.41	2.70	6.11
75	Chisel	Injected	148.9	65.9	3.52	2.80	6.33
75	Chisel	Dribble	140.8	65.8	3.33	2.69	6.02
150	No Till	Broadcast	148.2	63.1	3.50	2.93	6.43
150	No Till	Injected	154.4	62.9	3.65	3.03	6.68
150	No Till	Dribble	159.1	63.4	3.76	2.98	6.74
150	Ridge Till	Broadcast	154.6	64.8	3.65	2.63	6.29
150	Ridge Till	Injected	168.0	64.6	3.97	3.16	7.13
150	Ridge Till	Dribble	165.3	64.4	3.91	2.87	6.78
150	Chisel	Broadcast	164.0	64.8	3.88	2.96	6.84
150	Chisel	Injected	158.8	63.8	3.75	3.02	6.78
150	Chisel	Dribble	167.0	66.4	3.95	3.19	7.14
300	No Till	Broadcast	161.1	62.6	3.81	3.08	6.89
300	No Till	Injected	158.2	62.8	3.74	3.08	6.82
300	No Till	Dribble	151.1	62.9	3.57	3.08	6.66
300	Ridge Till	Broadcast	167.1	64.1	3.95	2.97	6.92
300	Ridge Till	Injected	158.8	64.1	3.75	2.97	6.73
300	Ridge Till	Dribble	169.0	66.7	3.99	2.88	6.88
300	Chisel	Broadcast	161.3	64.7	3.81	3.23	7.05
300	Chisel	Injected	165.7	64.6	3.92	2.98	6.90
300	Chisel	Dribble	165.1	65.9	3.90	2.89	6.80

Table 4. Continued

Treatments Tillage System	Grain Yields	Grain DM	Dry Matter Production Grain	Stover	Total
	Bu/A	%	----------T/A----------		
Factorial Arrangement (Excludes controls)					
Tillage					
No Till	149.7	63.1	3.54	2.87	6.41
Ridge Till	158.3	64.7	3.74	2.82	6.57
Chisel	157.3	65.3	3.72	2.94	6.66
P-Value (%)	99	98	99	56	89
BLSD (.05)	2.7	1.5	0.06		
N-Rate					
75	143.3	64.6	3.39	2.64	6.03
150	159.9	64.2	3.78	2.97	6.76
300	161.9	64.3	3.83	3.02	6.85
P-Value (%)	99	31	99	99	99
BLSD (.05)	6.6		0.16		0.23
Method					
Broadcast	152.4	64.2	3.60	2.81	6.42
Injected	156.8	64.0	3.71	2.94	6.65
Dribble	156.0	64.9	3.69	2.88	6.57
P-Value (%)	84	99	84	95	94
BLSD (.05)		0.6			
Tillage X N-Rate	1	39	1	58	10
Tillage X Method	11	58	11	80	46
N-Rate X Method	85	56	85	96	94
Tillage X N-Rate X Method	71	73	71	32	37

Table 5. continued

Treatments Tillage System	N-Concentration Leaf	Stover	Grain	N Removal Grain	Stover	Total
	----------%----------			----------#/A---------		
Factorial Arrangement (Excludes controls)						
Tillage						
No Till	2.96	0.72	1.39	99.1	42.1	141.2
Ridge Till	2.87	0.68	1.34	101.0	39.1	140.2
Chisel	2.78	0.65	1.39	104.2	38.8	143.1
P-Value (%)	96	62	96	98	39	22
BLSD (.05)			0.04	3.2		
N-Rate						
75	2.69	0.57	1.27	86.5	30.6	117.1
150	2.90	0.71	1.40	106.3	42.3	148.7
300	3.02	0.77	1.45	111.5	47.1	158.7
P-Value (%)	99	99	99	99	99	99
BLSD (.05)			0.04	5.5	4.1	8.3
Method						
Broadcast	2.87	0.69	1.35	98.5	39.6	138.1
Injected	2.95	0.70	1.41	104.8	41.9	146.8
Dribble	2.79	0.66	1.36	101.0	38.5	139.5
P-Value (%)	99	80	99	99	84	99
BLSD (.05)			0.04	3.8		6.3
Tillage X N-Rate	39	71	54	11	47	28
Tillage X Method	98	93	8	1	98	74
N-Rate X Method	99	78	82	87	83	71
Tillage X N-Rate X Method	15	98	40	65	84	60

Table 5. Influence of nitrogen rates, tillage systems and methods of 28% N application, on leaf N content, grain N content and nitrogen removal by corn. Goodhue Co. MN - 1984

Treatments			N-Concentration			N-Removal		
N-Rate	Tillage System	Method Applied	Leaf	Stover	Grain	Grain	Stover	Total
#/A			----------%----------			----------#/A----------		
Control	No Till	---------	1.91	0.52	1.12	43.9	19.3	63.2
Control-Knife	No Till	---------	1.93	0.44	1.11	44.8	16.6	61.4
Control	Ridge Till	---------	1.70	0.41	1.10	37.1	13.0	50.2
Control-Knife	Ridge Till	---------	1.79	0.40	1.06	36.8	13.3	50.2
Control	Chisel	---------	1.85	0.46	1.06	45.9	14.9	60.9
Control-Knife	Chisel	---------	1.90	0.47	1.05	46.3	17.6	64.0
75	No Till	Broadcast	2.67	0.69	1.24	75.5	33.4	109.0
75	No Till	Injected	2.93	0.67	1.29	89.3	36.2	125.5
75	No Till	Dribble	2.60	0.60	1.28	85.6	32.2	117.8
75	Ridge Till	Broadcast	2.53	0.61	1.15	78.0	30.8	108.8
75	Ridge Till	Injected	2.89	0.52	1.32	95.0	29.1	124.1
75	Ridge Till	Dribble	2.66	0.53	1.24	86.1	28.5	114.7
75	Chisel	Broadcast	2.69	0.54	1.26	86.6	30.2	116.9
75	Chisel	Injected	2.85	0.55	1.36	96.2	31.1	127.3
75	Chisel	Dribble	2.40	0.45	1.28	86.0	24.2	110.2
150	No Till	Broadcast	3.02	0.58	1.44	100.8	34.1	134.9
150	No Till	Injected	3.03	0.85	1.46	106.5	51.2	157.8
150	No Till	Dribble	3.01	0.82	1.40	105.1	48.5	153.7
150	Ridge Till	Broadcast	2.96	0.68	1.40	103.0	36.0	139.0
150	Ridge Till	Injected	2.98	0.77	1.37	109.5	48.7	158.3
150	Ridge Till	Dribble	2.84	0.56	1.27	99.7	32.6	132.4
150	Chisel	Broadcast	2.84	0.75	1.40	108.9	45.3	154.2
150	Chisel	Injected	2.83	0.67	1.46	109.8	40.7	150.6
150	Chisel	Dribble	2.61	0.68	1.43	113.6	43.8	157.4
300	No Till	Broadcast	3.10	0.79	1.46	111.8	49.0	160.8
300	No Till	Injected	3.17	0.76	1.51	113.1	47.3	160.4
300	No Till	Dribble	3.15	0.75	1.46	104.4	46.9	151.3
300	Ridge Till	Broadcast	2.98	0.77	1.42	112.2	46.0	158.3
300	Ridge Till	Injected	2.92	0.91	1.46	110.2	54.7	165.0
300	Ridge Till	Dribble	3.05	0.78	1.44	115.3	45.5	160.9
300	Chisel	Broadcast	3.08	0.80	1.43	109.5	51.9	161.4
300	Chisel	Injected	3.01	0.64	1.45	114.0	38.4	152.5
300	Chisel	Dribble	2.77	0.76	1.44	113.1	44.1	157.3

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The driftless soils area has the greatest county average estimated soil losses from cropland in Minnesota, ranging from 4.0 to 6.6 t/ac/yr in the six counties involved. Typical soils of the region such a Fayette-Dubuque, Seaton, and associated soils, are highly erodible, form dense crusts if unprotected from raindrop impact, and consequently, have low final infiltration rates and high runoff from the intense storm events common to the region. New and improved tillage practices are increasingly being relied upon to meet environmental goals under more intense cropping systems. These systems modify the soil and water losses as well as the kind and concentration of materials in the runoff. A more complete understanding of these tillage systems will allow a more accurate prediction of their effect on the environment; will permit the maximization of the crop production benefits of the tillage systems; 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 mulched plots of the same tillage treatment. On mulched subtreatments of the moldboard, chisel and paraplow treatments, 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 1984. In 1984 corn (Pioneer 3747) was planted (at 29,000 seeds/acre) on May 15. The conventional (moldboard) treatment was plowed about May 1 and secondary tillage with a disk was done on May 14 on the conventional and chisel treatments. The fall chisel and paraplow treatments were carried out in early November of 1983. All plots were planted with a 4-row John Deere 7000 Max-Emerge planter equipped with fluted coulters on one side and "trash whippers" on the other side which effectively removed residue from an 8 to 9 inch area over the row.

Nitrogen (240 lbs/A as anhydrous ammonia) with N serve was injected on October 31, 1983 prior to fall tillage. The starter fertilizer at planting was 180 lbs. of 6-24-24. The insecticide was Counter at 10 lb/A. Chemical weed control used per acre was 2 qts. Dual, 2 qts. Bladex and 1/4 pt. Banvel applied preemerge. One pound Atrazine and 1 quart crop oil per acre were applied post-emergence.

Percent cover was determined from slides made soon after planting. Planting depth, rate of emergence, plant height, silking date, and leaf number measurements were made on designated portions of each plot.

Ten plot frames (45-3/4 x 45-3/4 inches) were emplaced on May 16 and covered to protect the surfaces. Infiltration measurements were made on the paraplow normal, no-till bare and mulch, and conventional normal and mulch treatments on June 4-8. Random roughness measurements were made before and after each run. Residue amounts were measured for the mulch treatments.

Neutron probe measurements were made weekly on each plot starting June 9 through August 9. Bulk density of the surface layer was measured periodically. Hourly spring soil temperatures were measured on chisel, paraplow and no-till treatments in Rep. 3 for both mulch added and bare treatments (chisel normal) at depths of 1, 5, 10, 15, 50, 100 cm. Yields were determined by hand harvesting 60 foot samples (two 30-ft. subsamples) from each plot in mid October, 1984.

RESULTS-CORN YIELDS:

In 1984,corn yields were reduced on all treatments by water stress due to drought during pollination and grain filling stages; only 1.52 inches of precipitation occurred during the 45 day

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

period from July 17 to August 31, 1985, while air temperatures were 2.8°F above normal in August (table 2). Corn yields of individual tillage, residue, and in-row residue management treatments were not significantly different; however, corn yields between replicates were highly significantly different. As in 1983 average corn yields were related to average depth of rooting measured as depth to residual clay layer (table 3 and figure 1). In 1984 rep average corn yields increased 13 bu/ac as depth increased from 29 to 62 inches. In 1983 under more severe drought conditions rep average corn yields differed by 40 bu/acre. In 1981 and 1982 when water stress was minimal there was no relationship between depth to clay and average yield per rep. Thus the effect of rooting depth and available water holding capacity in the root zone on yield depends greatly on the climatic conditions in the individual year as well as on the crop grown. Under the water stress conditions in 1983 and 1984 at Lancaster, yield consistently decreased as rooting depth decreased (fig.1).

SEEDBED CONDITIONS

Significant differences in planting depth were measured (table 1) following emergence. In general, treatments planted with trash whip attachment (TW) had a greater planting depth than those planted with a fluted coulter (C). The trash whip attachment was adjusted for no-till and paraplow conditions and consequently ran excessively deep in the looser soil conditions of the moldboard and chisel plow treatments. Rainfall following planting moved soil into the trench created by the trash whip units in the moldboard plow treatment and resulted in the significantly deeper planting depth measured on the moldboard plow treatment.

In-row residue cover was reduced by the trash whip attachments (TW) compared to the in-row cover resulting from the coulter units (C) (table 1). The trash whip units were more effective in removing residue from the row on the no-till treatments than on the paraplow treatments indicating the importance of adjustment to the effective functioning of the unit. For each level of residue on the no-till and paraplow treatments, rate of emergence was more rapid following use of the trash whip than with the coulter except for the normal residue paraplow treatment where residue averaged only 24 percent (tables 1 and 4). This is to be expected since the trash whip units consistently decreased the level of residue in the row compared to the coulter treatments resulting in higher soil temperatures in the seedbed zone for the trash whip treatments.

The situation was reversed for the chisel and moldboard plow treatments (table 4) because the trash whip units created a shallow trench which decreased soil temperature and slowed the rate of emergence compared to the coulter treatments. This illustrates the necessity of proper adjustment of the trash whip units to the individual soil conditions created by the tillage treatment; such an adjustment between plots was not practical with the plot layout used in this study. As in-row residue levels increased with mulch level, the rate of emergence decreased and number of days to 75% emergence increased. The regression equation

$$\text{Days to 75\% emergence} = 10.3 + 0.0635\ (\text{\% in-row cover})$$

explained 75% of the variation in days to 75% emergence. When the corn yields from individual replicates of the paraplow and no-till treatments were analyzed as a 2 x 5 factorial design, the effect of coulter vs. trash whip is significant at the 5 percent level. Thus the use of trash whip attachments on the no-till and paraplow residue combinations significantly increased yields in 1984 compared to the coulter attachment.

Average population at harvest ranged between 23,400 to 27,200 plants/acre. The 14-tillage and residue treatments differed significantly with respect to population at harvest. With the exception of the paraplow mulch treatment, the tillage treatments with low residue and the tillage and residue treatments with trash whip had the highest populations. This indicates removal of residue from the row permitted the establishment of better seedbed conditions including presumably better seed soil contact. The equation

$$\text{population} = 26{,}622\ \text{PPA} - 33.3\ \text{PPA}\ (\text{\% in-row cover})$$

explained 66% of the variation in population at harvest.

The effect of in-row surface residue cover and tillage on soil temperature and on corn growth was evaluated at Lancaster in 1983 and 1984. Hourly soil temperatures were recorded for 1, 5, 10, 15, 50 and 100-cm depths under the row on the chisel normal and mulch, no-till bare and mulch, and the

paraplow normal and mulch treatments in 1984. Soil temperatures on both trash whip and coulter treatments were measured on paraplow and no-till mulch treatments. Soil temperatures were measured using 4-couples in parallel for 15 cm and shallower depths. Leaf stage observations were taken periodically. Cumulative 5-cm soil and air temperature growing degree days (GDD) from planting to 6-leaf stage (Hanway) were linearily related for each treatment. The number of soil temperature GDD per unit of air temperature GDD was a linear function of in-row surface residue cover. The cumulative air temperature GDD from planting to 6-leaf stage was also a linear function of cover. These results are in agreement with those from similar residue management-tillage studies at Waseca and Rosemount Experiment Stations done by Edward Schneider and the St. Paul, USDA-ARS, staff respectively. The combined results were summarized and presented in the paper "Tillage and Surface Residue Effect on Soil Temperature and Corn Growth" by J. B. Swan, E. C. Schneider, J. F. Moncrief and W. H. Paulson at the 1984 ASA-SSSA Annual Meetings in Las Vegas, Nevada.

Large differences in final (55) minute infiltration rates were measured between treatments (tables 5 and 6). When residue was present on tilled treatments (moldboard plow mulch and normal paraplow treatments) infiltration rates were consistently greater than where residue was absent (moldboard plow normal and no till bare). The final infiltration rates for no-till mulch were very low averaging only 0.5 inches per hour. This was due in part to the sealed soil surface and higher water content due to the mulch cover. The surface of the no-till treatment was disturbed by fall injection of anhydrous ammonia; however, by the planting date of May 15 the soil surface had resealed and final infiltration rates in 1984 were less than those measured on the conventional bare treatment, as was the case in 1982. In 1983, two passes with the anhydrous injector knives in late April, produced 9-10 inch deep slots about 18 inches apart. When protected by mulch these deep injection marks and their fracture planes were highly effective in increasing the infiltration rate. In contrast, in 1981, 1982 and 1984 the dense no-till surface was broken only in the narrow planter slot and the infiltration rate averaged about the same as or less than the bare conventional treatments' infiltration rate. Thus when the no-till surface is sealed, mulch cover is of little benefit in increasing the infiltration rate compared to conventional tillage, however, when the no-till surface has channels through which water can move readily, the heavy mulch cover is very effective in maintaining a high infiltration rate. These results illustrate the dual requirement of 1) a porous surface with high saturated hydraulic conductivity and, 2) a protective mulch cover, which are both necessary in order to have rapid sustained infiltration. Residue cover by itself is not sufficient to produce a high infiltration rate.

SUMMARY

Five and six year results with continuous corn at Lancaster show nearly equal average yields from conventional, chisel, and ridge plant treatment with no-till (slot plant) slightly lower in some years (table 7).

To evaluate tillage-residue management practices, a simple tillage-management model was developed which quantifies the effects of the major physical factors of planting date, final plant population, net growing degree days (GDD), and estimated water stress. GDD are included only when below a threshold value required to mature the crop. The net GDD are calculated as the cumulative air temperature GDD from planting to frost minus any residue management caused delay in growth up to the 6-leaf stage. Lancaster data from 1972 through 1983 was used to develop the model, which has an R^2 of 82 percent and a standard error of approximately 12 bu/acre. For the years of 1981-83 the model accounted for 89 percent of the variation with a standard error of 10 bu/ac. The major effect of tillage on yield was through the effect of tillage on seedbed conditions and water management. Seedbed conditions were affected by seed-soil contact and depth and accuracy of seed placement which affect final plant population as well as in-row residue cover which strongly affects the rate of phenological development of corn up to the 6-leaf stage. The between row surface residue cover and soil conditions strongly affect water infiltration and runoff from the soil surface.

Thus farmers in the driftless soil area can choose between a variety of tillage options which have yields comparable with conventional tillage, but which are superior in soil and water conservation and also offer savings in time, labor, and fuel compared to conventional moldboard plow tillage methods.

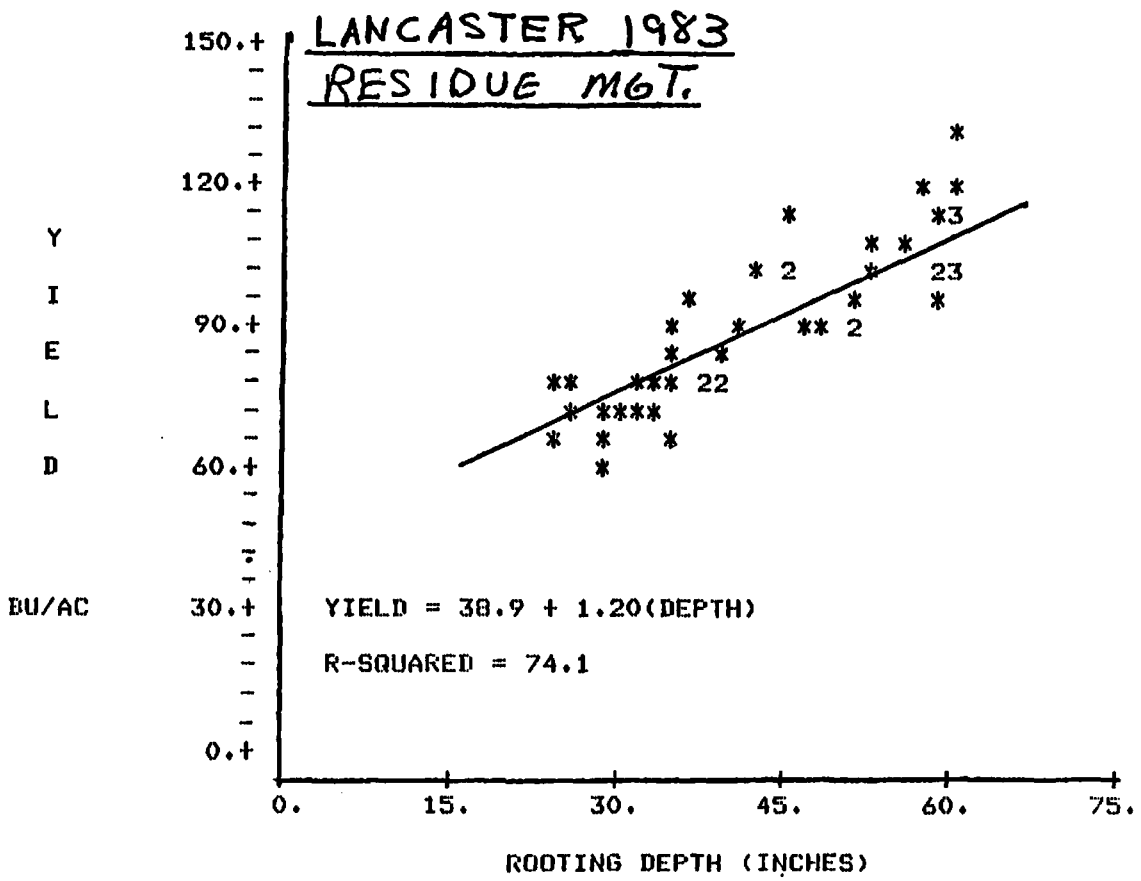

Fig 1. Relationship of 1983 corn yield to rooting depth (Depth to clay residuum).

Table 1. Effect of tillage and mulch treatments on percent cover, planting depth, corn emergence, silking date, population and yield.

Treatments			Percent Cover						
Tillage	Residue	In Row Residue Mgt.	Row	Entire Area	Avg Planting Depth mm	Days Post Plant To 75% Emergence	Date 50% Plants Silked July	Avg Population At Harvest Plants/Ac	Avg Yield Bu/Ac
Paraplow	Normal (N)	C	24		22 de	11	24.5	25,700 abcd	105.5
		TW	12		26 cde	12	24.5	26,700 ab	116.1
	Mulch (1X+N)	C	78		21 e	15.7	25	24,000 de	112.6
		TW	39		32 bc	13.3	25.3	24,600 cde	109.1
No Till	Bare (0)	C	6		26 cde	13	23.8	26,600 ab	116.5
		TW	2		27 cde	10	23.8	26,100 abc	121.7
	Normal (1X)	C	41		24 cde	12	23.8	25,200 bcde	107.7
		TW	11		30 bcd	11.5	23.8	26,500 ab	118.7
	Mulch (2X)	C	72		24 cde	14.8	25.5	24,600 cde	109.0
		TW	23		31 bcd	12.8	25.5	27,000 ab	118.3
Fall Chisel	Normal (N)	C	3		26 cde	9	23.3	27,200 a	114.5
	Mulch (1X+N)	C	67		29 cde	14	25.3	25,000 bcde	107.3
Conventional	Normal (0)	C	1		31 bcd	9	23.5	25,300 abcd	121.2
(Sp. Plow)	Mulch (1X)	C	66		31 bcd	14.5	25	23,400 e	116.4
Significance Level					0.01			0.01	0.10

Table 2. 1984 WEATHER SUMMARY, LANCASTER EXPERIMENT STATION

Month	Precipitation Inches Total	Precipitation Inches Departure	Growing Degree Days °f 1984	Growing Degree Days °f Departure	Temperature Avg May	Temperature Avg Min	Temperature Average	Temperature Departure
					°f			
April	3.98	0.78	--	--	56.6	35.9	46.2	-0.3
May	3.92	0.45	201	-95	64.1	43.0	53.6	-4.0
June	7.77	3.08	547	31	78.6	57.9	68.2	1.2
July	2.57*	-1.64	599	-58	81.3	57.7	69.5	-1.8
August	1.37*	-3.10	649	51	84.3	59.3	71.8	2.8
September	2.36	-1.04	355	-88	72.1	48.1	60.1	-0.8
October	7.31	4.91	--	--	61.9	42.1	52.0	1.4
	29.28	3.44	2351	-159				

First fall low temperatures: Sept 26 (29°F); Oct 23 (27°F)

* 1.52 inches of precipitation between July 17 and Aug 31.

Table 3. Average yields by repilcate and precipitation for 1981 - 1984 and depth to residual clay layer, Lancaster, Wisconsin

Year	Number 1	Number 2	Number 3	Number 4	Monthly Precipitation May	June	July	August
	Bu/Ac				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**
Avg depth to clay residuum in inches	29	41	46	62				

*1983 - 1.13 inches precipitation from July 3 to Aug 25 (53 days).

**1984 - 1.52 inches precipitation from July 17 to Aug 31 (45 days).

1981- Subplots with population < 17,000 omitted.
1983- Subplots with population < 18,000 omitted Rep II, III, IV.
1982- Missing values estimated for 8 plots out of a total of 48 plots.

Table 4. Influence of tillage method and in row residue management on rate of emergence.

Treatment			DAYS POST PLANT				
		In Row Residue	-----Percent of final emergence-----				
Tillage	Residue	Mgt	7	10	13	16	22
Paraplow	Normal (N)	C	2	71	83	92	100
		TW	0	58	82	95	100
	Mulch (1X+N)	C	0	11	51	78	100
		TW	0	27	73	98	100
No Till	Bare (0)	C	5	66	76	90	100
		TW	2	77	94	100	100
	Normal (1X)	C	1	61	84	95	100
		TW	0	61	89	98	100
	Mulch (2X)	C	0	22	60	87	100
		TW	0	28	79	94	100
Chisel	Normal (N)	C	21	86	90	97	100
		TW	1	53	82	98	100
	Mulch (1X+N)	C	0	51	72	84	100
		TW	0	32	63	95	100
Conventional Moldboard	Normal (0)	C	28	90	94	99	100
		TW	0	39	82	98	100
	Mulch (1X)	C	0	39	61	89	100
		TW	0	21	50	81	100

Table 5. 1984 Lancaster Infiltration rate measurments.

Tillage	Residue		Application Rate In 1 Hour	Water Applied Before Runoff Inches	Infiltration rate X minutes after runoff commences - In/Hour 2.5	7.5	12.5	17.5	25	35	45	55
No Till	Bare	E	4.72	0.39	4.36	3.16	2.56	2.08	1.96	1.84	1.72	1.72
		W	4.40	0.29	3.68	2.96	2.00	2.00	1.88	1.46	1.34	1.64
	Mulch	E	4.64	0.70	3.92	2.84	1.16	1.04	0.80	0.32	0.56	0.56
		W	5.20	0.69	4.00	1.12	0.88	0.88	0.88	0.76	0.76	0.64
Conventional	Normal	E	4.96	1.65	4.00	3.16	2.08	2.44	2.05	1.60	1.24	1.36
(Moldboard Plow)		W	5.28	2.11	4.20	3.48	2.88	2.64	2.28	1.92	1.92	2.04
	Mulch	E	5.28	10.56*								
		W	4.64	2.86	3.92	3.20	3.08	2.96	2.90	2.78	2.84	2.90
Paraplow	Normal	E	4.72	0.39	4.08	4.08	4.08	4.08	3.96	3.90	3.84	4.32
		W	4.64	0.31	4.04	3.80	3.56	3.20	2.84	3.14	2.72	3.02

*No runoff due to presence of large vertical drainage channel below plow layer.

Table 6. Infiltration rate* 55 minutes after runoff begins.

Treatment		1981	1982	1983	1984	Avg.
Tillage	Residue	Inches/Hour				
No Till	Mulch	1.46	1.10	3.53*	0.60	
	(No Till Mulch) / (Conv. Bare)	(1.51)	(0.72)	(6.53)	(0.35)	
Conventional	Bare	0.97	1.52	0.54	1.70	1.18
	Mulch	2.72	2.34	1.49	2.90	2.36
	(Bare/Mulch)	(0.36)	(0.65)	(0.36)	(0.58)	(0.50)

*Soil disturbed prior to planting by anhydrous ammonia injection in spring prior to planting.

Table 7. Continuous corn tillage yield results at Lancaster, Wisconsin 1979-1983.

Tillage	1979	1980	1981	1982	1983	1984	Average 1979-83	Average 1979-84
	Bu/Ac							
Ridge plant*	162	157	157	147	100	-	145	-
Slot plant	163	146	151	141	85	108	137	132
Chisel	160	150	167	154	95	115	145	140
Conventional	169	159	168	151	89	121	147	143
Paraplow	-	-	-	-	-	106	-	-

*Planted flat in 1979 and 1981 - corn not cultivated to form ridges in 1980 and 1983.

The Effect of Tillage and Potassium Placement on the Availability of Potassium to Corn

P. Burford, J. Moncrief, J. Swan, and B. Schreiber

Cooperator: Dale Flueger

With the trend towards increased use of conservation tillage taking place, present recommendations for fertilizer application need to be looked at critically. Farmers interested in adopting conservation tillage are looking for ways to conserve soil and reduce input costs without experiencing yield reductions. Potassium is a relatively immobile nutrient and remains concentrated near the soil surface if not incorporated. With conservation tillage this could lead to positional availability problems if the roots become inactive in this region.

The objectives of this study are:

1. To determine the effects of tillage on K availability to corn.

2. To determine the effects of row applied K and tillage on K availability and growth of corn over a range of soil K levels resulting from broadcast K treatments.

3. And to characterize the effect of tillage on the distribution of soil K and determine how this relates to soil test interpretation.

METHODS AND MATERIALS

The experimental plots are located on approximately three and one third acres land in Sec. 15 of Haycreek Township of Goodhue County, Minnesota on a deep loess soil over limestone. The soil is a Typic Eutrochrept (Timula silt loam) with initial soil test values of 20.7 ± 5.3 ppm phosphorus (Bray-1), and 83.0 ± 18.1 ppm potassium (ammonium acetate extraction). Initial pH was 6.5 ± 0.5 with about 2.5 percent organic matter. Three T/ac of limestone were applied in 1980. Oats and alfalfa were grown at the site in 1978, followed by two years of alfalfa. Corn as silage was grown in 1981 and corn as grain from 1982 to 1984. A 95 day single cross hybrid (Pioneer 3906) was planted at a rate of 28,000 plants/ac at a row spacing of 38 inches on 20 May 1984.

Terbufos (Counter) was used for control of root worms at a rate of 1.3 lb/ac a.i. Atrazine/Alachlor (Atrazine/Lasso) mixture was applied at the 4-5 leaf stage for general weed control at a rate of 2.5 lb/ac a.i. of both herbicides.

Equipment used consisted of: a chisel plow (Glencoe Soil Saver) with chisels 3.5 inches wide and spaced 13.3 inches apart with twisted shovels, a field cultivator (Bushog), and a planter (Hinicker) equipped with 2 inch fluted coulters.

This study was designed as a randomized complete block with six replications. Tillage treatments used were, spring chisel plowing (7-9 inches deep) followed by a field cultivator (4-5 inches deep) and no-till. Broadcast K applications were made in the spring prior to tillage (0, 200 or 400 lb/ac K_2O). Because of preexisting variability in soil K, regression was used to characterize treatment differences. Potassium was applied in the row at planting (0-0-5) to every other row. Nitrogen and phosphorus were also applied (7-21-.1) to all rows. Potassium present in the N-P row application was due to contamination. The actual application rate of K_2O with these two row applied fertilizers is in table 1. Nitrogen as ammonium nitrate was applied to the entire plot area (15 May 1984) at a rate of 300 lb/ac to eliminate its effects.

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

Table 1. K Applied as Row Fertilizer.

0-0-5 K	7-21-.1 K
---(lb/ac)---	
5.1	.2

Table 2. Fertilizer treatment application schedule.

Fertilizer Type	Date Applied	Method	Rate Applied
Potassium Chloride (KCl)	15 April 1984	Broadcast	0, 200 and 400 lb/ac K_2O
Ammonium polyphosphate+ urea (7-21-0)	20 May 1984	Row	20 gal/ac
Ammonium polyphosphate+ urea (7-21-0)+ Potassium Chloride (0-0-7)	20 May 1984	Row Row	20 gal/ac 10 gal/ac

In 1983 and 1984 ten samples per plot were taken, composited for the 0-6, and 6-12 inch depths. Ten soil samples per plot were also taken and composited for the 0-2, 2-4, and 4-6, inch depths. Soil samples were taken on two dates in 1983 and 1984, 26 April 1983, 16 June 1983, 10 April 1984, and 2 July 1984 before fertilizer application and chisel plowing and after fertilizer application and chisel plowing, respectively for each year. The samples were dried at 97° F, and ground to pass a

Samples for bulk density and soil moisture were taken 7 Sept. 1984 for the 1-4 inch depth increment. Sampling was done between the row, in and out of wheel traffic. Samples were dried at 105°F.

Whole plant samples were taken at approximately the 6-10 leaf stage of development on 22 June 1984. Plants were cut at ground level (10 plants/plot). Grain and stover samples were taken at harvest. All samples were dried at 140°F and ground to pass a 1 mm sieve.

Residue was measured by the line intersect method (Laflen et al., 1981). The K levels in the soil tested were determined using ammonium acetate extraction (Recommended Chemical Soil Test Procedures, 1980).

RESULTS AND DISCUSSION

Table 3 shows the effects of tillage on soil cover both in and between the row. There was approximately three times the level of cover without tillage than with chisel plowing regardless of position relative to the row. Within tillage treatments, the cover in the row was approximately two thirds of that between the

row. The cover with no-till was more variable due to poor distribution by the combine. Although, there was some effect of cover and tillage on date of emergence there was no effect on final stand (see table 4).

Table 3. The effect of tillage on soil cover in and between the row (6/7/84).*

Tillage	In Row	Between Row
	----------%----------	
No-till	42.2 (25.3)	74.0 (13.9)
Chisel	16.5 (12.3)	24.0 (14.6)

* Numbers in parenthesis represent the standard deviations, n=12. In and between the row are defined as the 8 inch area centered over the row and the remainder, respectively.

Table 4. The effect of tillage on corn emergence and final stand.*

Tillage	5/30	Emergence 6/1	6/3	6/4	6/5	Final stand 6/14/84
	----------% of final stand----------					plants/ac x 10^3
No-till	0	29.8 (16.9)	77.4 (15.1)	90.3 (8.3)	96.7 (4.5)	26.5 (1.4)
Chisel	0	50.0 (27.2)	84.7 (16.8)	95.4 (5.8)	98.7 (2.1)	25.7 (1.7)

* Numbers in parenthesis represent the standard deviations, N=12.

Table 5 shows the moisture content of incremented samples taken 2 July 1984 as affected by tillage. There was greater moisture in the 0-2, and 2-4 inch depths with no-till than with chisel plowing at the time of sampling.

Table 6 shows that significant differences between no-till and chisel plow treatments existed for bulk density and soil moisture when no traffic was over the area (no-till having greater moisture and bulk density). No-till and chisel plowing responded differently to traffic. Bulk density and soil moisture both increased in the chisel treatment with traffic, while with no-till no differences were seen in bulk density or soil moisture with or without traffic. There were no significant differences between tillage treatments when traffic was present for bulk density or soil moisture.

Table 5. The effect of tillage on soil moisture content on 7/2/84.*

Depth	Tillage No-till	Chisel
inches	--------% by wt.-------	
0-2	16.2 (2.2)	11.8 (1.7)
2-4	18.4 (1.4)	17.5 (1.3)
4-6	18.9 (1.1)	18.2 (1.3)
0-6	18.2 (1.6)	16.2 (1.7)
6-12	19.2 (1.2)	18.8 (1.6)

*Numbers in parenthesis represent the standard deviations, n=12.

Table 6. The effect of tillage and traffic on the bulk density, and soil moisture in the surface 1-4 inches 7 Sept. 1984.*

Sample Position	Tillage	Bulk Density	Soil Moisture
Between Rows		(g/cm^3)	(% by Vol.)
No-traffic	No-till	1.4 (.07)	30.0 (2.87)
	Chisel	1.2 (.09)	26.4 (1.67)
With-traffic	No-till	1.5 (.08)	29.3 (2.09)
	Chisel	1.4 (.05)	28.3 (3.00)

*Values in parenthesis represent the standard deviations, N=6.

The vertical distribution of soil K to a depth of 6 inches is shown in figure 1 for no-till and chisel treatments. The effect of the 1983 tillage is still present at the first sampling date in 1984 (figure 1a and b for no-till and chisel, repectively), however, soil buffering and fixation brought the soil test K down at all depths in both tillage systems from levels of the previous season. There were no significant differences in soil K between tillage treatments at any depth or rate of broadcast K on 4/10/84. Broadcast K applications caused a steep gradient of K in no-till to the 6 inch depth (figure 1c). There was also a gradient of K with the chisel treatment, but not as dramatic as with no-till (figure 1d). No-till plots had significantly higher concentrations of K in the surface 2 inches compared to the chisel treatment with the 200 and 400 lb/ac rate of broadcast K_2O. Chisel plowing had greater soil K than no-till in the 4-6 inch depth increment with the 200, and 400

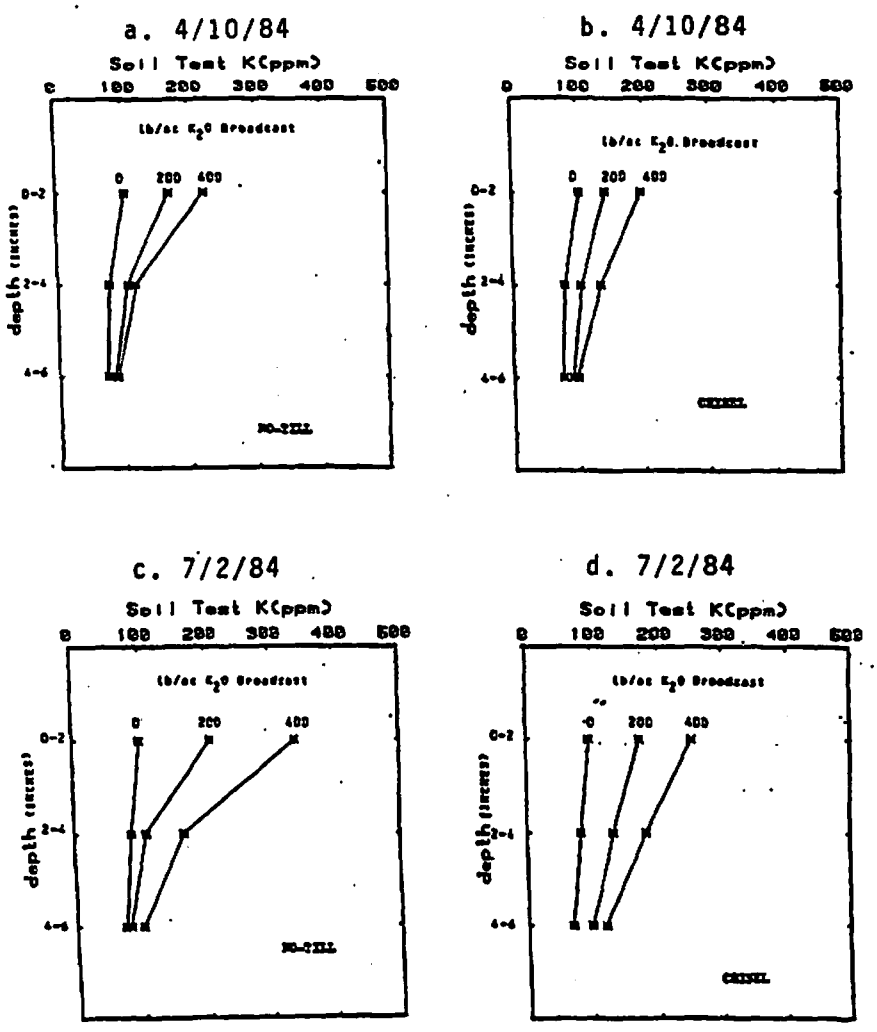

Figure 1. The effect of tillage and annual K application on soil test K distribution before and after tillage in 1984.

lb/ac rate of broadcast K_2O. Six inch cores had the same increase in soil test K with a given application rate of broadcast K with both tillage treatments (see table 7). This differed from 1983 responses to a given K application. No-till had greater increases in soil K with a given K application in 1983. This difference may be, in part, due to differences in weather conditions (see figure 8), and the longer period of time between fertilizer application and soil sampling in 1984 compared to 1983 (83 and 54 days in 1984 and 1983, respectively) which allowed more time for soil fixation of K to occur. No significant differences between tillage treatments were seen at the 6-12 inch depth.

Table 7. The effect of tillage and annual broadcast K applications on soil test K for the 0-6 and 6-12 inch depths for 1983 to 1984 sampling dates.*

Rate of K O Applied Annually	Depth	26 April '83	16 June '83	10 April '84	2 July '84
(lb/ac)	(inches)	----------Soil test K (ppm)----------			
			NO-TILL		
0	0-6	70.5 (12.7)	65.2 (13.8)	81.2 (11.1)	81.8 (13.0)
	6-12	54.0 (19.6)	54.7 (22.5)	70.2 (14.5)	76.8 (13.8)
200	0-6	84.5 (16.4)	124.5 (29.1)	112.7 (21.8)	127.8 (13.6)
	6-12	60.9 (23.1)	62.6 (22.8)	72.8 (26.1)	81.0 (17.3)
400	0-6	101.7 (11.0)	175.5 (30.0)	140.2 (30.9)	173.7 (40.4)
	6-12	55.8 (17.6)	58.2 (6.2)	74.2 (8.1)	82.7 (15.4)
			CHISEL		
0	0-6	68.5 (15.3)	72.0 (18.0)	83.7 (12.4)	79.8 (10.0)
	6-12	55.8 (10.0)	54.8 (12.4)	72.5 (12.1)	80.3 (14.9)
200	0-6	75.8 (18.8)	111.5 (30.9)	102.2 (25.3)	131.7 (18.6)
	6-12	53.5 (16.0)	55.3 (15.2)	78.0 (10.0)	87.0 (18.4)
400	0-6	111.8 (29.8)	152.7 (36.3)	138.0 (28.7)	174.5 (36.3)
	6-12	59.5 (22.2)	59.5 (24.8)	72.7 (22.9)	82.3 (19.7)

*Values in parenthesis represent the standard deviations, n=9.

Early growth of corn is shown in figure 2. Early growth was similar for both tillage treatments within row application treatments, and was independent of soil test K. Row applied K significantly increased early growth in both the no-till and chisel treatments. At the 400 lb/ac rate of broadcast K, the increase due to row applied K was greatest with both tillage treatments.

Early uptake of K is shown in figures 3. Row applied K significantly increased uptake in both tillage treatments. With or without row applied K the uptake of K by early growth with the chisel treatment leveled off after the broadcast rate of 200 lb/ac of K_2O, while with no-till uptake continued to increase.

Figures 4 and 5 show the effects of soil test K (0-6 inch 7/2/84 sample), and row applied K on grain and stover yields, respectively. Regression equations corresponding to the figures are in table 8. Non-significant regressions are accompanied by NS, and represent the least squares fit of the data.

Responses of grain yields were significantly related to soil test K levels with

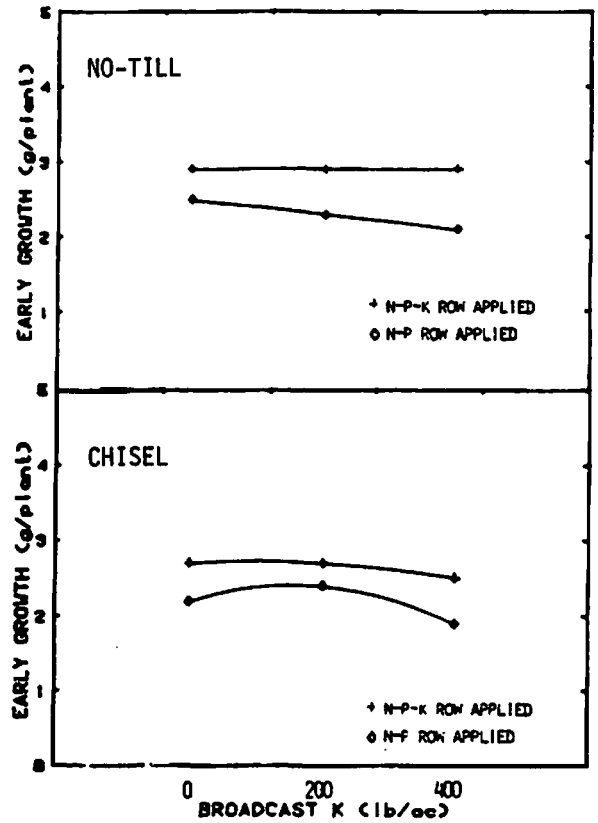

Figure 2. The effects of broadcast K, and row applied K on early growth with no-till and chisel plow treatments.

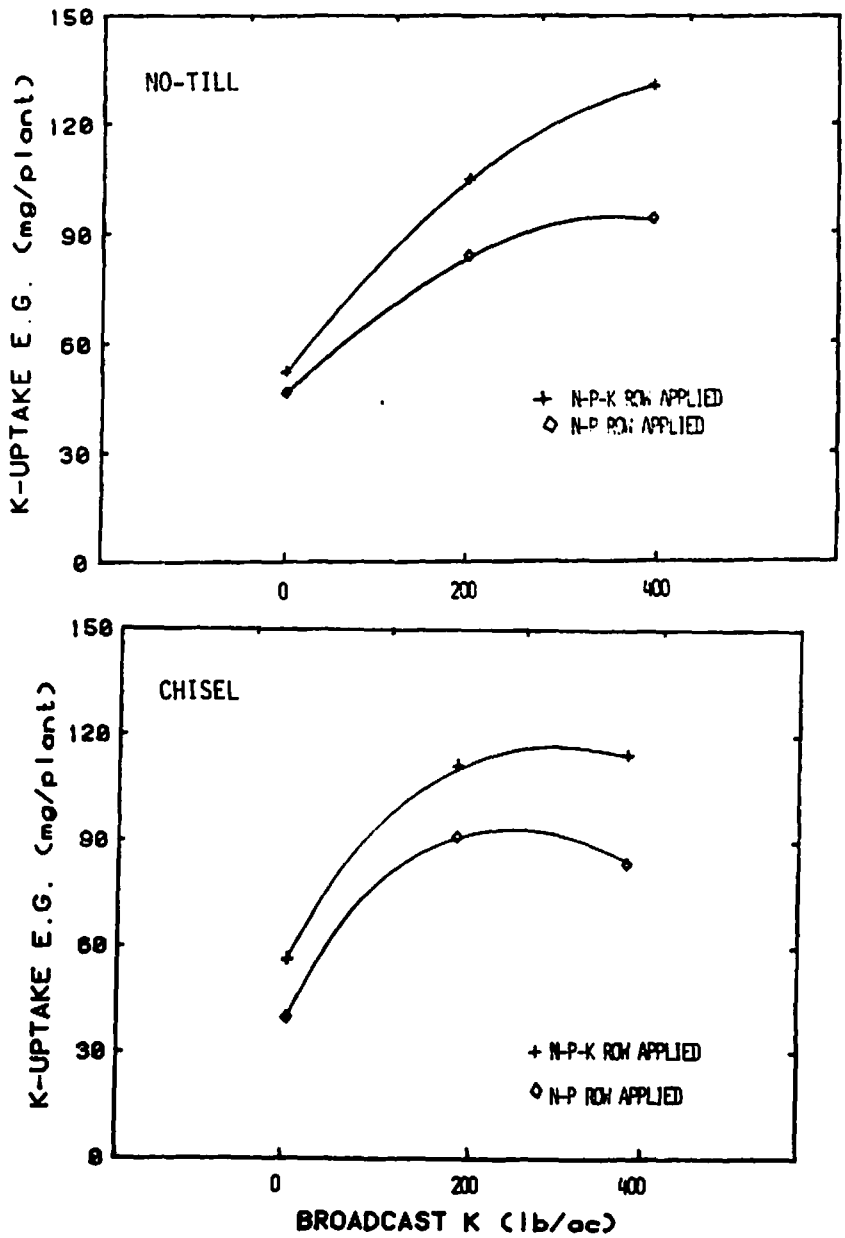

Figure 3. The effects of broadcast K, and row applied K on early K uptake with no-till and chisel treatments.

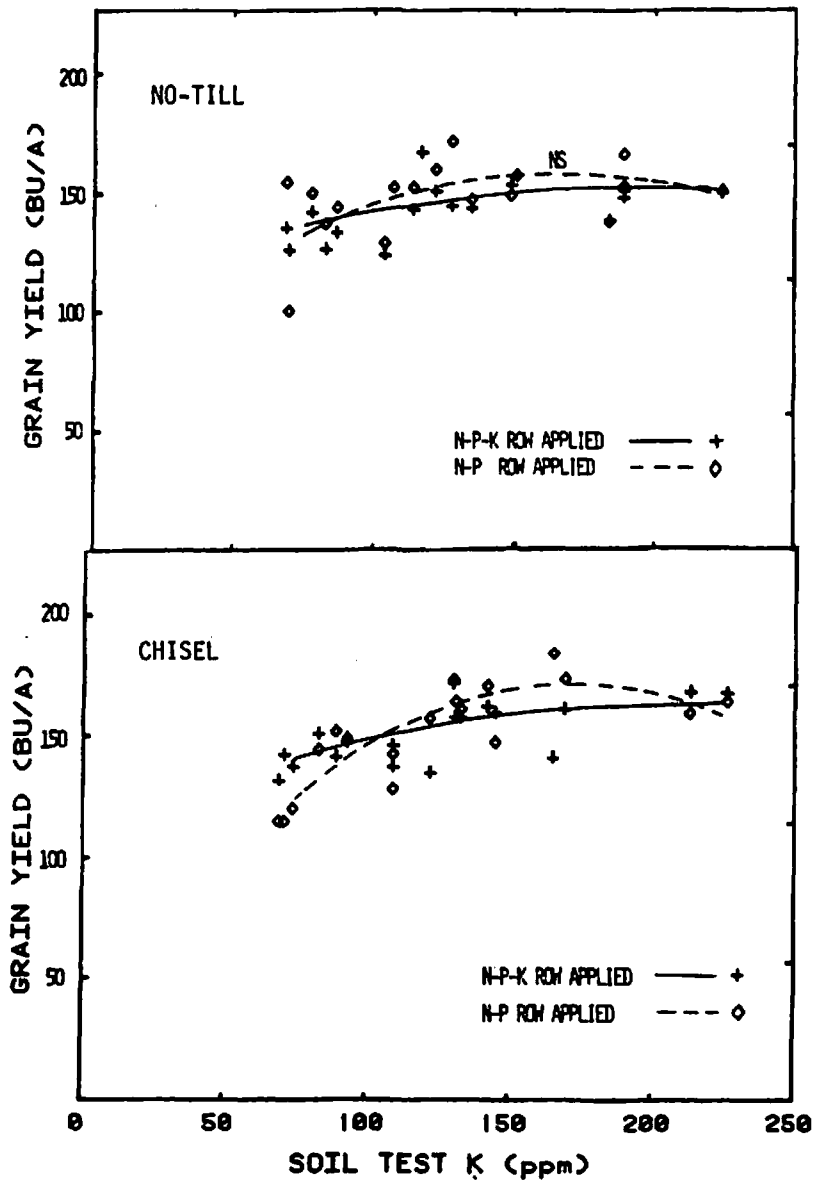

Figure 4. The effects of broadcast K, and row applied K on grain yields with no-till and chisel plow treatments.

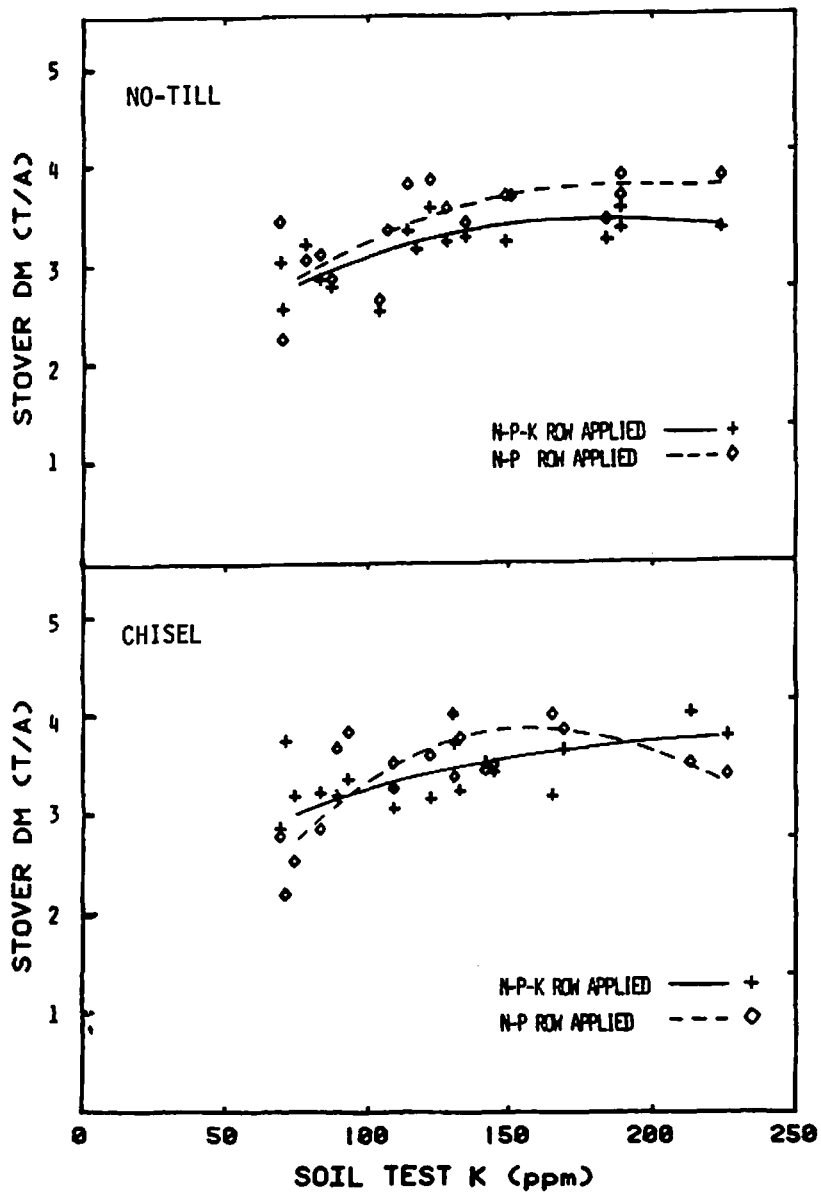

Figure 5. The effects of broadcast K, and row applied K on stover yields with no-till and chisel plow treatments.

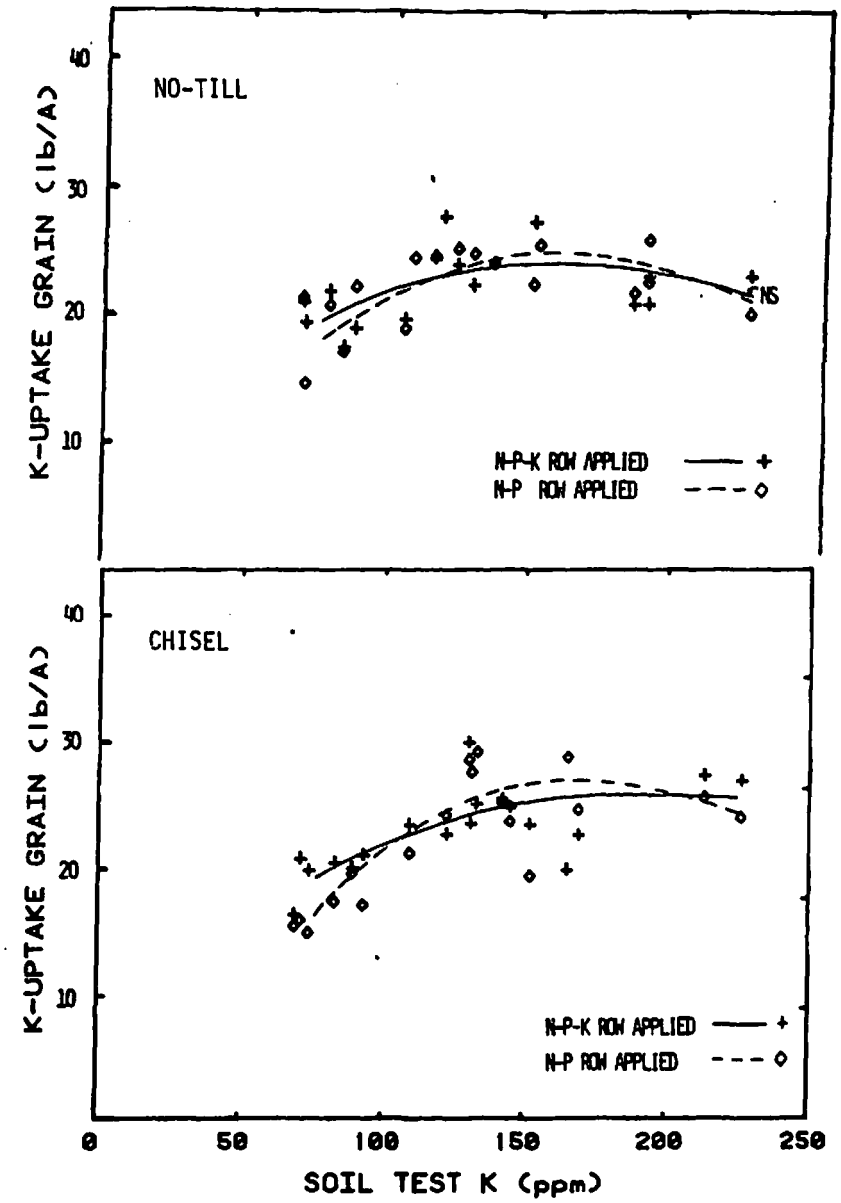

Figure 6. The effects of broadcast K, and row applied K on the K uptake by grain with no-till and chisel plow treatments.

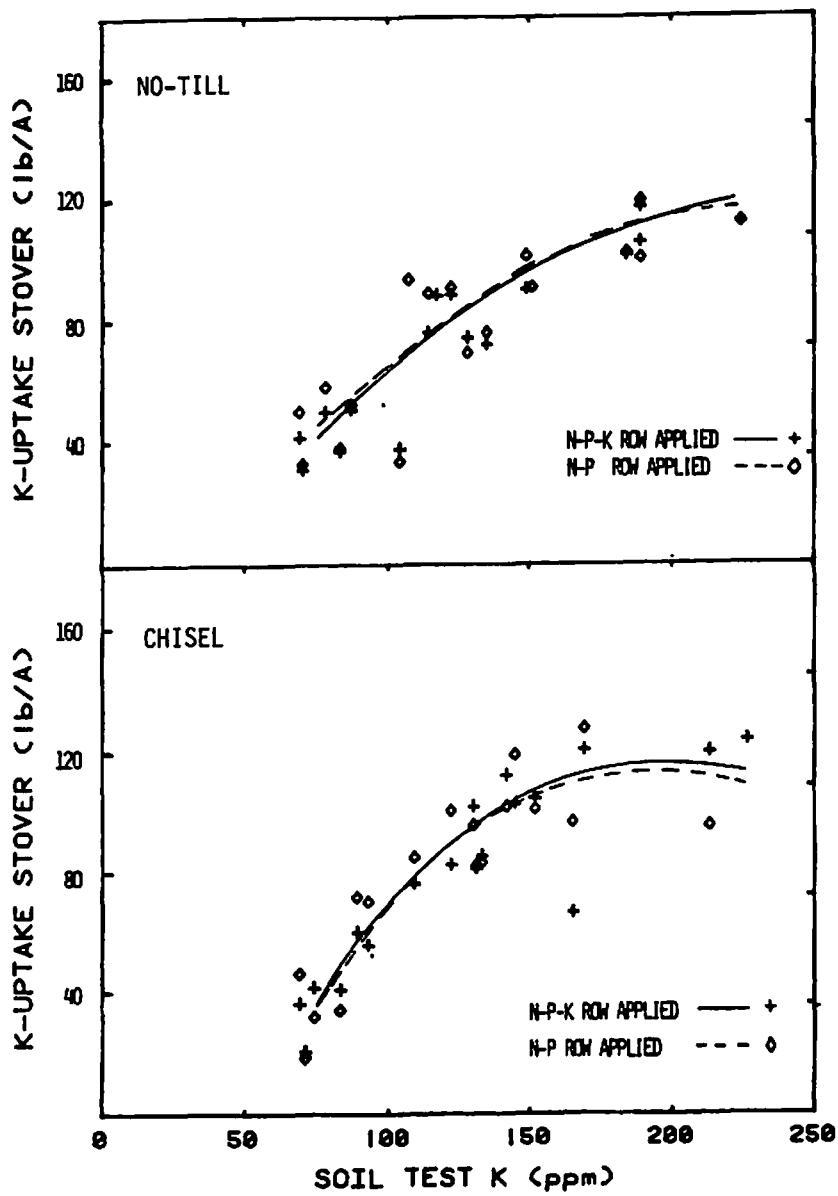

Figure 7. The effects of broadcast K, and row applied K on the K uptake by stover with no-till and chisel plow treatments.

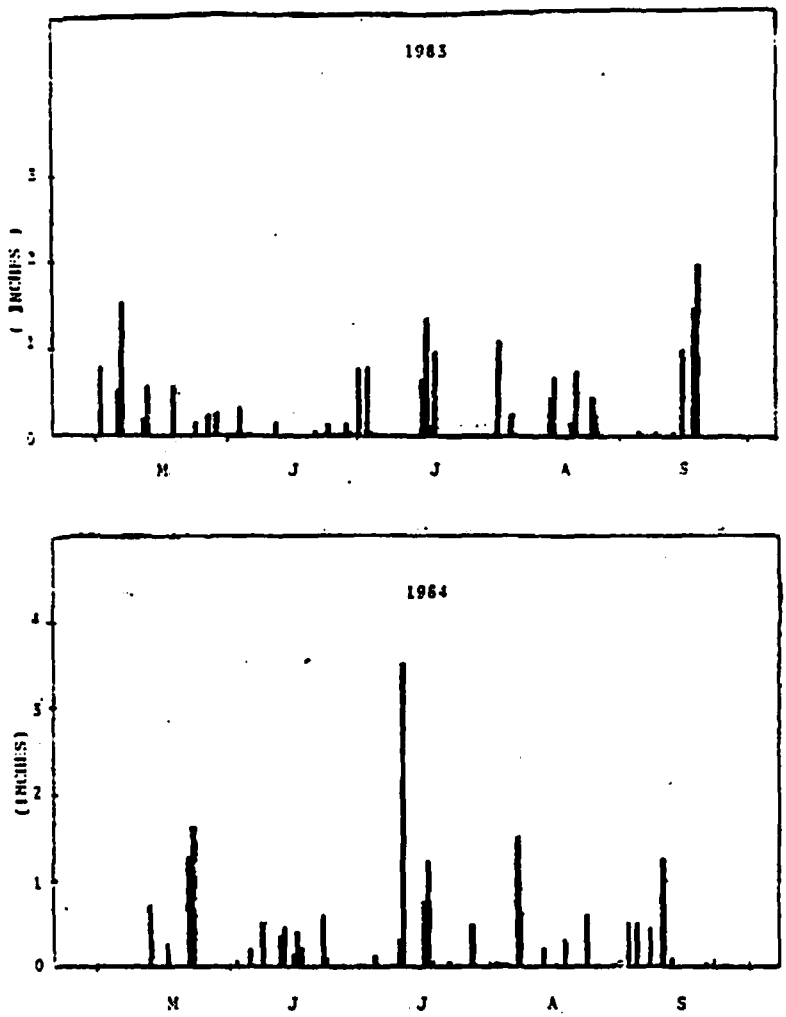

Figure 8. Precipitaion at the study site during the 1983, and 1984 growing seasons.

both tillage treatments when row applied K was used. Chiseled corn also responded in grain yields to soil K without the use of row applied K. Row applied K did not affect grain yields with the no-till treatment. At low levels of soil K row applied K increased grain and stover yields with the chisel treatment. Grain yields were similar for both tillage treatments. Stover yields responded to soil test K significantly in all cases. Row applied K increased the harvest index with the no-till treatment at medium to high soil K levels. Stover yields were similar for both tillage treatments.

Uptake of K as affected by soil test K, and row applied K is shown in figures 6 and 7 for grain and stover, respectively. Corresponding regression equations are given in table 9. Uptake of K by grain did not respond significantly to soil K with the use of row applied K with the no-till treatment, however, grain and stover uptake of K did respond in all other cases. Row applied K did not affect total uptake of K with the no-till treatment. Chisel plowing had greater K uptake by grain at low soil K levels due to row applied K, but stover uptake was not influenced by the row application.

Table 8. Regression equations used to describe yields.

Equation: $y=e^{a} K^{b}$.

y = Yields (Mg/ha)
K = 0-6 inch soil test K (ppm)

Row Fertilizer	Tillage	Equation Exponents a	Equation Exponents b	R^2	p-value
Grain Yields					
N-P-K	No-till	1.3793	.13333	.335	.05
	Chisel	1.1886	(.22504 - .00841 ln K)	.399	.05
N-P	No-till	-5.0793	(2.8382 - .28021 ln K)	.279	.23
	Chisel	-8.7585	(4.2640 - .41612 ln K)	.648	.00
Stover Yields					
N-P-K	No-till	-.95672	(1.0170 - .08663 ln K)	.424	.08
	Chisel	1.0185	.20136	.488	.00
N-P	No-till	-3.4629	(1.9949 - .17799 ln K)	.487	.05
	Chisel	-14.511	(6.6408 - .66389 lnK)	.667	.00

Table 9. Regression equations used to describe K-uptake by corn.*

Equation: $y=e^{a} K^{b}$.
y = K-Uptake (kg/ha)
K = 0-6 inch soil test K value (ppm)

Row Fertilizer	Tillage	Equation Exponents a	Equation Exponents b	R^2	p-value
Grain K-Uptake					
N-P-K	No-till	-6.7935	(4.0485 -.40666 lnK)	.322	.17
	Chisel	-3.4911	(2.5410 - .23516 ln K)	.555	.01
N-P	No-till	-12.473	(6.3647 -.64179 lnK)	.490	.05
	Chisel	-15.487	(7.3494 -.71553 lnK)	.775	.00
Stover K-Uptake					
N-P-K	No-till	-10.106	(4.9287 -.39819 lnK)	.833	.00
	Chisel	-26.188	(11.604 -1.0848 lnK)	.859	.00
N-P	No-till	-7.4253	(3.9562 - .31005 ln K)	.682	.00
	Chisel	-31.042	(13.646 - .23516 ln K)	.788	.00

SUMMARY

1. Under no-till conditions corn emergence was delayed about one day over that grown with chisel plowing.

2. Final stand was not affected by tillage.

3. Bulk density was greater with no-till than with the chisel plow treatment in the 1-4 inch depth when there was no traffic over the area.

4. Soil moisture was higher under no-till conditions compared to chisel plowing. This difference was associated with the top 4 inches.

5. The no-till treatment resulted in three times the soil cover of chisel plowing.

6. Soil cover in the row was two thirds of that between the row with both tillage treatments.

7. The spring distribution of soil K was not significantly different between tillage treatments.

8. Soil K distribution 83 days after application of K was greatly influenced by tillage.

9. With broadcast K applications, soil K in the surface 2 inches was higher with no-

till than with the chisel plow treatment.

10. With broadcast K applications, soil K in the 4-6 inch depth increment was higher with chisel plowing than with the no-till.

11. Changes in soil K with a given K application were similar for six inch cores with both tillage treatments in 1984.

12. Early growth was increased with row applied K and independent of soil test K.

13. Early growth was similar with both tillage treatments within row application treatments.

14. The increase in early K uptake due to row application of K was greater at higher soil test K levels with both tillage treatments.

15. Chisel plow treatments leveled off in early uptake after a broadcast rate of 200 lb/ac of K O, while no-till continued to increase.

16. Grain yields were not influenced by row application of K with the no-till treatment.

17. Chiseled corn had increased grain and stover yields at low levels of soil test K due to row applications of K.

18. Grain yields were similar for both tillage treatments.

19. Row K increased the harvest index at medium to high levels of soil K with the no-till treatment.

20. Uptake of K by grain was increased by row applied K at low levels of soil test K with the chisel treatment.

21. Total K uptake was similar for both tillage treatments.

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THE EFFECT OF TILLAGE, N RATE, AND NITRIFICATION INHIBITOR ON CORN RESPONSE ON AN IRRIGATED LOAMY SAND SOIL AND DRYLAND SILT LOAM SOIL

J.F. MONCRIEF, G.L. MALZER, G.W. REHM, AND J. CHAPLIN

Proper N management with conservation tillage is of paramount importance. Success or failure when growing continuous corn with very little tillage depends primarily on: 1) managing the crop residue to minimize reduced soil temperature affects, 2) adequate weed control, and 3) proper fertilizer management. Nitrogen management is important to minimize potential losses from increasd leaching and denitrification due to higher soil moisture levels.

The experimental sites are located at the Sand Plains Experiment Station, Becker, MN and on a cooperator's farm near Goodhue, MN. The Becker, MN site is located in East Central (EC) Minnesota on a soil formed in glacial outwash. The soil at this site is classified as a Udorthentic Haploboroll (Hubbard, loamy sand). These soils are capable of high production levels when irrigated. Nitrogen management is always of paramount importance on these soils. Growers are interested in conservation tillage on these soils to minimize wind and water erosion (water erosion from natural rainfall and also water application with low pressure irrigation systems). They are also motivated by the potential of reducing production inputs with conservation tillage. The other experimental site is located in South Eastern (SE) Minnesota on a soil formed in a deep-loess cap over limestone. This area of Minnesota has the highest potential for soil erosion.

Methods: At the EC site a Buffalo planter equipped with clearing discs was used to plant the ridge till treatment. A White planter with 2" fluted coulters was used for all other tillage treatments at this site. At the SE site a Hiniker Series 1 Econo Till planter was used for all tillage treatments. The cleaning discs were raised for the no till and chisel treatments. Cultural practices utilized in this study are summarized in Table 1. A continuous corn rotation was used at both sites.

Anhydrous ammonia was used as the nitrogen source. A sidedressed treatment was used at the SE site in addition to the Spring treatment at both sites. Nitrogen was applied at three rates with and without a nitrification inhibitor (N Serve) at both sites. The experimental design is a complete factorial arrangement with four replications as shown in Table 2.

RESULTS AND DISCUSSION

Tillage characterization: The resulting soil cover as a result of tillage is shown in Table 3. Soil cover slows soil moisture evaporation. This coupled with the increased soil density associated with the absence of tillage can result in denitrification (most likely the SE site) or increased leaching (the EC site). With moldboard tillage there is little residue and no difference relative to the row. The ridge till treatment resulted in about one-third the cover in the row as between rows at the SE site and about one-half as much at the EC site. The chisel treatment at the EC site resulted in less residue in the row but about the same at the SE site. No tillage resulted in 60-70% cover at both sites.

The effect of tillage on stands is shown on Table 4. There is no effect of tillage on stand. The ridge till treatment at the EC site had much less variability, however.

The effect of tillage on soil density and moisture is shown in Table 5. At the EC site there was traffic on all rows due to the necessary passes to apply N treatments and herbicides. With traffic all tilage effects have been masked out. There is a significant effect of tillage on soil moisture, however. These samples were taken the day following .58 inches of rain. The moldboard appears to be drying down the fastest. It is difficult to explain the higher soil moisture associated with chisel plowing.

Yield and N uptake: Tillage has been shown to affect the rate of several soil N transformations. In some cases there has been less N available with extremes in tillage reduction. One question this experiment was designed to address is "Is there a difference in N availability resulting from the tillage associated with anhydrous ammonia application"? The data collected in this reguard is shown in Table 6. There is no apparent effect of the tillage associated with anhydrous application (no N was applied).

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

Treatment means for yields and N uptake for the EC site are shown in Table 7. There was a significant effect of all treatments on grain yields and uptake at this site. It is interesting to look at the tillage in x N-rate X inhibitor interaction. This is shown in figure 1 and 2 for grain yields and grain N uptake respectively. At the first rate of N there was a greater inhibitor yield response with the no till treatment. The curves for the moldboald and ridge till treatment are similar in shape. There was considerable precipitation at this site in June (figure 3). The yields are similar without inhibitor at the 75 lbs/A rate for all four tillage treatment. There is more of an increase with the no till treatment with inhibitor at this rate. This suggests that the nitrification progressed more slowly under no till conditions. This is probably due to cooler temperature under this treatment which slowed the degredation of the inhibitor and N was present as NH_4^+ during the June rainfall. It is difficult to offer an explanation for the apparent response at the high rate of N with chisel plowing.

Treatment effects on yield and N uptake at the SE site are shown in Table 8. Generally the ridge till and chisel treatments resulted in similar yields which were higher than the no till treatments. Spring N application was consistantly better than sidedress. This is probably a result of the rainfall distribution (figure 4). June was fairly dry and with the exception of one 3 inch rain in July, it was also. Sidedress was especially a poor option with the chisel treatment.

There was no consistant effect of the nitrification inhibitor at this site. Again, it was dry and one would not expect an advantage with an inhibitor.

SUMMARY

Tillage affected soil moisture at both sights. Higher soil cover resulted in more soil moisture. There was no effect of the tillage associated with anhydrous application an corn yields (no N applied). Traffic masked the effects of tillage on soil density. There was a differencial inhibitor response (due to tillage) at the EC site. This is probably due to the temperature effect on the persistance of the NH_4^+ form of N. There was no consistant response of inhibitor at the SE site. This is the result of the difference in rainfall between sites. The Spring N application was better than sidedressed N.

Table 1: Cultural practices utilized.

Management Practice	East Central Minnesota	Date	South East Minnesota	Date
Tillage	Moldboard Plow	4/24		5/8
	Chisel Plow	4/25		6/29
	Ridge Till-Cultiviation	6/25		
Planting Date		5/3		5/9
Corn Hybrid	Pioneer 3906		Pioneer 3906	
Planting rate	29,600 plants/A		28,000 plants/A	
Row spacing	30 inches		38 inches	
Fertilizer Applications				
Row applied at planting	150/lbs/ 8-10-30	5/2-5/3	14 gal/A 7-21-7	5/9
Anhydrous Ammonia	All other spring N treatment	5/4	All Spring N treatment	5/10
	300 lb/A + N Serve	5/8	Sidedress N	6/25
Broadcast	300 lb/A 0-0-22 (Sulpomag)			
Insecticide				
At Planing	Lorsban 15G 7 lbs/A	5/3	Counter 15G 6 lbs/A	5/9
Through irrigation system	Lorsban 4e 7 lbs/A	7/11		
	Lorsban 4e 7 lbs/A	8/20		

Table 1: (cont.)

Herbicide				
Preemergence	Atrazine & Dual 2 lbs/A 1 lbs/A	5/3	Lasso + Bladex 2.5 lbs/A 1.5 lbs/A	5/9
Post Emergence	Atrayine & Oil 2 lbs/A 1 qt/A	5/29	Atrazine & Oil 2 lbs/A 1 qt/A	6/11
			Banvel 1/8 16/A	6/13

Table 2: Summary of Treatment

	Location	
	EC	SE
Tillage		
Moldboard	X	
Chisel	X	X
Ridge Till	X	X
No Till	X	X
Time of Application		
Spring	X	X
Sidedress		X
N Rate		
0	X	X
75	X	X
150	X	X
300	X	X
Nitrification Inhibitor		
with	X	X
without	X	X

Table 3: The affect of tillage and percent soil cover.*

Location	Tillage	In Row	Between Row
East Central Minnesota 6/8	Moldboard	3.5 (4.6)	2.5 (3.5)
	Chisel	25.0 (13.7)	41.3 (17.4)
	Ridge Till	16.7 (12.4)	32.0 (14.5)
	No Till	64.0 (18.0)	73.0 (14.6)
South East Spring N 6/19	No Till	70.0 (20.8)	51.0 (15.4)
	Ridge Till	13.8 (10.9)	31.8 (9.9)
	Chisel	27.8 (14.5)	26.0 (13.5)
Sidedress N 6/19	No Till	69.8 (17.8)	64.3 (14.4)
	Ridge Till	6.5 (3.5)	22.3 (12.3)
	Chisel	18.5 (10.3)	23.8 (11.2)

*Numbers in parenthesis are standard deviation N = 16. Measurements were made on the 300 lbs/A N rate only. In row is defined as the 8" area centered on the row.

Table 4: The effect of tillage on stand.*

Tillage	Location: EC Spring N	SE Spring N	SE Sidedress N
	plants/A x 10^3		
Moldboard	28.7 (3.1)	———	———
Chisel	29.2 (1.7)	26.7 (2.3)	27.9 (1.6)
Ridge Till	29.5 (0.8)	26.2 (1.8)	25.5 (2.5)
No Till	28.5 (2.5)	25.9 (3.2)	27.2 (2.4)

* The numbers in parenthesis are standard deviation, n = 16. Stand counts are for the high N rate only.

Table 5: The effect of tillage and traffic on soil density and moisture in the 1-4" soil depth (3" cores).

Location	Tillage	Bulk Density	Percent Moisture by Vol. *
East Central 9/4 (between the row with traffic)	Moldboard	1.57 (.04)	17.3 (1.5)
	Chisel	1.58 (.05)	22.9 (2.3)
	Ridge Till	1.57 (.07)	18.3 (2.2)
	No Till	1.59 (.07)	19.4 (3.1)

		Bulk Density		Percent Moisture by Vol.	
		No Traffic*	Traffic	No Traffic*	Traffic*
South East 9/4 (Between the row)	Chisel	1.19 (.07)	1.40 (.10)	26.9 (3.4)	29.8 (1.4)
	Ridge Till	1.27 (.06)	1.44 (.04)	28.7 (1.9)	33.2 (2.1)
	No Till	1.26 (.09)	1.40 (.08)	28.9 (3.5)	31.6 (2.9)

* Tillage is significant at a $\alpha = .10$. At the SE location traffic is significant a $\alpha = .10$ for both bulk density and soil moisture, there is no interaction.

Table 6: The effect of the tillage associated with anhydrous application on yields and N uptake (No N applied).

Location	Yields: Grain Bu/A		Stover T/A		N uptake: Grain		Stover	
East Central	Knife	No Knife	Knife	No Knife	Knife	No Knife	Knife	No Knife
Moldboard	56	56	1.3	1.3	32	30	11.7	9.2
Chisel	51	60*	1.2	1.4	31	31	12.7	10.2
Ridge Till	53	52	1.3	1.2	28	32	8.0	9.0
No Till	43	45*	1.0	1.0	23	23	8.9	9.3
South East								
Spring								
Chisel	93	91	1.7	1.5	46	46	16	14
Ridge Till	74	71	1.3	1.4	38	37	11	11
No Till	85	83	1.6	1.6	45	44	14	16
Sidedress								
Chisel	81	91	2.0	2.2	46	46	13	13
Ridge Till	83	71	2.0	1.7	47	37	12	10
No Till	83	83	1.9	2.0	45	44	16	17

*Significant as the result of a paired t test at $\alpha = .10$, n = 4.

Table 7: The effect of tillage, N rate, and nitrification inhibitor on corn yield and N uptake at Becker, MN, 1984.

Tillage	N Rate lbs/A	Inhibitor	Yield Grain Bu/A	Yield Stover T/A	N uptake lbs/A Grain	N uptake lbs/A Stover
No Till	75	-	93	2.11	57	20
"	"	+	144	2.75	90	31
"	150	-	125	2.36	77	28
"	"	+	158	2.85	110	39
"	300	-	164	3.03	121	48
"	"	+	169	3.12	115	50
Ridge Till	75	-	115	2.12	65	20
"	"	+	135	2.17	85	25
"	150	-	164	2.72	107	31
"	"	+	156	2.42	119	32
"	300	-	184	3.37	138	50
"	"	+	185	3.02	137	41
Chisel	75	-	101	2.48	58	24
"	"	+	118	2.34	72	22
"	150	-	141	2.59	90	29
"	"	+	167	3.02	113	32
"	300	-	168	3.01	118	43
"	"	+	187	3.39	148	45
Moldboard	75	-	72	].63	42	15
"	"	+	122	2.29	69	22
"	150	-	152	2.77	103	28
"	"	+	141	2.97	88	38
"	300	-	183	3.10	133	40
"	"	+	175	3.13	127	41

Main Effects

	Yield Grain Bu/A	Yield Stover T/A	N uptake lbs/A Grain	N uptake lbs/A Stover
Tillage				
No Till	143	2.70	95	36
Ridge Till	156	2.64	108	33
Chisel	147	2.81	100	33
Moldboard	141	2.65	94	31
P value	99	46	97	77
N rate lbs/A				
75	113	2.24	67	22
150	150	2.7]	101	32
300	177	3.14	130	45
P value	99	99	99	99
Inhibitor				
-	139	2.61	92	32
+	155	2.79	106	35
P value	99	97	99	97
Interactions				
Till X Rate	93	68	88	2]
Till X Inhibitor	90	95	94	89
Rate X Inhibitor	99	62	96	92
Till X Rate X Inhibitor	93	67	97	28

Table 8: The effect of tillage, N rate, time of application, and nitrification inhibitor on corn yield and N uptake at Goodhue Co., MN, 1984.

Tillage	N Rate lbs/A	Time of Application	Inhibitor	Yield Grain Bu/A	Yield Stover T/A	N uptake lbs/A Grain	N uptake lbs/A Stover
No Till	75	Spring	-	147	2.71	104	42
"	"	"	+	138	2.66	101	40
"	"	SD	-	149	2.67	99	40
"	"	"	+	147	2.44	104	38
"	150	Spring	-	150	2.92	110	60
"	"	"	+	155	2.90	107	46
"	"	SD	-	149	2.56	100	42
"	"	"	+	155	2.90	117	49
"	300	Spring	-	155	2.86	106	49
"	"	"	+	155	3.05	114	55
"	"	SD	-	149	2.71	100	46
"	"	"	+	146	2.69	102	45
Ridge Till	75	Spring	-	154	2.45	99	37
"	"	"	+	157	2.82	107	41
"	"	SD	-	160	2.71	112	41
"	"	"	+	157	2.59	104	39
"	150	Spring	-	166	2.96	113	51
"	"	"	+	168	2.93	127	50
"	"	SD	-	155	2.75	107	43
"	"	"	+	164	2.92	121	47
"	300	Spring	-	158	2.83	110	48
"	"	"	+	162	3.03	111	54
"	"	SD	-	164	2.91	117	49
"	"	"	+	161	3.03	116	50
Chisel	75	Spring	-	162	3.00	116	45
"	"	"	+	162	2.91	113	42
"	"	SD	-	155	2.77	103	39
"	"	"	+	147	2.62	88	33
"	150	Spring	-	171	3.14	118	52
"	"	"	+	161	2.99	115	48
"	"	SD	-	153	2.76	101	51
"	"	"	+	160	2.76	118	40
"	300	Spring	-	157	3.21	111	52
"	"	"	+	159	2.86	121	50
"	"	SD	-	157	2.93	116	41
"	"	"	+	155	2.82	114	49

Main Effects

	Yield Grain Bu/A	Yield Stover T/A	N uptake lbs/A Grain	N uptake lbs/A Stover
Tillage				
No Till	150	2.76	105	46
Ridge Till	161	2.83	112	46
Chisel	159	2.90	111	45
P value	99	40	99	02
N Rate				
75	153	2.69	104	40
150	159	2.88	113	48
300	157	2.91	112	49
P value	98	99	99	99
Time of Application				
Spring	158	2.90	111	48
Sidedress	155	2.75	108	44
P value	98	99	97	99

Table 8: (cont.)

Inhibitor				
-	156	2.83	108	46
+	156	2.83	108	45
P value	06	06	96	29
Interactions				
Till X Rate	16	36	84	27
Till X Time	96	96	98	58
Till X Inhibitor	51	99	55	71
Rate X Time	69	35	40	48
Rate X Inhibitor	84	46	99	87
Time X Inhibitor	19	07	06	20
Till X Rate X Time	97	23	99	19
Till X Rate X Inhibitor	13	64	49	16
Till X Time X Inhibitor	16	60	81	49
Rate X Time X Inhibitor	91	97	99	64
Till X Rate X Time X Inhibitor	58	46	60	93

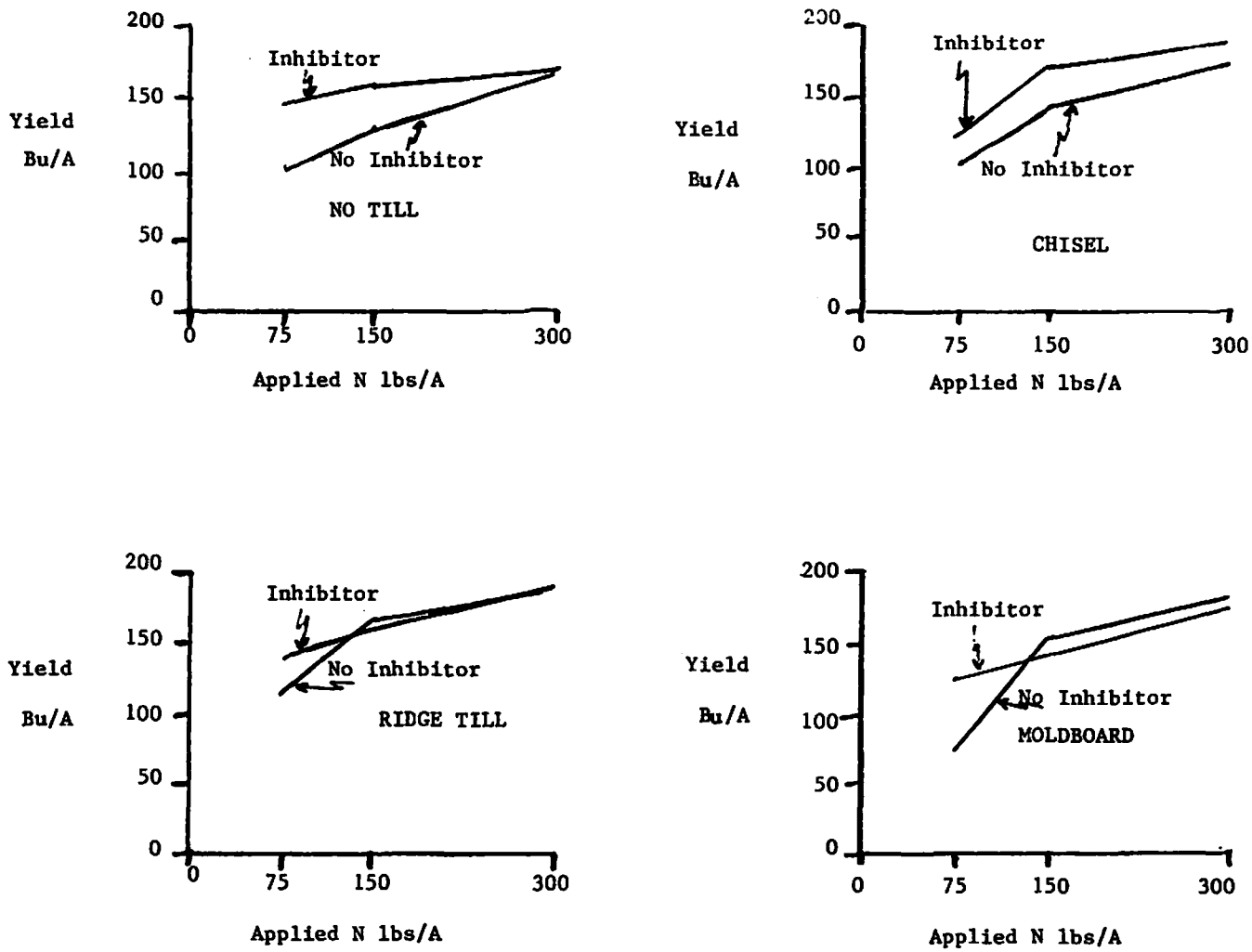


Figure 1: The effect of tillage, N rate, and nitrification inhibitor on grain yields, Becker, MN, 1984.

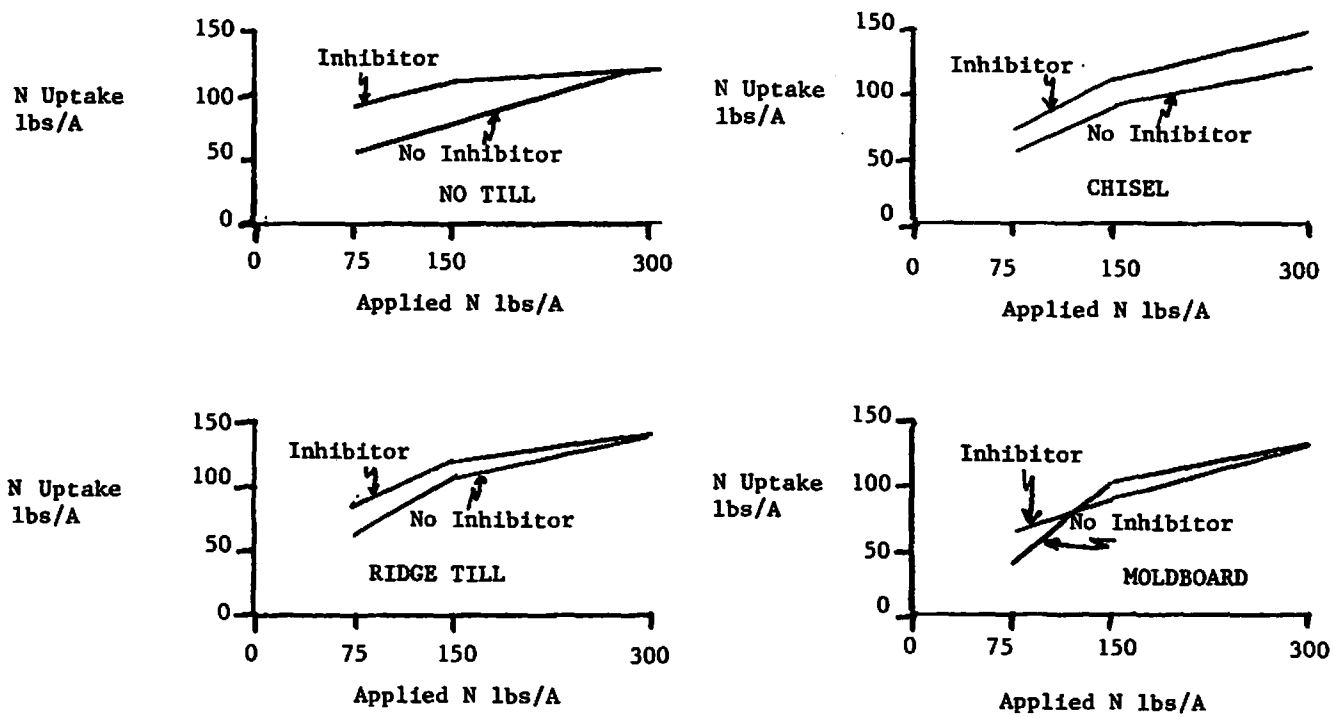


Figure 2: The effect of tillage, N rate, and nitrification inhibitor on grain N uptakes, Becker, MN, 1984.

Figure 3: Precipitation and irrigation at the EC site.

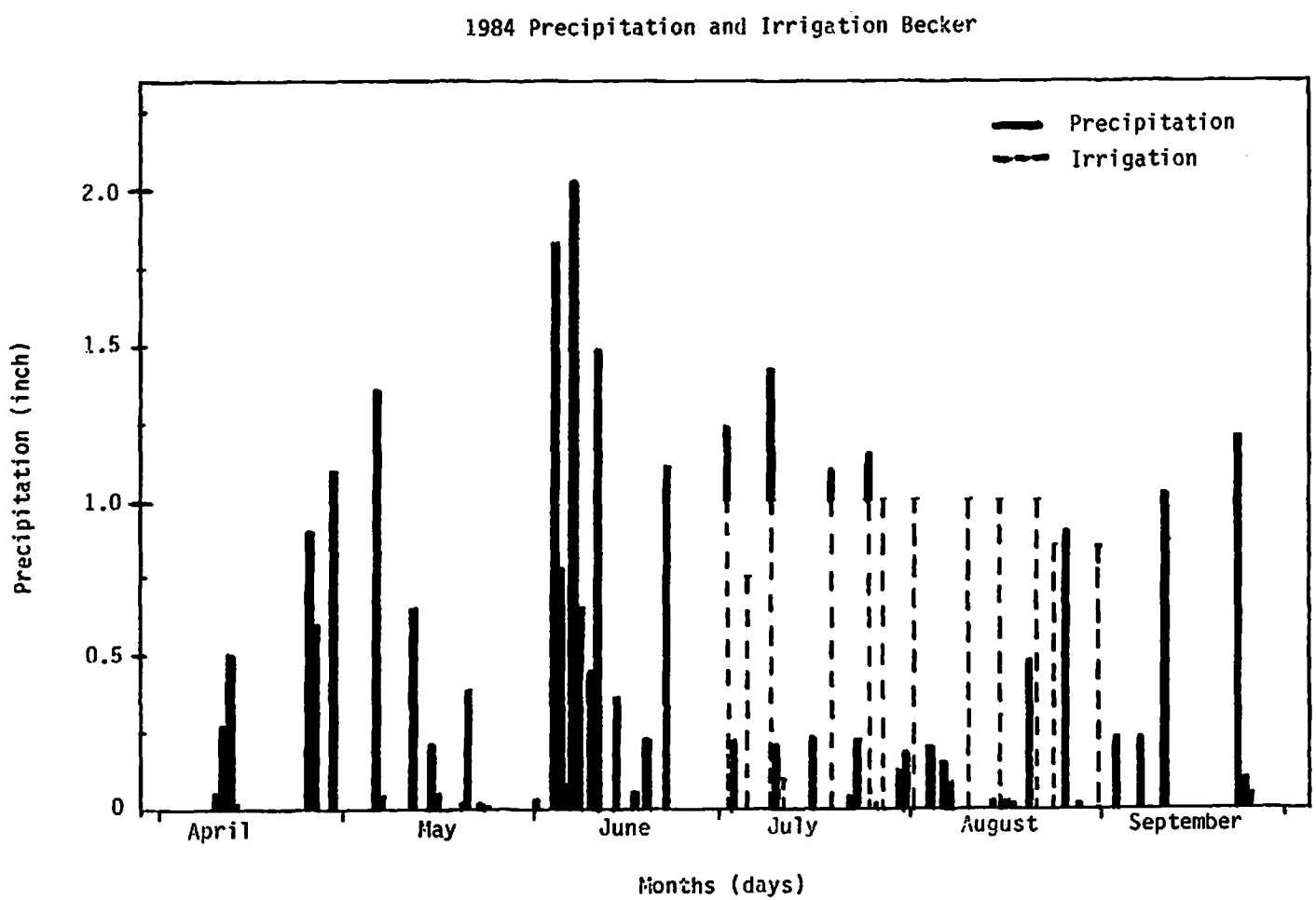
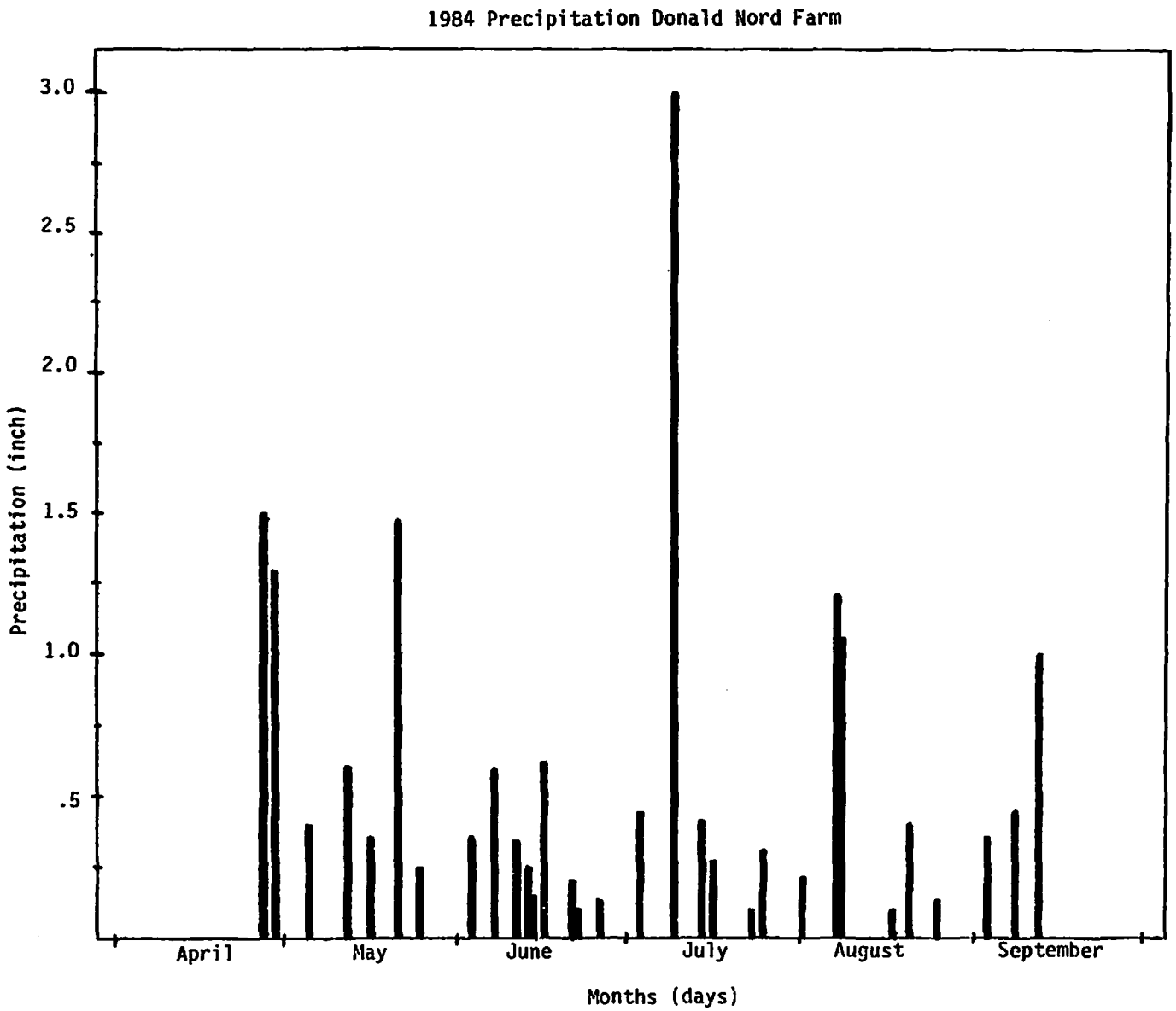


Figure 4: Precipitation at the SE site.



The Effect of Tillage on Corn and Soybean Production on a Typic Hapludalf Soil

J. F. Moncrief, J. Chaplin, D. Breitbach, C. Eberlein
T. L. Wagar, R. W. Hoff, M. P. Metz, and L. J. Svien

Demonstration plots were established on a Typic Hapludalf soil (Fayette, silt loam) in Wabasha County, Minnesota in the spring of 1984. The plot area has a slope of 2 to 6 percent. The farmer - cooperator (Francis Kottschade) idled the land in 1983 (PIK program) and planted it to sweet clover.

Soil Test and Fertilizer

The pH values range from 6.3 to 6.8. Soil P is generally in the high range (greater than 40). Soil K is in the medium to high range (200 - 300 lbs/A). The study area is remarkably uniform.

A row application of 12.5 gal/A of 7-21-7 was made at planting on all corn. This should have eliminated any limitation due to P and K at the soil levels of this site. Nitrogen was injected at 75 lbs/A as 28% urea-ammonium nitrate solution on the no-till, paraplow, and ridge till plots. No N was applied on chisel plowed plots. Research has shown that there will be less N released under no-till conditions after a legume. There should be adequate N released with the chisel plow treatment. The sweet clover stand was excellent.

Weed Control

Herbicide applications are summarized in table 1. The entire demonstration area received an application of Glyphosate (Round up). This was necessary to control a moderate stand of Quack and Bromegrass. Excellent weed control in the corn was obtained with a burndown application of 2,4-D ester plus dicamba (Banvel) followed by a preemergence application of alachor (Lasso) plus cyanazine (Bladex).

Soybean plots were split to evaluate a preemergence vs. post emergence weed control strategy. This comparison presented the following problems:

1. The glyphosate burndown on the preemergence plots (treatment A) did not adequately kill the sweet clover.

2. The soybeans had to be replanted due to crusting rains and resulted in disturbance of the preemergence treatment.

3. An accurate weed map was not available and several unanticipated weeds were present at moderate levels. This comparison will be made in 1985.

All tillage treatments received similar herbicide applications for both corn and soybeans.

Soil Cover

The soil cover with crop residue after planting corn is shown in table 2. The no-till and ridge till treatments are similar. At this point in time during the establishment year they are identical. There is about 25% less cover in the row than between with all tillage treatments except chisel plowing. "In" is defined as an 8 in. area centered on the row and "between" the remainder. The paraplow treatment resulted in about 10 to 15% less cover than no-till. The chisel plowing left much less residue and there was no difference in and between the row. Measurements were also made perpendicular to the rows and gave values similar to the weighted average of the in and between row measurements (data not shown).

The cover after planting soybeans is shown in table 3. Due to the late planting date and the narrow row drill (8 in. rows) with a 2 inch fluted coulter (Tye no till drill) the residue levels are generally lower than the corn plots. The same planter was used on both corn and soybean ridge till plots (Buffalo till in the no-till configuration). The measurements made perpendicular to the row is similar to the weighted average of the "in" and "between" values.

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Stands

The effect on tillage of plant populations is shown in table 4. Corn populations were similar for the no-till, paraplow, and ridge till treatments. The lower population associated with the chisel treatment is probably the result of a crusting rain which followed planting.

Due to the soil crusting at this site the soybeans were replanted in the no-till, paraplow and chisel treatments (narrow rows). These treatments had extremely low populations prior to replanting. The ridge till treatment was not replanted because the expected yield loss due to late planting was similar to the expected loss due to low population (about 10-15%). The other three treatments had similar stands after replanting. With the exception of the ridge till treatment in the soybean study plant populations would not be expected to limit yields.

Yields

Grain yields were measured by harvesting the center 8 rows of each corn plot and a 14 foot swath from the center of each soybean plot. Plot length measurements were made to be used in the yield calculation for each plot (~ 233 feet). A weigh wagon (± 1 lb) was used to determine plot grain weights.

Corn grain yields and moisture are shown in table 5. There is no significant difference in grain yields or moisture due to tillage. The chisel treatment had a severe infestation of leaf minor between the 8 and 12 leaf stage of growth in one plot which may be responsible for this lower trend in yields with this treatment.

Earleaf concentrations of N, P and K are shown in table 6. It is interesting to note that the chisel plow treatment resulted in higher N concentrations even though there was none applied. This is likely the result of slower mineralization and subsequent N release from sweet clover residue with the other tillage treatments. Lower K concentrations with extremes in tillage reduction are typical on these types of soils. Potassium or nitrogen would not be expected to be yield limiting in this study.

Soybean yields and moisture are shown in table 7. The soybeans grown with ridge tillage are pioneer 1677. All others are Dawson (see stand section). For this reason the ridge till treatment is excluded from the statistics analysis. Of the remaining treatments only the preemergence - no till treatment had a significantly lower yield. This was due to a poor control of the existing sweet clover sod with the burndown treatment (glyphosate). The tillage associated with the other treatments in conjunction with the glyphosate burndown eliminated any effect of the sweet clover on soybean yields. The pre vs. post-emergence comparison is of limited value for other reasons (see weeds). On July 4th all soybeans received an application of Bentazon (Basagran), poast, and crop oil (see table 1). Weed control was excellent under all treatments.

Summary

In spite of unforseen difficulties encountered this year there is still a valid comparison of most tillage treatments. After some difficulty excellent weed control was obtained in all plots. The lesson to be learned here is to get an accurate weed map the year prior to establishing a demonstration. Relying on farmer observations may be misleading. The crusting problem is something that must be accepted as a possibility on these silt loam soils. Crop residue appeared to lessen the severity of stand reduction.

Corn yields were similar regardless of tillage. When weeds were controlled soybean yields were also independent of tillage. This is an establishment year. It is not recommended to plant soybeans following a legume for obvious reasons.

In 1984 all tillage treatments and logistics of carrying out this demonstration have been established. This will enable the ultimate test of bottom line comparisons of four tillage strategies in southeastern Minnesota for corn and soybeans in 1985.

Information and Education Activities

This tillage demonstration plot generated a lot of interest in conservation tillage in Wabasha and surrounding counties. Despite the fact that this was an establishment year a number of activities were carried out.

Two field tours were conducted. One tour was held for cooperating agency field staff. This included SCS, Extension, SWCD and ASCS personnel with approximately 40 people attending. A second tour was conducted for the general public with approximately 60 area farmers attending.

A large sign was placed at the site to identify the project and the cooperating agencies. Local SCS and Extension Field staff prepared a number of news articles. This local publicity resulted in numerous individual farmer visits to observe crop growth and weed control. These are estimated at approximately 50 plot visits. Results from the plots will be utilized at farmer meetings being planned for early 1985.

Interest and enthusiasm remain at a high level for continuing this project in 1985. One anticipated benefit from this project was that it would generate interest in establishing demonstration plots in other surrounding counties. This is being done in an adjoining Major Land Resource Area and will serve as a demonstration site for a new cluster for counties.

Table 1. Management practices at the Wabasha County, Minnesota site in 1984.

Management Practice	Remarks	Date
Soil samples	10 core composites 0-6 in.	April 9
Burndown Corn	Sweet Clover 8 in. tall 2, 4-D ester .5 lbs/A Dicamba .25 lbs/A Glyphosate 2 lbs/A	May 10
Soybeans	A. Glyphosate 21 lbs/A or B. Poast .19 lbs/A + Petroleum oil 1 qt./A + 2, 4-D ester .5 lbs/A	
Inject N	28% Urea Ammonium Nitrate Solution 75 lbs/A All tillage treatments except chisel plowing	May 14
Corn Planted (Pioneer 3906)	25,500 plants/A Buffalo till planter in no-till configuration (38 inch rows)	May 16
	All tillage treatments except chisel plowing chisel plots planted	May 16 May 18
Row fertilizer	All corn plots received 12.5 gal/A of 7-21-7	
Soybeans planted (Pioneer 1677)	225,000 plants/A Tye no till drill 10 inch rows (38 inch rows Ridge till)	May 18
Preemergence Herbicide on corn	Cyanazine (Bladex) 1.5 lbs/A + Alachlor (Lasso) 2 lbs/A	May 22
Preemergence Herbicide on soybeans (treatment A)	A. Alachlor 2 lbs/A (Lasso) + Metribuzin .25 lbs/A (Sencor) + Chloramben 2.4 lbs/A (Ambiben) Glyphosate 2 lbs/A (Roundup) (all soybean plots)	May 23
Rotary hoe over all plots		May 30
Soybeans replanted Dawson	10 inch rows - no-till Paraplow, and Chisel	June 11

Post emergence Herbicide on soybeans (treatment B)	B. Bentazon 1 lb/A (Basagran) + crop oil 1 qt./A	June 19
Cultivate	Ridge corn (38 inch rows) Cultivate soybeans (38 inch rows)	July 2
Post emergence Herbicide on all soybeans	Bentazon 1 lb/A (Basogran) + Poast .5 lb/A + Crop oil 1 qt/A	July 4
Cultivate	Ridge soybeans (38 inch rows)	July 20
Harvest	All plots (4 row combine)	Oct. 24
Tillage	Chisel Plow Paraplow	Nov. 8 Nov. 14

Table 2. The effect of tillage on percent soil cover on June 7, 1984 after planting to corn.[1]

	Position Relative to Row		
	In	Between	Perpendicular
	percent		
No-till	59.0 (15.1)	84.5 (8.4)	80.3 (8.7)
Paraplow	43.3 (14.4)	71.0 (11.3)	69.5 (14.2)
Ridge Till	56.0 (17.3)	83.3 (15.3)	84.3 (9.3)
Chisel	16.8 (7.6)	16.3 (8.5)	19.0 (8.9)

[1]Numbers in parenthesis represent the standard deviation, n=16

Table 3. The effect of tillage on percent soil cover on June 27, 1984 after planting to soybeans.[1]

	Position Relative to Row		
	In	Between	Perpendicular
	percent		
No-till	59.5 (16.7)	55.5 (8.5)	61.5 (10.4)
Paraplow	48.3 (17.8)	50.0 (15.3)	46.0 (10.6)
Ridge Till	70.0 (11.8)	80.5 (8.1)	77.0 (7.1)
Chisel	9.0 (5.0)	9.0 (4.3)	7.3 (4.2)

[1]Numbers in parenthesis represent the standard deviation, n=16.

Table 4. The effect of tillage on corn and soybean stands on June 7 and 27th respectively.[1]

	Corn	Soybeans[2]
	Plants $A^{-1} \times 10^3$	Plants $A^{-1} \times 10^3$
No-Till	24.9 (4.2)	184 (23)
Paraplow	26.8 (3.2)	172 (41)
Ridge Till	26.3 (3.9)	55 (12)
Chisel	21.6 (3.1)	191 (35)

[1]Numbers in parenthesis represent standard deviation, n=16 and 8 for corn and soybeans respectively.

[2]Because of poor stand soybeans were replanted on June 11 with the exception of the ridge till treatment.

Table 5. The effect of tillage on corn yields following sweet clover (Wabasha Co., MN 1984).

Tillage	Yield Bu/A^{-1} @ 15.5%	Harvest Moisture (%)
No-till	154	24.7
Ridge Till	148	24.9
Paraplow	154	24.6
Chisel Plow	146	25.0

Table 6. The effect of tillage on corn ear leaf concentrations of N, P, and K (Wabasha Co., MN 1984).

Tillage	N	P	K
	----------	%	----------
No-Till	2.07	.29	1.80
Ridge Till	3.08	.29	1.57
Paraplow	2.97	.28	1.63
Chisel Plow	3.22*	.29	2.07*

*α= .10, n = 4

Table 7. The effect of tillage and weed control strategy on soybean yields (Wabasha Co., MN 1984).

	Pre	Post	Moisture %	
Tillage	Bu A^{-1}	Bu A^{-1}	Pre	Post
No-Till	40.3*	43.4	15.6	15.9
Ridge Till[1]	35.0	34.2	17.2	17.5
Paraplow	46.7	45.1	15.6	15.5
Chisel	43.7	44.0	15.6	15.5

[1]All treatments but ridge till were replanted, making an analysis including this treatment invalid.

*$\alpha = .10$, $n = 4$.

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

J.F. MONCRIEF, S.D. EVANS, AND A.E. OLNESS

Recently there has been much interest in the interaction between corn hybrid and N response. Tsai et al. evaluated 16 corn hybrid responses to N fertilizer (spring applied as anhydrous ammonia). They grouped hybrids into three N reponse types: 1. low fertility types, moderate fertility types, and high fertility types. Low fertility types didn't respond beyond 60 lbs N/A. High fertility types responded over the entire range of applied N (400 lbs N/A). They hypothesize three possible responsible mechanisms for differences: 1. ability to absorb late season N, 2. rate of grain N assimilation, and 3. duration of grain filling. The economic implications and obvious.

There is also local data from Minnesota suggesting differences in N response between hybrid. Geadelmann tested 45 hybrids on a loamy sand soil over a range in applied N (0-300 lbs N/A) under irrigation and found similar results. A study under dryland conditions comparing two hybrids also resulted in differences (Randall and Walters, 1984).

There have also been numerous studies showing reduced N availability under extremes in tillage reduction with a continuous corn sequence. (Moncrief, et al., 1984; Malzer et al., 1984). One suspected mechanism for reduced N availability is immobilization of applied N which would result in N becoming available later is the season when some hybrids would be unable to utilize it. Other suspected mechanisms are reduced mineralization and increased denitrification.

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

Methods: The experimental site is located in west central Minnesota on a Pachic Udic Haploboroll (Tara, silt loam) soil. The experimental design is a split plot with tillage main plots, N rate subplots, and corn hybrid sub-subplots. There are four replications. Treatments are summarized in Table 1. Weed control was obtained with Alochlor (Lasso) 3 lbs/A + Cyanizine (Bladex) 2.2 lbs/A applied preemergence. There was excellent weed control. Row fertilizer was applied at planting (9.4 gal of 7.4-25-0).

RESULTS AND DISCUSSION

Yields: The relationship between tillage and soil cover, stand and harvest index are shown in Table 2 and 3. Moldboard plowing resulted in a considerable amount of cover. The ridge till and chisel had similar cover although most was between the row with the ridge till treatment. It is interesting to note the interaction between tillage and stand. There is a significant reduction under no till conditions with the Dekalb hybrid. This may be the result of susceptability of this hybrid to residue borne disease. This will be investigated more thoroughly in 1985.

Grain yields are shown on Table 4. Due to above average rainfall in June (figure 1) corn generally responded over the entire range in applied N. At a given level of applied N grain yields were higher with the Pioneer hybrid. Although the tillage X N rate interaction is not significant (R value = 81), the no till treatment tended to reach a plateu at the intermediate rate of applied N. The other tillage treatments continued to respond beyond this rate.

The pioneer hybrid had a more favorable harvest index (HI). Both hybrids had about the same stover yield. The ridge till treatment resulted in the highest HI. This has been shown in other Minnesota research (Moncrief et al., 1984). There was also an interaction between N rate and hybrid (fig. 2). At the higher N rates both hybrids had similar harvest indexes. This may be related to time of N uptake. Studies which had a time of application variable show late N to increase HI.

Moisture Stress: Tillage changes levels of soil moisture, soil hydraulic conductivity, and root distribution. One way of estimating the integrated effects of many interacting changes is to measure the moisture stress in the plants themselves. The potential energy of the moisture in the plants

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under high evaporative demand are shown in Table 5. With the exception of the early morning reading (0545) on July 18, which was beyond the sensitivity of the instrument, P 3906 showed less stress than the DXL8 hybrid. There also was an absence of any interaction with tillage. Generally the ridge till treatment shows the highest stress, again independent of hybrid. Stress levels below -8 bars are considered moderate and as anticipated the differences in stress due to tillage did not show up in grain yields. Interestingly, the moldboard and no till treatment appear to have similar stress. The chisel treatment changes in rank from low to high with time.

These measurements were made at tassel and silk emergence. Other research has shown this to be related to yields if stress in excess of -10 bars is encountered at this time (Moncrief, 1981). Soil moisture levels are shown in Table 6. These data support the stress measurements.

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Table 1: Treatment summary at Morris, MN 1984

Treatment	
Tillage:	Fall Moldboard plow Fall Chisel plow Ridge till No till
N Rate:	0, 40, 80, 120, 160 lbs N/A applied Oct. 27, 1983 prior to tillage as anhydrous ammonia
Hybrid:	Pioneer 3906 Dekalb XL8

Table 2: Probability levels of treatment effects on measured variables.

Source	% Cover	Yield Grain	Yield Total	Harvest Index*
Tillage	99	95	97	67
Nitrogen	98	99	99	99
Till X N	86	81	32	25
Hybrid	51	99	99	99
Till X Hybrid	63	61	53	90
N X Hybrid	43	62	87	99
Till X N X Hybrid	82	42	93	60

*Harvest index is defined as the ratio of ear dry matter over total.

Table 3: The effect of tillage and hybrid on stand and harvest index.

Tillage	Percent Cover	Stand P 3906	Stand D XL8	Harvest Index* P 3906	Harvest Index* DXL8
	%	---plants/A X 10^3--			
Moldboard	16.4	26.6	20.8	58.2	54.6
Chisel	54.7	27.7	28.0	57.4	54.6
Ridge till	54.3	27.0	28.1	60.1	57.1
No till	86.2	28.2	29.1	58.7	52.5

* Harvest index is defined as the ratio of ear yield to total.

Table 4: The effect of tillage and corn hybrid on grain yields (Morris, MN, 1984).

N Rate (lbs/A)	Tillage	Pioneer 3906	Dekalb XL8
		---Bu/A---	
	No Till	116	106
N = 160	Ridge Till	137	125
	Chisel	128	120
	Moldboard	135	126
	No Till	117	97
N = 120	Ridge Till	128	103
	Chisel	120	98
	Moldboard	129	121
	No Till	117	82
N = 80	Ridge Till	120	99
	Chisel	120	95
	Moldboard	118	111
	No Till	95	78
N = 40	Ridge Till	93	75
	Chisel	99	88
	Moldboard	102	87
	No Till	63	48
N = 0	Ridge Till	72	61
	Chisel	86	56
	Moldboard	82	61

Table 5: The effect of tillage and hybrid on leaf water potential at Morris, MN, 1984.

Date	Time	Hybrid	Tillage[1] No Till	Ridge Till	Chisel	Moldboard	Significance[2] Till	Hybrid	Till X Hyb.
			(- bars)						
7/18	1345	P 3906	8.4 (1.1)	8.6 (.33)	7.0 (1.1)	7.3 (1.1)	*	*	
		DXL8	8.9 (7.2)	10.1 (.37)	8.6 (.51)	9.6 (.28)			
	0545	P 3906	.65 (.10)	.63 (.13)	.68 (.10)	.58 (.05)			
		DXL8	.68 (.15)	.68 (.10)	.83 (.05)	.65 (.10)			
7/19	0950	P 3906	3.5 (.76)	3.4 (.17)	2.8 (.44)	3.3 (.21)	*	*	
		DXL8	4.2 (1.1)	4.8 (.66)	3.7 (.89)	4.0 (.40)			
	1305	P 3906	4.9 (.93)	5.4 (1.1)	5.3 (.52)	4.4 (1.1)	*	*	
		DXL8	5.5 (.46)	7.0 (1.4)	6.7 (.94)	5.5 (.97)			
7/26	1955	P 3906	2.0 (.30)	2.2 (.33)	2.0 (.31)	2.3 (.44)		*	
		DXL8	2.5 (.63)	3.1 (.78)	2.6 (.49)	2.8 (.40)			
7/21	0920	P 3906	1.5 (.49)	1.9 (.56)	1.7 (.17)	1.6 (.46)		*	
		DXL8	1.8 (.77)	2.4 (.90)	2.2 (.52)	2.1 (.35)			
	1340	P 3906	4.4 (.95)	6.1 (1.4)	5.3 (.98)	4.8 (1.5)	*	*	
		DXL8	6.4 (1.3)	7.7 (.84)	6.7 (.53)	5.9 (1.6)			

[1]Numbers in parentheses represent the standard deviation.
[2]Treatments with asterisk are significant at a probability level of 90.

Table 6: The effect of tillage on soil moisture distribution on July 27, 1984, Morris, MN

	Depth 0-6	6-12	12-18	Avg.
	% by wt.			
No Till	23.3	25.6	22.4	23.7
Ridge Till	21.5	23.2	19.8	21.5
Chisel	21.0	22.8	20.9	21.6
Moldboard	22.8	27.4	23.7	24.6

Figure 1: Precipitation, Morris 1984.

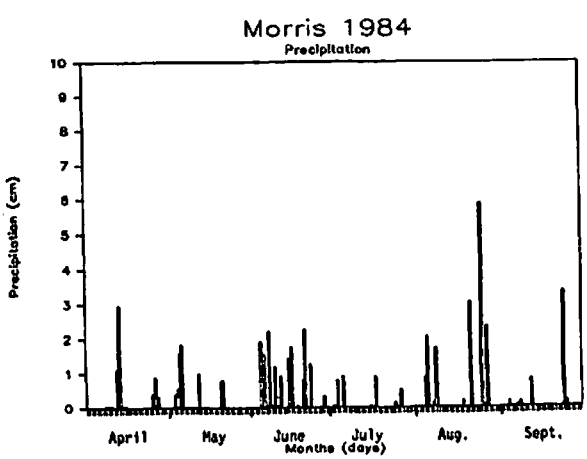
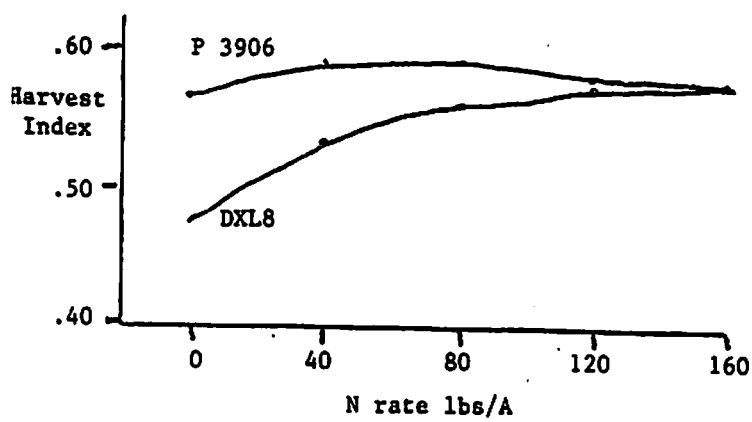


Figure 2: The effect of N rate and hybrid on harvest index.



EFFECT OF TILLAGE AND FREQUENCY OF MANURE APPLICATION ON N-UPTAKE AND CORN YIELD - 1983-1984 SUMMARY

J. Swan, J. Moncrief, P. Burford, and B. Schreiber

Cooperator: Dale Flueger

The purpose of this study is to determine the effect of tillage and of frequency of manure application on corn yield and on N uptake. A second purpose is to determine the amount of nitrogen take up from manure applications applied one and two years prior to the current cropping year.

Procedure: Liquid dairy manure is injected either annually, biennially or triennially on chisel plowed treatments and annually or biennially on no-till treatments. Yields are compared with check treatments which receive broadcast potassium and starter phosphorus but no nitrogen fertilizer and with "fertilized check" treatments receiving high rates of N, P and K. The tillage treatments, site, cropping history and herbicide applications are identical with those described in "The Effect of Tillage and Potassium Placement on the Availability of Potassium to Corn" in the 1983 and 1984 bluebook. Nitrogen and potassium uptake are measured and reference nitrogen measurements are made annually on selected plots.

In summary, the greater amount of nitrogen mineralized following tillage with the chisel plow appears the most likely explanation for the greater yields measured on the checks and carryover application treatments following chiseling compared to no-till planting. The yield of the biennial carryover treatment on no-till was significantly lower than current applications in both 1983 and 1984. Yields from the biennial carryover treatments were not significantly different than yields from current applications for chisel plowing in either 1983 or 1984. The check treatments were significantly lower in yield than all other chisel or no-till treatments.

Average concentrations of N, P and K in the liquid manure are quite consistent (table 2). On the average, slightly more than one-half the nitrogen was in the ammonium form.

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

Table 1. Corn Yield - Bu/Acre

Manure Application	1984		1983	
	No Till	Chisel	No Till	Chisel
None	66.4 c	85.7 c	82 c	95 c
Annual	144.9 a	163.4 a	129 a	133 a
Biennial				
Current yr	155.3 a	157.4 ab	123 a	117 b
Carryover from previous year	101.1 b	133.4 ab	107 b	122 ab
Triennial				
current yr	----	149.1 ab	----	----
Carryover from previous year	----	125.1 b	----	----
Carryover from 2 years previous	----	128.1 ab	----	----
Significance level	5%	5%	5%	5%

All yields are the average of 3 reps.
All years and tillage systems are analyzed separately.

Table 2. Nutrient analysis of liquid dairy manure from Dale Flueger farm for 1982, and 1983.

	Concentration of Liquid Manure		
	1982 Spring	1983 Spring	1983 Fall
NH_3-N	0.185%	0.1735%	0.177%
Total N	0.365%	0.3060%	0.348%
% Solids	7.21%	6.99%	7.35%
Phosphorus	624 ppm	(10260 ppm) (solids)	672 ppm
Potassium	1895 ppm	(34940 ppm) (solids)	2443 ppm

	Amount of N, P_2O_5 and K_2O in 9000 Gal. of Liquid Dairy Manure			
	1982 Spring	1983 Spring	1983 Fall	Avg.
	lbs/acre			
NH_3-N	139	130	133	134
Total N	274	230	261	255
P_2O_5	106	128	114	116
K_2O	171	221	221	204

THE EFFECT OF TILLAGE ON SOYBEAN PRODUCTION IN MINNESOTA

J.F. Moncrief, W.E. Lueschen, S.D. Evans, J.H. Ford, W.W. Nelson
G.W. Randall, D.D. Warnes, W.C. Stienstra, and D.R. Hicks

Conservation tillage has gained recent impetus due to a higher level of public awareness of the importance of soil erosion control and the potential for reducing production inputs to ease the economic squeeze present day farmers are experiencing. Soybeans are a major crop in Minnesota. In 1982 a study designed to assess the effect of tillage on soybean production was established at three locations (the Morris, Lamberton, and Waseca Ag. Exp. Sta.).

Methods: The experimental sites represent diverse climatic and soil conditions. Generally the Morris and Lamberton sites have lower rainfall than the Waseca site. The Morris site has a shorter growing season than the other two. The Lamberton and Waseca sites are on soils with aquic suborders although both are well tiled. The Morris site has better natural internal drainage. Soybeans followed corn at all sites. At Morris they were also preceeded by spring wheat. The various management practices utilized at each site is shown in Table 1. There was a very agressive weed control program at each site and in some instances several post emergence applications were made to control weeds. Excellent weed control was obtained at all sites.

RESULTS AND DISCUSSION

Cover: Soybeans were planted in both 10 and 30 inch rows. The till plant treatment was managed with and without a ridge. A Buffalo planter was used at Lamberton and Waseca and a Hiniker at Morris for the till plant treatment (all equipped with clearing discs). An Almaco no till drill was used for all other tillage treatments (both 10 and 30 inch rows).

Stalks were chopped for the fall chisel plow (fall), till plant (fall for ridged and spring for non ridged). Ridges were built during the corn year. Soybeans were not cultivated.

The soil surface covered with residue is shown on Table 2. At the Morris and Waseca locations cover with fall moldboard plowing ranged from 5 to 20 percent. At Lamberton there was a wider range in cover following this treatment. Chisel plowing in the fall resulted in similar cover to the spring disc (tandem finishing disc) treatment at Waseca but varied by crop and year at the other two sites. No till wheat resulted in higher cover than corn at Morris. No till after corn at the other two locations resulted in more cover than Morris.

The till plant treatment was quite variable in the amount of cover. When ridges are built in the fall after spring wheat, straw is moved into the ridge. During the planting operation, this straw is exposed. The result is a fairly high amount of cover in the row. The cover in the row ranged from 22 to 70 percent with this treatment. The cover in the row after a corn crop ranged from 2 to 53 percent. This variability is the result of moisture content of stover at planting, setting of tillage depth on the planter, and speed. This illustrates the wide variation that can be obtained with this tillage approach. Generally there is more cover in the row after corn with the non-ridged treatment and the converse following wheat. This is the result of concentrating the straw in the ridge during ridge formation and in the case of corn residue, reduced depth of tillage during planting with the non-ridged treatment. With the range in soil cover established by tillage in this study there would also be extremes in soil temperature, moisture, and aeration due to tillage.

Grain Yields: The levels of signficance for treatment effects are shown in Table 3. Morris is analyzed separately due to fewer replications (4 vs. 6 at other two locations) and a better drained soil. There are two analyses for each site grouping. The first includes row spacing treatment (10" vs. 30") but excludes the till plant treatments. The other is for 30" row spacing only and includes the till plant treatments. Treatments which had significant effects on soybean yields but are not discussed are: row spacing (10" 30"), and planting date (early late, only early is presented).

At the Morris location there is a significant interaction between preceeding crop, year, and tillage, on soybean yields. This is illustrated in figure 1. In 1982, no till soybeans grown after wheat resulted in a lower yield but not after corn. Several no till (after wheat) plots were located in a lower spot in the field and suffered frost damage in 1982 and this be responsible for the lower

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yields with this treatment (both row spacings). In 1983 the no till soybeans outyielded the other tillage treatments in 10" rows. Yields were similar in 1984. Yields after wheat were higher each year presumably due to earlier recharge after wheat and higher soil moisture levels going into the season.

It appears that there may be an advantage to less soil cover in the row with the till plant treatment. The "till plant-flat" treatment generally has less cover in the row after wheat than the ridged treatment. The opposite is the case after corn. The soybean yields are also ranked in the same direction. This may illustrate an advantage of a clean row area with 30" soybeans. The narrow row soybeans grown under no till conditions generally yielded as well as a cleaner treatment, however.

At the Waseca and Lamberton sites there was a significant interaction between year, location, and tillage. Yields are shown in figure 2. At Waseca, the no till, chisel, and spring disc are similar (10" rows) and the moldboard treatment tended to fluctuate with year.

This may be due to differences in precipitation. Growing season precipitation is shown in figure 3 a, b, and c for Morris, Waseca, and Lamberton respectively. In 1983 there was an extremely dry July and first half of August at Waseca. At the Lamberton site the chisel treatment appears to be quite variable. This is most likely due to the soil moisture level at the time of fall tillage. In wet falls chiseling was detrimental.

At both the Waseca and Lamberton sites, the till plant-ridged treatment appeared to show an advantage in 1982 and 1983. In 1984, there was little or no advantage to the ridged treatment over the flat.

SUMMARY

The effects of tillage on soybean yields at three locations and years in Minnesota varied by both location and year. At the west-central site over the three years and two crops, tillage main effects were non-significant. Performance of a ridged vs flat treatment appeared to be related to cover in the row. At the Lamberton and Waseca sites, the tillage treatments appeared to be the most variable in their relative ranking.

Within the range in soil types and climate of this study it appears that there is no consistant effect of tillage on soybean yields.

Table 1A: Management variables of tillage-soybean study for 1982, 1983, and 1984 at Morris.

		Morris		
		1982	1983	1984
Soil Type		Pachic Udic Haploboroll (Aastad, clay loam)	Udic Haploboroll (Barnes, clay loam)	Pachic Udic (Aastad, clay loam)
Soil test	pH			6.9 - 7.5
lbs/A	P	59		26 - 56
	K	32		384 - 600+
Fertilizer Applied	N	96		
lbs/A	P_2O_5	396		
	K_2O	204		
Date applied (Broadcast)		1/2 Oct 1980 1/2 April 1982		
Soybean variety		Evans	Evans	Evans
Planting Date		May 6	May 2-3	May 2-3
Herbicide Program	Preemergence	Lasso 3	Lasso 3	Lasso 3
		Amiben 2.5	Amiben 2.5	Amiben 2.5
lbs/A		May 6	May 4	May 4

Table 1A: (cont.)

Postemergence soil is applied at 1 qt/A as concentration at 1 qt/A as concentrate	Poast .29 + Oil June 8 (spot spray)	Basagran 1 + Oil June 23	Basagran 1 + Poast Oil June 20
	Poast .29 + Oil June 16	Roundup + 1% solution Hand wick June 17 (for perennials)	
	Poast .19 + Oil July 16	Poast .38 + Oil July 22	

Table 1B: Management variables of tillage-soybean study for 1982, 1983, and 1984 at Lamberton.

		Lamberton		
		1982	1983	1984
Soil Type		Cumulic Haplaquoll Typic Haplaquoll (Ves - Webster clay loam)	Typic Haplaquoll Typic Haplustoll (Webster Delft clay loam)	Cumubic Haplaquoll Typic Haplaquoll (Ves - Webster clay loam)
Soil test	pH			
lbs/A	P	56		
	K	176		
Fertilizer applied	N			
lbs/A	P_2O_5	100	100	
	K_2O	100	100	
Date applied		Fall	Fall	
Soybean variety		Corsoy 79	Corsoy 79	Corsoy 79
Planting Date		May 1	May 12	May 18
Herbicide Preemergence Program lbs/A		Lasso 3 + Amiben 2.5 May 1	Lasso 3 + Amiben 2.5 May 16	Lasso 3 + Amiben 2.5 + Roundup .75 May 19
Postemergence oil is applied at 1 qt/A as concentrate			Basagran 1 + Poast .2 June 8	Basagran 1 + Oil June 29
				Poast .2 + Oil July 2

Table 1C: Management variables of tillage-soybean study for 1982, 1893, and 1984 at Waseca.

		Waseca		
		1982	1983	1984
		Typic Haplaquoll (Webster, clay loam)	Typic Haplaquoll (Webster, clay loam)	Typic Haplaquoll (Webster, clay loam)
Soil test	pH			7.5
lbs/A	P	55	70	75
	K	475	475	520
Soybean variety		Corsoy 79	Corsoy 79	Corsoy 79
Planting Date		April 28	April 30	May 11
Herbicide Preemergence		Lasso 3	Lasso 3	Lasso 3
		+	+	+
Program		Amiben 2.5	Amiben 2.5	Amiben 2.5
lbs/A		April 28	May 10	May 11
Postemergence		Basagran 1.5	Basagran .75	Poast .2
oil is applied		+	+	
at 1 qt/A is concentrate		Poast .2	Poast .2	July 2
		+	+	
		Oil	Oil	
		July 1	June 25	

Table 2: The effect of tillage and previous crop on percent soil covered by crop residue after planting.

Location:	Morris											
Year:	1982				1983				1984			
Previous Crop:	Wheat		Corn		Wheat		Corn		Wheat		Corn	
Row Spacing:	10"	30"	10"	30"	10"	30"	10"	30"	10"	30"	10"	30"
Tillage:												
Moldboard	12	10	12	15	5	5	8	10	8	10	11	15
Chisel	36	34	43	35	20	17	21	34	16	19	30	33
Spring Disc	47	53	47	46	18	19	38	36	27	27	50	50
No Till	97	96	79	76	79	83	54	58	85	89	71	74
Till Plant												
In Row		58		32		22		8		29		17
Flat Between Row		66		63		68		58		85		60
Ridged In Row		70		24		29		11		49		12
Between Row		81		77		62		52		60		52

Location:	Lamberton					
Year:	1982		1983		1984	
Previous Crop:	Corn					
Row Spacing:	10"	30"	10"	30"	10"	30"
Tillage:						
Moldboard	34	23	6	7	11	18
Chisel	55	57	45	49	50	50
Spring Disc	58	54	49	56	56	51
No Till	82	71	74	84	89	90
Till Plant						
In Row		45		32		53
Flat Between Row		60		76		76
Ridge In Row		54		24		40
Between Row		75		43		69

Location:	Waseca					
Year:	1982		1983		1984	
Previous Crop:	Corn					
Row Spacing:	10"	30"	10"	30"	10"	30"
Tillage:						
Moldboard	20	18	11	11	10	15
Chisel	49	51	36	31	37	37
Spring Disc	49	49	35	32	28	28
No Till	86	91	84	83	80	77
Till Plant						
In Row		41		37		22
Flat Between Row		46		65		77
Ridge In Row		25		12		2
Between Row		28		32		26

Table 3A: Levels of signficance of treatment effects on soybean yields at Morris, MN for 1982, 1983, and 1984. Morris is analyzed separately due different soil type, and replication (4 vs. 6 at other two locations). The are two analysis of varience for each site grouping. One includes row spacing treatments (10" vs. 30") but excludes the till plant treatments. The other is for the 30" row spacing only and includes the ridge till treatments.

Morris

Source	
yr[1]	100
cp[2]	99
Yr x cp	99
Blocks (yr x cp)	--
Till[3]	30
Yr x Till	80
Cp x Till	97
Yr x Cp x Till	97
Blocks (Yr x Cp x Till)	--
PD[5]	100
Yr x PD	100
Cp x PD	71
Yr x Cp x PD	86
Till x PD	47
Cp x Till x PD	29
Yr x Till x PD	62
Yr x PD x Till x Cp	4
Blocks x PD(YR x PD x Till)	—
RS[5]	100
Yr x Rs	100
Ca x Rs	94
Till x Rs	14
PD x Rs	56
Cp x Yr x Rs	75
Yr x PD x Rs	94
Cp x Till x Rs	55
Yr x Till x Rs	59
Till x PD x Rs	60
Cp x PD x Rs	99
Cp x Yr x Till x Rs	24
Cp x Till x PD x Rs	41
Cp x Yr x PD x Rs	93
Yr x Till x Pd x Rs	99
Cp x Yr x Till x PD x Rs	68
Blocks x Rs (Yr x Cp x Till x PD)	—

Source	
yr[1]	100
cp[2]	100
Yr x cp	100
Block (yr x cp)	—
Till[4]	14
Yr x Till	73
Cp x Till	100
Yr x Cp x Till	99
Blocks x Till (Yr x Cp)	--
PD[5]	100
Yr x PD	99
Cp x PD	26
Yr x Cp x PD	97
Till x PD	84
Cp x Till x PD	65
Yr x Till x PD	52
Yr x Cp x Till x PD	55
Blocks x PD (Yr x Cp x Till)	—

1. Years: 1982, 1983, 1984
2. Previous Crops: Wheat and Corn
3. Tillage: moldboard plow, chisel plow, spring dics & no till
4. Tillage: moldboard plow, chisel plow, spring dics, till plant-ridge, and till plant no ridge
5. Planting Date: early (4/28-5/18) and late (5/20-6/2)

Table 3A: Levels of signficance of treatment effects on soybean yields at Waseca and Lamberton, MN for 1982, 1983, and 1984.

Waseca and Lamberton			
Source		Source	
Yr[1]	100	Yr[1]	100
Loc[2]	99	Loc[2]	98
Yr x Loc	100	Yr x Loc	100
Blocks (Yr x Loc)	--	Blocks (Yr x Loc)	--
Till[3]	95	Till[3]	99
Yr x Till	92	Yr x Till	100
Loc x Loc	53	Loc x Till	84
Yr x Loc x Till	95	Yr x Loc x Till	90
Blocks x Till (Yr x Loc)	--	Blocks x Till (Yr x Loc)	--
PD[4]	100	PD[4]	100
Yr x PD	90	Yr x PD	70
Loc x PD	100	Loc x PD	100
Yr x Loc x PD	100	Yr x Loc x PD	100
Till x PD	43	Till x PD	51
Loc x Till x PD	67	Loc x Till x PD	82
Yr x Till x PD	66	Yr x Till x PD	44
Yr x Loc x Till x PD	83	Yr x Loc x Till x PD	8
Blocks x PD (Yr x Loc x Till)	--	Blocks x PD (Yr x Loc x Till)	--
Rs[5]	100		
Yr x Rs	83		
Loc x Rs	15		
Till x Rs	7		
PD x Rs	39		
Yr x Loc x Rs	7		
Yr x PD x Rs	5		
Loc x Till x Rs	25		
Yr x Till x Rs	43		
Till x PD x Rs	67		
Loc x PD x Rs	43		
Yr x Loc x Till x Rs	87		
Loc x Till x PD x Rs	31		
Yr x Loc x PD x Rs	20		
Yr x Till x PD x Rs	83		
Yr x Loc x Till x Pd x Rs	88		
Blocks x Rs (Yr x Loc x Till x PD)	--		

Figure 1: The effect of tillage previous crop, row spacing, and year on soybean yields at Morris, MN.

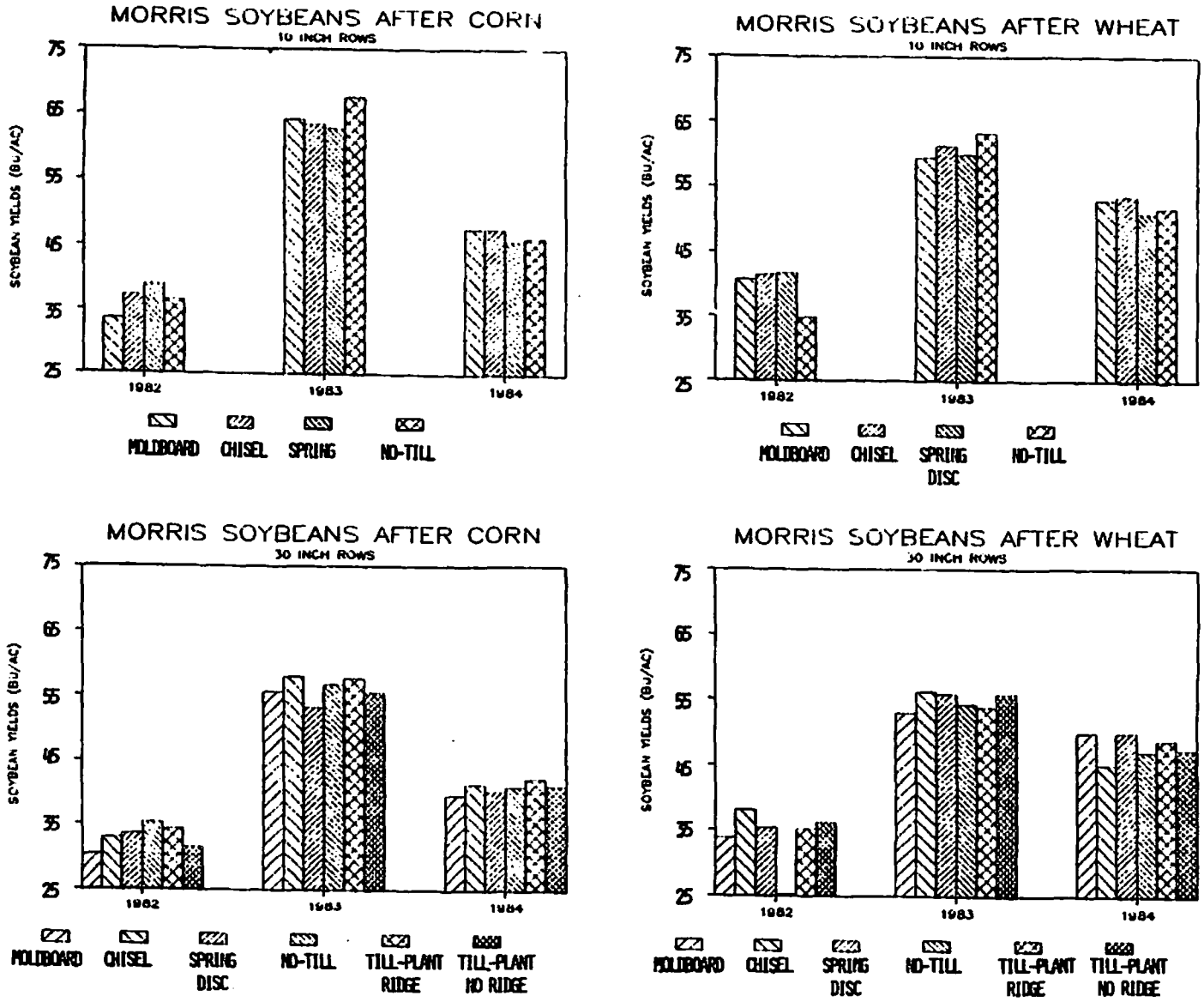


Figure 2: The effect of tillage, row spacing and year in soybean yields at Lamberton and Waseca, MN.

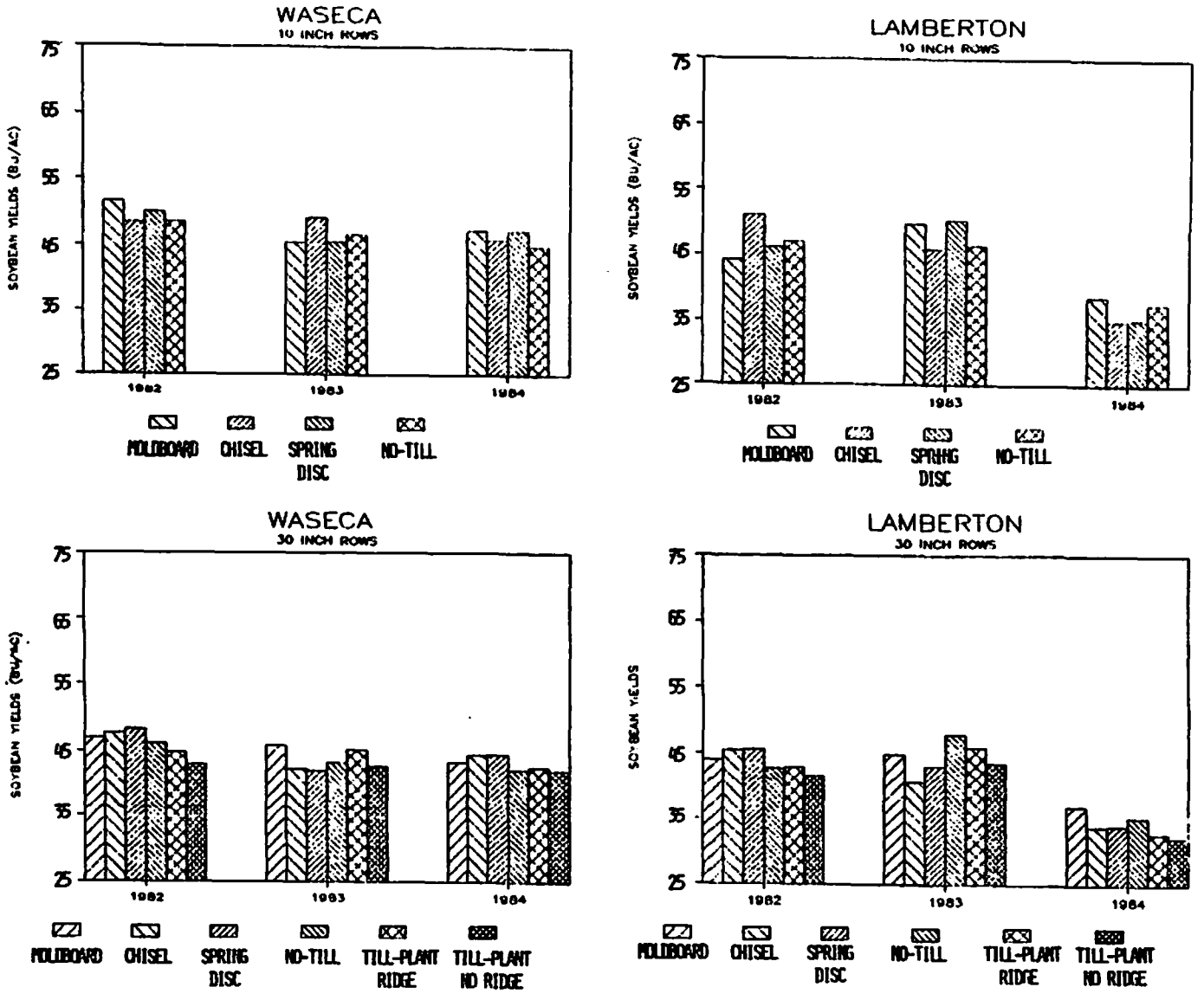
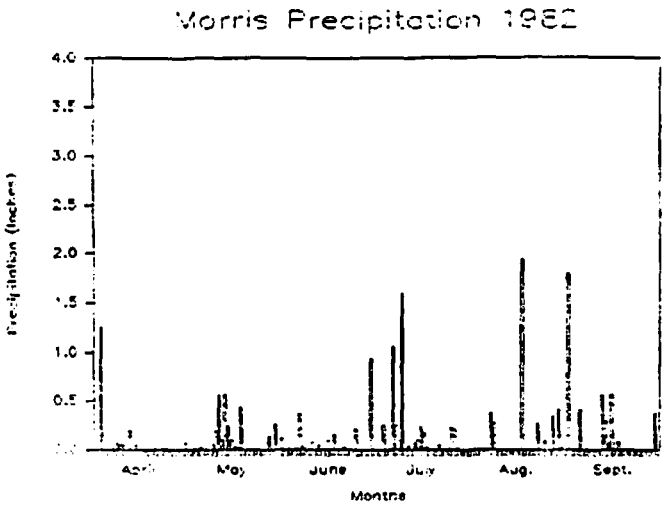
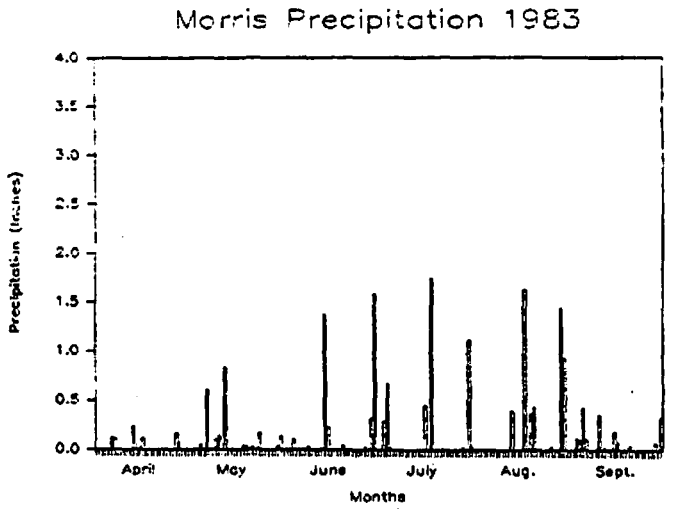


Figure 3a: Growing season precipitation for Morris respectively for 1982, 83,84.





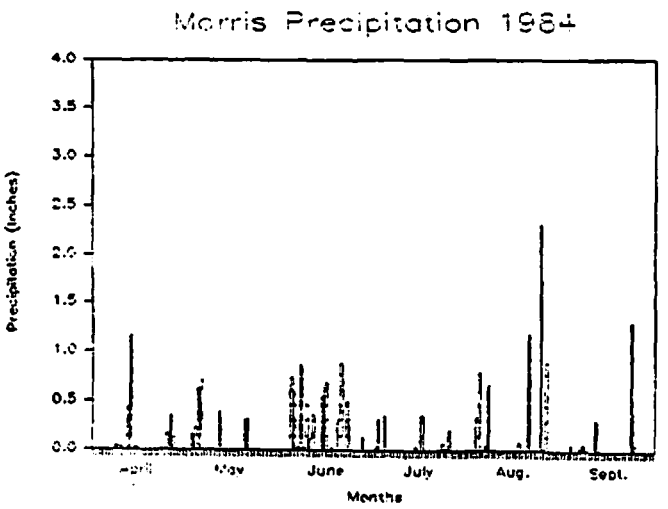
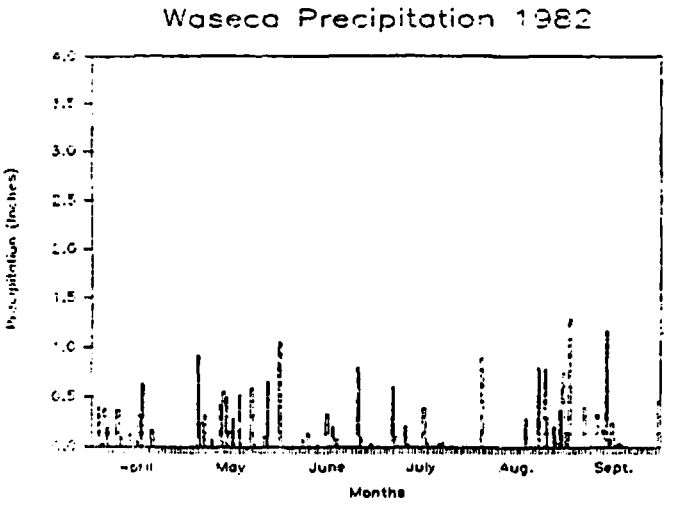
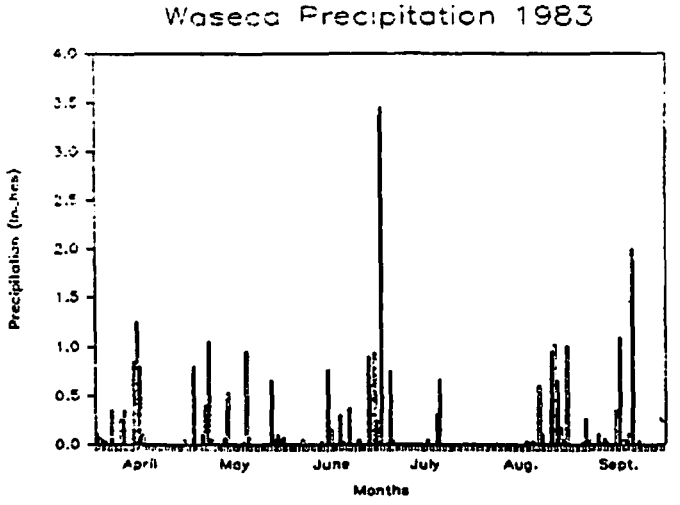


Table 3b: Growing season precipitation for Waseca respectively for 1982, 83, 84.





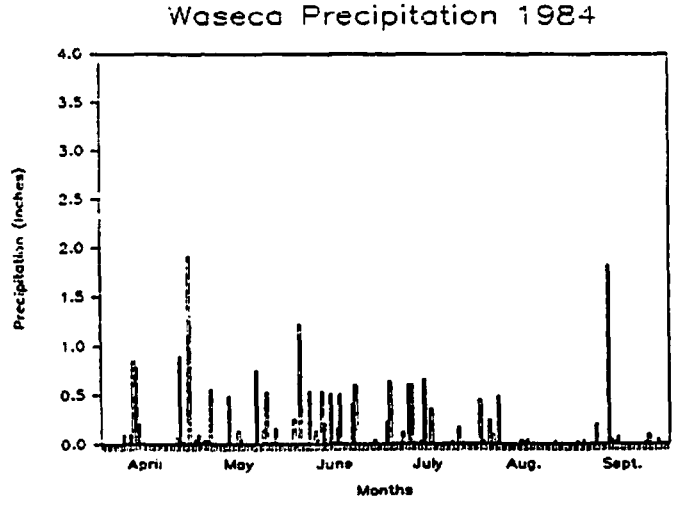
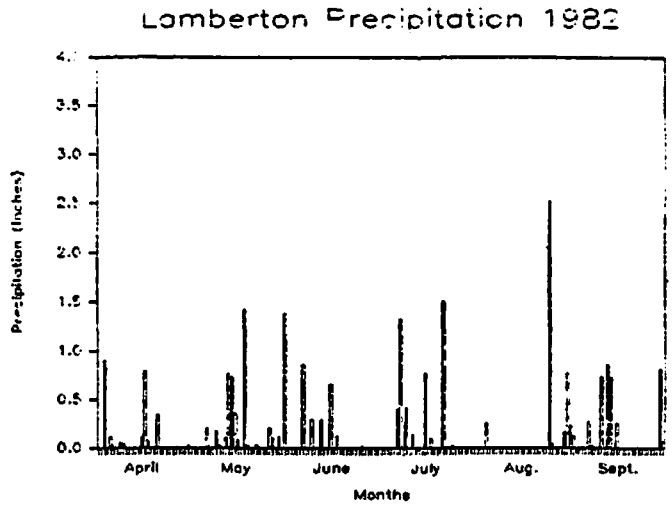
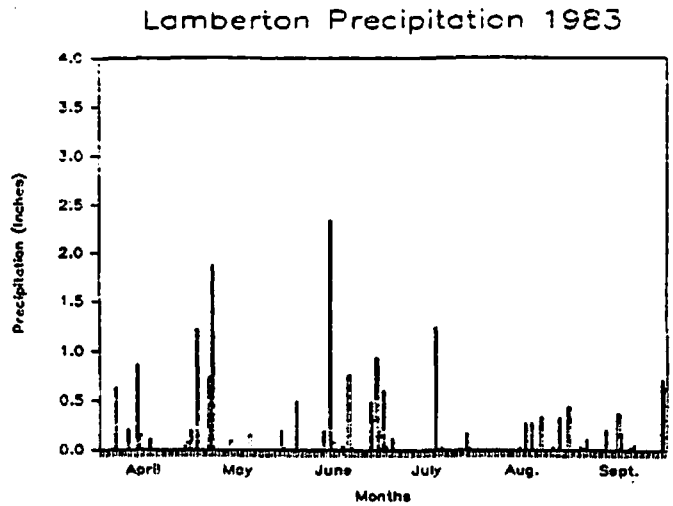
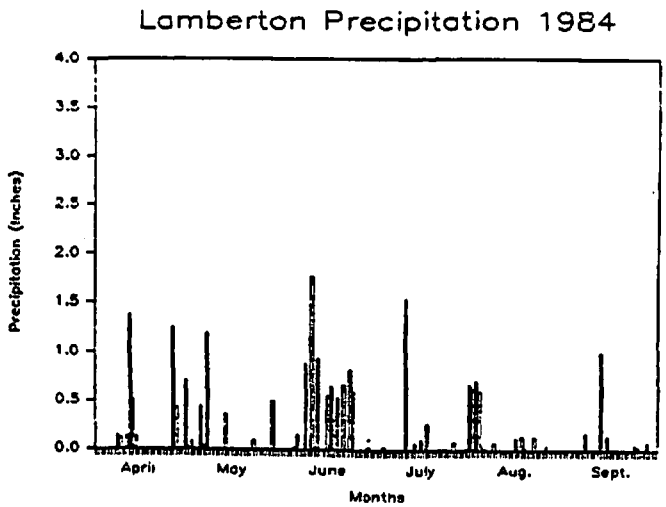


Table 3c: Growing season precipitation for Lamberton respectively for 1982, 83, 84.







RESEARCH IN WILD RICE FERTILIZATION - 1984

John Grava, Michael Meyer and Paul R. Bloom

Research during 1984 focused on nitrogen fertilization and nitrogen loss mechanisms in paddy soil and water. Soil, water and air temperatures were monitored during the growing season at Grand Rapids and St. Paul. A nitrogen source experiment was conducted with the K2 variety on a mineral soil at Grand Rapids, and a second experiment on peat in 4 x 4 ft. boses at St. Paul.

A. WEATHER CONDITIONS AND PLANT DEVELOPMENT

Average air temperatures at four locations were below normal during May, near normal during June, followed by below normal July and above normal during August (Table 1.).

Soil, water and air temperatures were measured at Grand Rapids within the experimental paddy No. 1 East, and on the St. Paul Campus within an area where experiments in 4 x 4 boxes were conducted (Fig. 1 and 2).

At Grand Rapids, K2 wild rice emerged on May 26, reached the jointing stage on July 6, 41 days after emergence and was harvested on August 23, 91 days after emergence. At St. Paul, K2 wild rice was seeded on May 14, reached the jointing stage on July 5 and reached maturity on August 22.

B. NITROGEN SOURCE STUDIES ON MINERAL SOIL

A nitrogen source and placement experiment with 2nd year stand of K2 wild rice was conducted in paddy No. 1 East at the North Central Experiment Station, Grand Rapids. The soil is classified as an Indus clay loam (very fine, montmorillonitic, frigid Typic Ochraqualf). Soil tests (Table 2) indicated a very high level of Bray-1 extractable phosphorus (102 lb/A) and a medium level of exchangeable potassium (195 lb/A).

Nitrogen fertilizers included in the experiment were as follows: granular urea (GU), 46% N; sulfur coated urea (SCU), 37% N; isobutylidene diurea (IBDU), 31% total N (28% water insoluble, 3% water soluble). Nitrogen was applied at a rate of 40 lb/A, either on May 15 and incorporated into the soil by rototilling or topdressed at jointing on July 6. A radomized block design was used in this experiment. Each treatment was replicated four times. Individual plots occupied a 14 x 14 ft. area and were separated from adjoining plots by 5 ft. wide alleys. Water level was maintained at 8 to 12 inches. Ten plants were collected at random from each plot at jointing, and five plants at late flowering for weight measurement and plant analysis. A 32 sq. ft. area from each plot was hand-harvested on August 23.

Individual plants at jointing had accumulated over 2 grams of dry matter (Table 3). All nitrogen fertilizers increased the plant weight above the control when incorporated into the soil. Deep placed granular urea produced the largest plants which accumulated 75 milligrams of nitrogen each. Surface applied urea had no effect on growth, nitrogen concentration of 2nd leaf or N uptake by wild rice. Fertilization with IBDU was nearly as effective as deep placed granular urea. At late flowering the plant had accumulated from 8.69 to 12.43 grams of dry matter and from 116 to 170 milligrams of nitrogen (Table 4). The grain yield (7% moisture) ranged from 212 to 314 pounds per acre (Table 4). Although deep placed nitrogen fertilizers tended to produce bigger plants and more grain than the control, however, the differences were not significant.

The growth of wild rice in this experiment was affected by a heavy infestation of water plantain. Although the stand was hand-weeded on July the weed problem became more serious as the season progressed. Water plantain appeard to affect the stand density, growth and tillering of wild rice and minimized the effectiveness of nitrogen.

Table 1. Average air temperature as measured at four weather stations.[1/]

Station Year	Month April	May	June	July	August	5 Month Average	GDD T_b=40
	----------average air temperature, °F ----------						
Fosston, Polk Co.							
Normal[2/]	41.0	54.6	63.6	69.4	67.5	59.2	2955
1974	41.0	50.5	63.4	71.6	62.8	57.9	2744
1975	34.8	55.7	61.9	70.5	64.6	57.5	2852
1976	46.6	54.9	66.8	68.8	70.9	61.6	3315
1977	49.1	66.4	64.6	70.3	60.6	62.2	3446
1978	41.7	59.2	63.4	67.8	67.7	60.0	3060
1979	36.0	48.7	63.6	69.6	63.6	56.3	2627
1980	48.9	61.3M[3/]	68.5	71.0	64.6	62.9	3466
1981	44.4	55.3	60.8	68.1	65.7	58.8	2898
1982	37.0	55.1	55.5	66.8	63.0	55.5	2477
1983	37.7	50.5[4/]	63.7[4/]	69.0	68.5	57.9	2819
1984	45.0	52.6	63.4	67.8	70.2	59.8	2906
Grand Rapids, N.C. School							
Normal	39.9	52.7	62.0	67.4	65.1	57.4	2681
1974	41.6	49.4	62.7	70.7	62.8	57.4	2670
1975	34.7	57.0	62.2	71.5	65.2	58.1	2951
1976	47.1	54.4	66.1	68.2	67.4	60.6	3166
1977	48.2	63.8	64.0	69.2	60.2	61.1	3284
1978	41.3	57.9	62.8	66.5	66.0	58.9	2892
1979	37.1	49.5	61.5	68.1	62.6	55.8	2511
1980	46.1	59.9	64.0	69.0	66.4	61.1	3237
1981	43.9	54.8	62.0	68.0	67.0	59.1	2941
1982	38.6	57.7	58.5	68.0	64.4	57.6	2753
1983	39.0	49.7	62.5	71.1	70.1	58.5	2873
1984	44.6	50.8	63.8	67.8	69.6	59.3	2842
Aitkin							
1974	42.9	49.8	63.1	71.1	63.3	58.0	2770
1975	39.0M	59.4M	64.4M	72.1	66.2M	60.2	3141
1976	47.5	54.8	66.8	69.3M	68.1	61.3	3267
1977	48.3M	64.4M	65.4M	70.3M	61.0	61.9	3446
1978	40.7M	57.5,	64.1M	67.0M	66.9	59.2	2938
1979	37.7	50.6	62.0	68.1M	63.4	56.4	2585
1980	53.9	58.3	64.0	68.5	66.0	62.1	3394
1981	45.1M	53.8	62.1M	67.5	66.0	58.9	2902
1982	38.3	57.4	57.6	68.6	64.8	57.3	2723
1983	39.6M	49.3M	60.3M	72.1M	71.9M	58.6	2881
1984	43.9	53.9M[5/]	64.4	69.1[5/]	69.3	60.1	2985
St. Paul, U of M							
1982	43.4	61.3	62.4	73.9	67.3	61.6	3332
1983	42.1	55.2	68.7	76.4	76.0	63.7	3640
1984	47.7	57.2	69.1	72.2	73.9	64.0	3478

1/ Source: Climatological Data, Minnesota, Vol. 90 (1984), U.S. Dept. of Commerce.
2/ Normals for the period 1931-1960.
3/ M = less than 10 days record missing.
4/ Northwest Divisional Data.
5/ East Central Divisional Data.

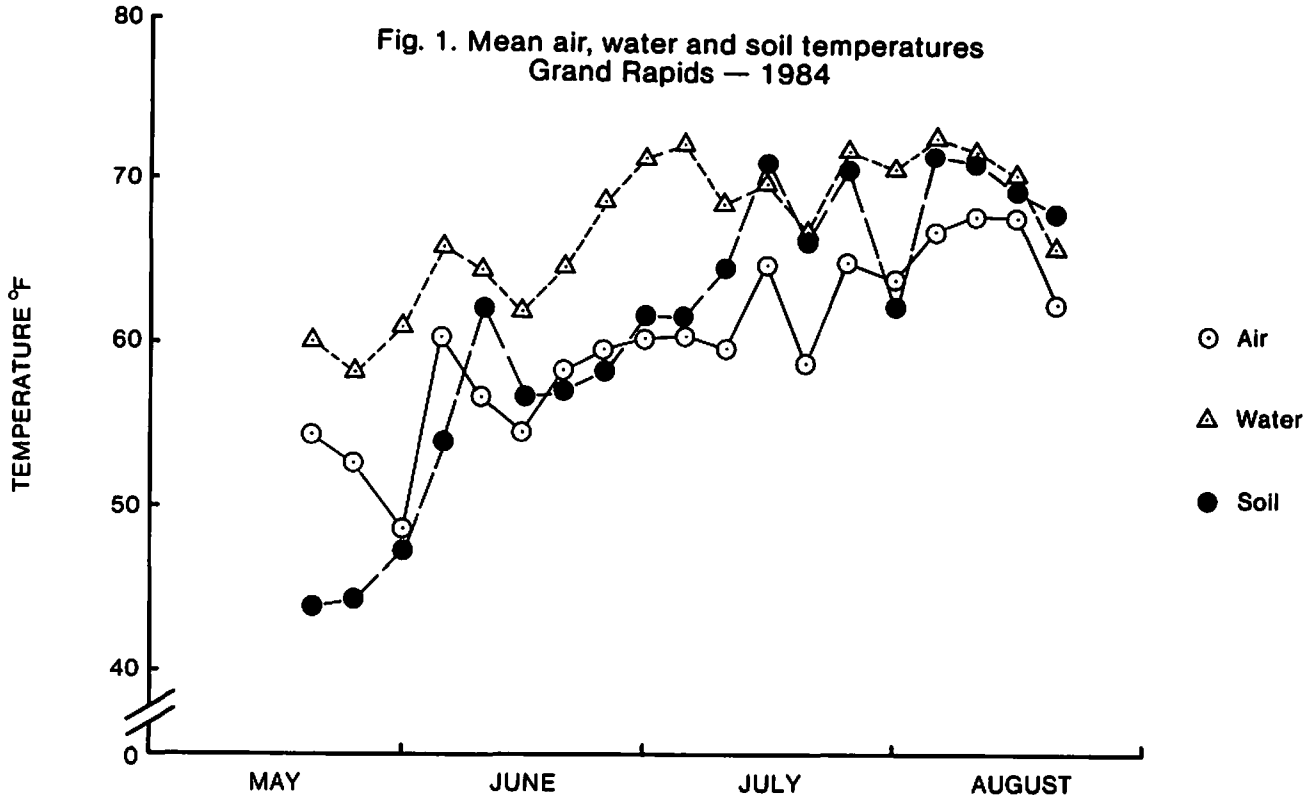


Fig. 1. Mean air, water and soil temperatures
Grand Rapids — 1984
TEMPERATURE °F
80
70
60
50
40
0
MAY
JUNE
JULY
AUGUST
Air
Water
Soil

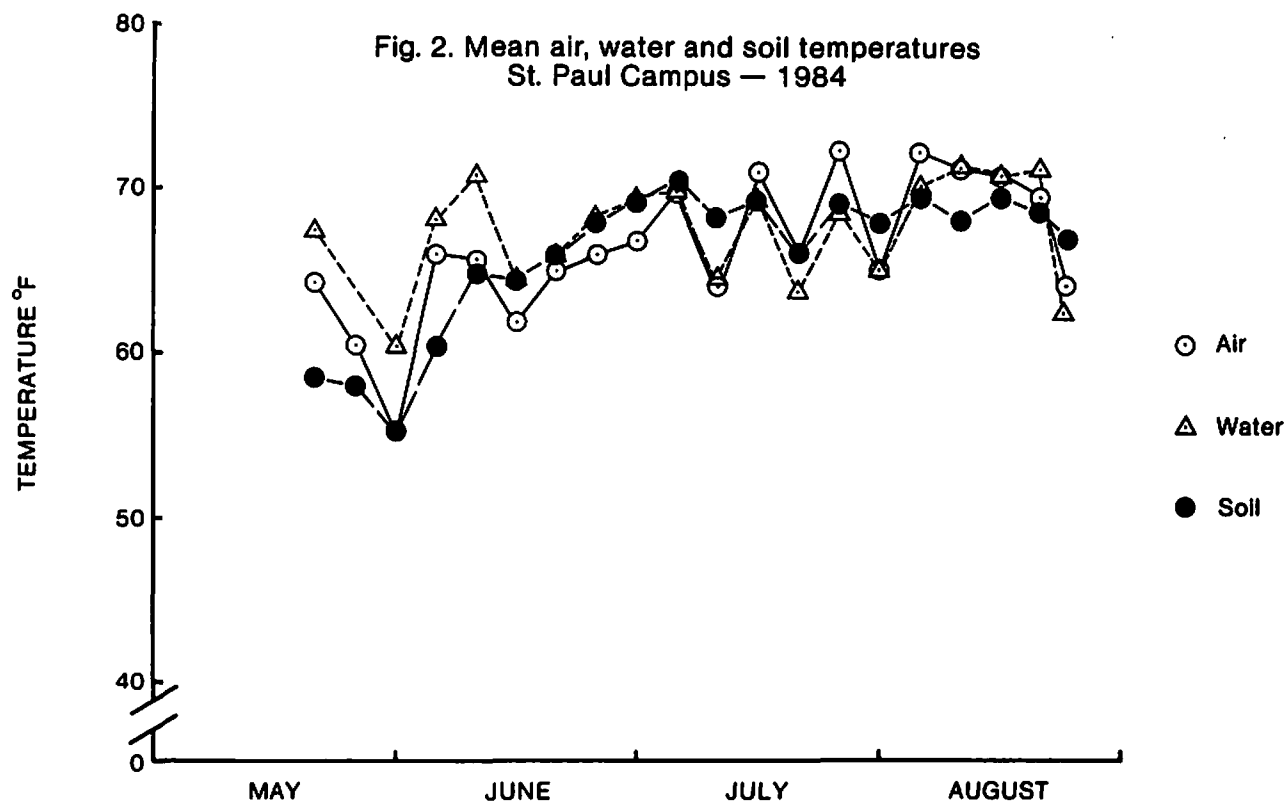


Fig. 2. Mean air, water and soil temperatures
St. Paul Campus — 1984
TEMPERATURE °F
80
70
60
50
40
0
MAY
JUNE
JULY
AUGUST
Air
Water
Soil

Table 2. Soil test values of experimental paddy No. 1 East, Grand Rapids[1)]

pH	Extract-able P pp2m	Exchange-able K pp2m	Nitrate-N lb/A	Organic Matter %	Zn ppm	S ppm	Cu ppm	Mg pp2m
5.6	102	195	17	2.8	7	8	1.7	514

1) Samples collected from 0-6 inch depth on 5/15/84.

Table 3. Effect of nitrogen source and placement on weight of dry matter, N-concentration in 2nd leaf, and total uptake of N by the wild rice plant at jointing. Grand Rapids, 1984.

Treatment	Dry matter grams per plant	N% in dry matter of 2nd leaf	N uptake in milligrams per plant
1. Control	2.08	3.05	49
2. GU, Surf applied	2.06	3.13	47
3. GU, 4-inch depth	2.92	3.30	75
4. SCU, 4-inch depth	2.20	3.23	57
5. IBDU, 4-inch depth	2.52	3.51	70
Significance	*	ns	**
BLSD (0.05)	0.11	0.43	15
C.V., %	13	7	17

Table 4. Effect of nitrogen source and placement on grain yield, dry matter production and total N uptake at late flowering. Grand Rapids, 1984.

Treatment	Grain yield lb/A[1/]	Dry matter at late flowering grams per plant	Total N uptake milligrams per plant
1. Control	224	8.91	119
2. GU, Surf applied	212	8.69	116
3. GU deep placed	300	12.43	170
4. SCU	282	11.34	164
5. IBDU	314	11.28	148
Significance	ns	ns	ns
BLSD (0.05)			
C.V., %	23	23	28

[1/] 7% moisture

C. NITROGEN SOURCE STUDIES IN BOXES

A nitrogen source and placement experiment was conducted in 4 x 4 wooden boxes on the St. Paul Campus. The following four nitrogen fertilizers were investigated: granular urea (GU); urea supergranule (USG), 2 gram granule; sulfur coated urea (SCU); and isobutylidene diurea (IBDU). Seven fertilizer treatments were replicated four times. Nitrogen fertilizers were applied at an 80 lb/A rate; all boxes received 60 lb P_2O_5/A and 120 lb. K_2O/A.

A 12-inch thick layer of partly decomposed hypnum peat (hemic), pH 6.4, was placed in the boxes. Properties of the peat are reported in Table 5. Phosphorus, potassium and deep placed nitrogen fertilizers were covered with a 4-inch unfertilized layer of peat. Seed of K2 variety was placed in rows and covered with about 1-inch layer of peat on May 14. On-surface application of nitrogen was made after seeding. Two extra boxes with deep placed granular urea were set up; No. 51 with wild rice and No. 52 without wild rice. The water depth in all boxes was maintained at 6 inches. In a split-application treatment, half of the granular urea was deep placed (4-inches) at seeding and half topdressed at jointing on July 5. Copper sulfate was applied to all boxes to control algae.

The wild rice plants were vigorous and lodged readily. Nitrogen produced dark green colored leaves and stems in contrast to the light green-yellowish colored plants of the control. Average plant density was 27 plants per box.

The grain yield (7% moisture) ranged from 173 to 274 grams per box (Table 6). Calculated on a field basis, the yield would correspond to 1179 and 1864 lb/A of grain. All applications of nitrogen produced significantly more grain than the control. Deep placed SCU and USG produced higher yield than IBDU and surface applied GU.

Ammonium N Depletion in Peat by Wild Rice

Two of the boxes at the St. Paul Campus were set aside for the study of the depletion of available nitrogen by a wild rice crop. Both boxes received 80 lb N/A as granular urea placed at the 4-inch depth. Box No. 51 was seeded with wild rice, Box No. 52 was maintained without plants. Wild rice in Box No. 51 produced 280 grams (1907 lb/A) of grain (7% moisture). Three ceramic cups 6.3 cm in diameter with 100 cm long plastic tubes were placed in each box to a depth of 15 cm. Soilwater was extracted from the tubes for ammonium N analysis.

Soil samples were collected from the boxes with a Macaulay peat sampler at 0-20 cm and 20-38 cm depths. Random triplicate samples were collected from each box on four different dates (6/11, 6/25, 7/13, 8/2). A grid sampling system insured that the same spot was not penetrated more than once with the sampler. Soil samples were extracted with 1M KCl and distilled. Ammonium N in soilwater was determined by direct distillation.

The amounts of ammonium N in soilwater and in the soil are reported in Tables 7 and 8. There was a slight increase in ammonium N from June 11 to June 25. This may have been due to mineralization of organic N in peat as the soil temperature increased. A striking decrease in ammonium N in soilwater and in the soil occurred in Box No. 51 with wild rice between June 25 and July 13. This coincided with the date of jointing on July 5, and early boot about a week later. Our previous research has shown that wild rice takes up 70% of total nitrogen between the jointing stage and maturity. It is evident that at the start of jointing the plant uptake of N is very great and acts as a sink for nitrogen.

In the box with wild rice, nitrogen depletion in the 20-38 cm zone was equal to that in the 0-20 cm zone. This demonstrates that wild rice in peat is able to utilize nitrogen from well below the reported rooting depth of 20 cm.

CONCLUSIONS

Nitrogen incorporation into the soil at the 4-inch depth during seedbed preparation was superior to on-surface application. Granular urea was as effective as the more expensive slow-release sources of nitrogen.

Table 5. Soil test values of peat. St. Paul, 1984

pH	Extractable P pp2m	Exchangeable K pp2m	Zn ppm	S ppm	Cu ppm	Mg pp2m	Ash %
6.4	11	29	5.7	38	0.9	648	27.5

Table 6. Effect of nitrogen source placement and time of application on grain yield of wild rice grown on peat in 4 x 4 ft. boxes. St. Paul, 1984

Treatment	Grain yield grams per 14 sq. ft. area 1/
1. Control	173
2. GU, Surf applied	227
3. GU, 4-inch depth	242
4. USG, 4-inch depth	265
5. SCU, 4-inch depth	274
6. IBDU, 4-inch depth	221
7. GU, Split-application 2/	252
Significance	**
BLSD (0.05)	34
C.V., %	121

1/ 7% moisture

2/ Split-application = 1/2 prior to seeding, 4-inch depth; 1/2 topdressed at jointing.