Table 1. Yield, quality and soil test data for N timing study.

Study Date				Yield	Sugar	Recoverable Sugar			Impurities			
									Na	K	Amino N	
4/20	5/20	6/10	7/1	t/ac	%	lb/ac	%	lb/ton	- - - ppm - - -			Index
0	0	0	0	16.0	16.3	4839	.93	301	205	1795	280	487
30	30	30	30	17.9	15.6	4980	.90	280	268	1835	528	677
60	60	0	0	19.1	16.0	5536	.90	289	218	1793	538	646
60	0	60	0	17.7	16.1	5130	.90	288	240	1880	580	691
60	0	0	60	15.6	14.9	4103	.88	263	310	1908	583	769
0	60	60	0	19.2	15.7	5429	.90	282	240	1815	540	675
0	60	0	60	16.4	15.9	4675	.90	286	273	1750	540	659
0	0	60	60	17.5	15.0	4723	.89	265	318	1885	585	765
120	0	0	0	15.9	15.8	4561	.90	286	228	1800	505	638
0	120	0	0	19.7	15.6	5550	.90	282	268	1868	480	652
0	0	120	0	17.9	16.0	5228	.91	292	240	1835	438	599
0	0	0	120	17.0	15.4	4661	.90	276	290	1880	503	685
Treatment				NS	++	NS	**	*	NS	NS	**	**
CV				13.6	4.0	15.1	1.3	4.9	26.7	5.1	16.3	11.6
LSD (.05)				3.4	0.80	1070	.016	20	99	133	119	110
LSD (.10)				2.8	0.75	891	.014	17	82	111	99	92

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

Soil Test		
NO_3^--N	28 lb/ac	0-2'
P	10 lb/ac	0-6"
K	170 lb/ac	0-6"

STARTER PHOSPHORUS FERTILIZER EFFECT ON SUGARBEET

John A. Lamb

OBJECTIVE: Determine if the fertilizer needs for a sugarbeet can be met with a starter fertilizer application alone.

PROCEDURES: Four locations were chosen for this study in 1985. Two in West Central Minnesota in the Holoway-Milan area and two near Crookston. Table 1 gives the soil test data. Four treatments were 10-34-0 broadcast or row applied at planting at 3 or 6 gallon rates. Three treatments involved preplant application of the Minnesota recommendations (Table 2) alone, or with 3 and 6 gallons of row-applied 10-34-0. An unfertilized check was also included making a total of eight treatments. At each site there were four replications in a randomized complete block design. One replication had to be abandoned at the Peterson site because of poor plant population.

The West Central Minnesota locations were planted May 8, 1985. The Northwest Experiment Station and Peterson locations were planted May 20, 1985, respectively. The plots were harvested between September 16 and September 28, 1985. Quality was determined by the American Crystal Tare Lab in Grand Forks.

RESULTS AND DISCUSSION:

ARNOLD LOCATION: The yield was increased by fertilization (Table 3). The largest yield occurred with the Minnesota recommendation plus 6 gallons of 10-34-0. The treatments with the Minnesota recommendations did better than the treatments without.

The sugar content was also greater in the Minnesota recommendation treatments. Recoverable sugar on the pound per acre basis was increased by fertilization. The Minnesota recommendation treatments with starter had the highest yield. The MN Rec + 3 gal 10-34-0 produced the same yield as MN Rec + 6 gal 10-34-0.

The largest recoverable sugar on a pound per ton of sugarbeet was the Mn Rec treatment. All the Mn Rec treatments did better than the starter alone.

JOHNSON LOCATION: Table 4 shows the yields for the Johnson location. No treatments affected yield. Except for the Mn Rec treatment, sugar content was decreased by fertilization. The recoverable sugar on a pound per acre was not affected by the treatments. Because of the reduction in sugar content the recoverable sugar on a pound per ton basis was decreased by fertilization except for the Mn Rec which was the same as the check.

NWES LOCATION: Fertilizer application increased the yield at the NWES location (Table 5). The Mn Rec + 3 gal 10-34-0, and Mn Rec + 6 gal 10-34-0 treatments performed better than the check, 3 gal 10-34-0 row, and 6 gal 10-34-0 row.

The sugar content was less than the check with the 3 gal 10-34-0 broadcast and 6 gal 10-34-0 broadcast. The Mn Rec, Mn Rec + 3 gal, Mn Rec + 6 gal, 3 gal 10-34-0 row and 6 gal 10-34-0 row are similar to the check.

The recoverable sugar on a pound per acre basis was greatest with the Mn Rec treatments. The other starter alone treatments were not different from the check. Recoverable sugar on a pound per ton of sugarbeet basis was the greatest with the 6 gal 10-34-0 row starter treatment. This was not significantly different from the check.

PETERSON LOCATION: The only significant yield differences occurred between the row and broadcast starter treatments (Table 6). The sugar content was not affected by any treatment. The recoverable sugar pound per acre was increased by the fertilizer treatments where the Mn Rec treatments on the average did better than the row starter treatments. Recoverable sugar on the pound per ton basis was not affected by the treatments.

SUMMARY: In most instances the Mn Rec treatment performed better than the starter treatments. The weather conditions observed in the 1985 season would tend to reduce the advantage attributed to starter fertilizers because of the above-normal May temperatures. In three of the four locations, the greatest recoverable sugar pound per acre basis was with the Mn Rec + 3 or 6 gal 10-34-0 treatment. On the pound per ton basis, the Mn Rec treatment did better than the row starter treatment at

all but the NWES location. These results are from one years data and may be different under different weather situations. This study will be conducted over more years in hopes to evaluate these treatments under different weather conditions.

Table 1. Soil test information.

	Site			
	Arnold	Johnson	NWES	Peterson
NO_3^--N 0-2' lb/ac	59	40	28	59
P 0-6" lb/ac	11	25	10	11
K 0-6" lb/ac	400	410	170	200
pH	7.8	6.7	8.2	8.0
OM, %	4.4	3.1	4.0	3.0

Table 2. Minnesota recommendations for each site in starter study.

	Site			
	Arnold	Johnson	NWES	Peterson
	- - - - - - - - - - lb/ac Applied - - - - - - - - - -			
N	61	80	92	61
P_2O_5	30	0	70	30
K_2O	0	0	40	0

Table 3. Yield and quality data for Arnold site, 1985.

Treatment	Yield t/ac	Sugar %	Index	Recoverable Sugar lb/ac	Recoverable Sugar lb/t
Check	15.4	15.5	575	4353	282
3 gal Broadcast	17.5	15.8	540	5079	291
6 gal Broadcast	20.8	15.6	513	5967	287
3 gal Row	21.7	15.4	596	6083	281
6 gal Row	21.7	15.8	528	6309	291
Mn Rec	22.1	16.2	495	6629	301
Mn Rec + 3 gal Row	24.3	16.1	484	7239	298
Mn Rec + 6 gal Row	24.9	16.0	555	7271	293
Treatment	**	+	NS	**	+
C.V.	9.3	3.0	11.7	9.2	3.7

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

Table 4. Yield and quality data for Johnson site, 1985.

Treatment	Yield t/ac	Sugar %	Index	Recoverable Sugar lb/ac	Recoverable Sugar lb/t
Check	21.1	15.8	518	6152	292
3 gal Broadcast	20.6	15.7	489	6003	291
6 gal Broadcast	22.2	15.3	563	6224	280
3 gal Row	24.1	15.3	576	6715	279
6 gal Row	21.7	15.2	549	6066	280
Mn Rec	25.3	15.8	549	7341	290
Mn Rec + 3 gal Row	24.2	15.4	560	6825	282
Mn Rec + 6 gal Row	24.3	15.6	609	6849	283
Treatment	NS	+	*	NS	+
C.V.	12.4	2.5	7.5	12.1	3.0

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

Table 5. Yield and quality data for NWES site, 1985.

Treatment	Yield t/ac	Sugar %	Index	Recoverable Sugar lb/ac	Recoverable Sugar lb/t
Check	13.5	15.5	564	3844	283
3 gal Broadcast	13.8	14.1	689	3499	253
6 gal Broadcast	13.3	15.0	620	3591	273
3 gal Row	14.4	15.2	590	3988	277
6 gal Row	15.0	15.9	551	4374	291
Mn Rec	17.0	15.5	629	4830	281
Mn Rec + 3 gal Row	17.4	15.9	601	5009	288
Mn Rec + 6 gal Row	17.6	15.4	657	4887	277
Treatment	**	++	+	**	++
C.V.	8.8	4.7	10.6	9.8	5.6

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

Table 6. Yield and quality data for Peterson site, 1985.

Treatment	Yield t/ac	Sugar %	Index	Recoverable Sugar lb/ac	Recoverable Sugar lb/t
Check	15.4	16.0	737	4341	285
3 gal Broadcast	16.2	16.3	712	4744	293
6 gal Broadcast	14.2	15.7	821	3901	276
3 gal Row	15.6	16.2	760	4476	287
6 gal Row	17.7	16.4	736	5122	291
Mn Rec	16.9	16.8	692	5083	301
Mn Rec + 3 gal Row	17.4	16.6	740	5138	295
Mn Rec + 6 gal Row	16.8	16.2	761	4826	287
Treatment	+	NS	NS	*	NS
C.V.	9.2	3.3	11.0	9.0	4.2

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

EFFECT OF PHOSPHORUS AND POTASSIUM FERTILIZATION ON YIELD AND QUALITY OF SUGARBEET GROWN IN WEST CENTRAL MINNESOTA

John A. Lamb

OBJECTIVE: To determine the effect of P and K fertilization on sugarbeet yield and quality in the corn and soybean production area of West Central Minnesota.

PROCEDURES: The study was established at the Dale Johnson farm near Milan, MN and the Dan Arnold farm near Holoway, MN. Soil test information is listed in Table 1.

The treatments were a factorial arrangement of N, P and K fertilizer and replicated 4 times in a randomized block design. Each element was applied at 3 rates (0, 50, 100 lb N/ac; 0, 20, 40 lb P/ac; and 0, 25, 50 lb K/ac). The fertilizer was a dry material (Urea, 0-44-0 and 0-0-60) broadcast and incorporated before planting.

The variety KW3394 was planted May 8, 1985 and thinned later to 125 plants/100 ft of row. Harvest occurred September 20, 1985 with quality determined by the American Crystal Tare Lab located in Grand Forks, ND.

RESULTS AND DISCUSSION:

Arnold Location: Yield was significantly increased from the application of both N and P (Table 2 and 3). The soil test would indicate a high probability of response to these inputs and not K. The maximum tonnage yield was not obtained from the high rates of N or P.

The sugar content was decreased by the 100 lb/ac rate of N. The P and K did not affect sugar content.

Nitrogen did not affect the amount of sugar recovered on a per acre basis but it did decrease the amount recovered per ton of sugarbeet processed at the high rate of N. Phosphorus increased the amount of recoverable sugar per acre but did not affect the amount recovered per ton.

The maximum recovered per ton of sugarbeet occurred at 50 lb N/ac or approximately 110 lb of fertilizer + soil N. This corresponds closely with the suggested recommendations. A surprising factor was that the addition of K fertilizer to a soil with high soil test K (400 lb) did not affect the K level in sugarbeet and thus not increasing the impurities in the sugar production.

Johnson Location: The yield was increased by N and K fertilization (Table 4 and 5). The N effect was expected but the K effect was not predicted from the soil value (410 lb/ac).

There was a significant interaction of P and K on yield. As the rate of P increased, the yield increase from K fertilization was greater (Table 7).

The sugar content was affected by N and P. The N response was positive up to 50 lb/ac and then decreased at the highest N rate. The decrease in sugar from the first 20 lb P/ac and then increase at 40 lb P/ac is not explainable.

Nitrogen increased the recoverable sugar per acre past the 100 lb/ac rate. The maximum amount recovered per ton of beet was at the 50 lb/ac rate or a soil + fertilizer N level of 90 lb/ac. This is a lower rate than would be expected. A depression of both recoverable sugar per acre and per ton occur at the 20 lb P/ac. The soil test would indicate the probability of a yield increase from P fertilization would be small. The surprise result was the increased recoverable sugar per acre at the 50 lb K/ac rate. The soil test would not have predicted a yield increase from K application. Table 7 also indicates a P by K interaction for recoverable sugar per acre similar to the interaction for yield.

The soil test listed in Table 1 is from a spring sample. The farmer's fall sample results indicate a K soil test of 195 lb/ac. At this soil test the probability of an increase in recoverable sugar per acre is higher than a soil test of 400 lb/ac. An explanation could lie in the accuracy of the soil sampling and the moisture content of the soil. Originally this difference was thought to be from the different sampling practices and areas sampled. The fall sample was taken on a field size area with a hydraulic corer. The spring sample came from the plot area and was taken by a hand sampler. Past literature indicates that soil moisture can affect the K soil test level

considerably. The fall sample was taken under drier soil moisture conditions than the spring sample. This location will be resampled to determine the correct K value.

Potassium application did not affect the recoverable sugar per ton of sugarbeet. Similar to the Arnold site, K did not increase the amount of potassium in the beet and thus did not increase the impurities in the beet.

The help of Dr. James Widner and Ken Dahl in locating these sites is greatly appreciated.

Table 1. Soil Test Information.

	Site	
	Arnold	Johnson
NO_3^--N 0-2' lb/ac	59	40
P 0-6" lb/ac	11	25
K 0-6" lb/ac	400	410
pH	7.8	6.7
OM	4.4	3.1

Table 2. Yield and quality data for Arnold site, 1985.

N Rate lb/ac	Yield t/ac	Sugar %	Index	Recoverable Sugar lb/ac	Recoverable Sugar lb/t
0	21.7	15.8	547	6304	290
50	22.8	15.9	541	6683	293
100	23.3	15.6	619	6603	284
	+	++	**	NS	**
P Rate lb/ac					
0	20.9	15.8	683	6042	289
20	22.5	15.8	566	6493	289
40	24.4	15.8	560	7056	289
	**	NS	NS	**	NS
K Rate lb/ac					
0	22.4	15.7	571	6440	287
25	22.5	15.8	570	6504	289
50	22.9	15.9	567	6646	290
	NS	NS	NS	NS	NS

Table 3. Statistics for Arnold location.

Source	Yield	Sugar	Index	Recoverable Sugar lb/ac	Recoverable Sugar lb/ton
Nitrogen Rate (N)	+	++	**	N.S.	**
Linear	*	+	**	N.S.	*
Phosphorus Rate (P)	**	N.S.	N.S.	**	N.S.
Linear	**	N.S.	N.S.	**	N.S.
Potassium Rate (K)	N.S.	N.S.	N.S.	N.S.	N.S.
Linear	N.S.	N.S.	N.S.	N.S.	N.S.
N * P	N.S.	N.S.	N.S.	N.S.	N.S.
N * K	N.S.	N.S.	N.S.	N.S.	N.S.
P * K	N.S.	N.S.	N.S.	N.S.	N.S.
N * P * K	N.S.	N.S.	N.S.	N.S.	N.S.
C.V.	14.9	3.2	14.4	16.1	4.3

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

N.S. is not significant ($P \geq 0.20$).

Table 4. Yield and quality data for Johnson site, 1985.

N Rate lb/ac	Yield t/ac	Sugar %	Index	Recoverable Sugar lb/ac	Recoverable Sugar lb/t
0	19.4	15.4	537	5499	283
50	22.8	15.7	529	6577	289
100	24.4	15.5	591	6914	283
	**	*	**	**	*
P Rate lb/ac					
0	22.4	15.6	551	6401	286
20	21.8	15.4	561	6170	282
40	22.4	15.6	545	6419	287
	NS	++	NS	+	+
K Rate lb/ac					
0	21.7	15.5	561	6158	283
25	21.7	15.5	549	6159	285
50	23.2	15.6	546	6663	287
	**	NS	NS	**	NS

Table 5. Statistics for Johnson location.

Source	Yield	Sugar	Index	Recoverable Sugar lb/ac	Recoverable Sugar lb/ton
Nitrogen Rate (N)	**	*	**	**	*
Linear	**	N.S.	**	**	N.S.
Phosphorus Rate (P)	N.S.	++	N.S.	+	+
Linear	N.S.	N.S.	N.S.	N.S.	N.S.
Potassium Rate (K)	**	N.S.	N.S.	**	N.S.
Linear	**	++	N.S.	**	+
N * P	N.S.	N.S.	N.S.	N.S.	N.S.
N * K	N.S.	N.S.	N.S.	N.S.	N.S.
P * K	*	N.S.	N.S.	+	N.S.
N * P * K	N.S.	N.S.	N.S.	N.S.	N.S.
C.V.	9.4	3.0	11.1	10.0	3.7

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

N.S. is not significant ($P \geq 0.20$).

Table 6. Interaction means for Johnson site, 1985.

lb P/ac	Yield (lb K/ac) 0	25	50
0	22.9	21.4	22.9
20	21.5	21.6	22.4
40	20.8	22.0	24.3

	Recoverable Sugar (lb/ac) 0	25	50
0	6420	6152	6631
20	6058	6109	6344
40	5997	6249	7013

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

J.A. Lamb and R.K. Severson

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

METHODS AND MATERIALS: Four sites were located for this study in 1985. The N fertilizer (urea) treatments (0, 30, 60, 90 and 120 lb N/ac) and inoculation treatment (none and inoculated) were applied and the plots planted to McCall soybean May 23, 24, 28 and 28 for the Marshall County, NWES, East Polk County and Norman County sites, respectively. The most recently matured trifoliate leafs were sampled July 25 through 28. The East Polk location was abandoned at that time because of a weed control problem. The plots were harvested by hand the first week of October.

RESULTS AND DISCUSSION: Tables 1, 2 and 3 list the grain yields, trifoliate N, and statistical analyses for 1985. The Marshall County site had an increased yield from inoculation. Application of N fertilizer did not affect yields. With a soil test of 50 lb NO_3^--N/ac 0-2 ft, a yield response was expected. The trifoliate data showed no effect of inoculation but did have an increase in N concentration with increasing rates of N. Some other factor was limiting yield response to N.

Yields at the NWES site were increased by both inoculation and N application. The trifoliate N concentration was increased by N application but not inoculation. It took over 60 lb N/ac applied to noninoculated soybean to equal the yield of inoculated soybean with no N applied. At the soil NO_3^--N level of 50 lb/ac 0-2 ft a response similar to this would be expected. The N fertilizer continues to increase yield up to the 90 lb/ac rate for inoculated soybean and up to the 120 lb N/ac rate for the noninoculated treatment.

The Norman County site had a soil NO_3^--N test 0-2 ft of 80 lb/ac. Inoculation did not affect yield and N application decreased yield except for the 120 lb N/ac treatment. The nonresponse would be expected because of the high soil NO_3^--N level. Trifoliate N analyses for the Norman County site were not available at the time of this report.

SUMMARY: Unlike 1984, the nodule formation in the inoculated plots was good. The noninoculated soybean did not set nodules. A good job of inoculating seed may be the most important aspect to getting soybean to produce nodules.

Table 1. Grain yields for 1985.

	Marshall County 50 lb NO_3^--N 0-2'			NWES 50 lb NO_3^--N 0-2'			Norman County 80 lb NO_3^--N 0-2'		
N Rate	0	I	$\bar{X}$	0	I	$\bar{X}$	0	I	$\bar{X}$
lb/ac	bu/ac								
0	19.5	18.6	19.1	15.1	19.2	17.2	26.9	25.8	26.3
30	15.4	19.0	17.2	17.3	20.1	18.7	25.6	24.8	25.2
60	16.2	18.4	17.3	18.7	20.8	19.8	23.7	24.8	24.3
90	15.7	20.9	18.3	22.0	23.8	22.9	23.9	22.6	23.3
120	15.9	19.6	17.8	24.1	24.7	24.4	26.5	27.4	26.9
$\bar{X}$	16.6	19.3	17.9	19.4	21.7	20.6	25.4	25.1	25.2

0 and I are noninoculated and inoculated, respectively.

Table 2. Most recently matured trifoliate N concentration at 1/2 bloom, 1985.

	Marshall County			NWES		
N Rate	O	I	$\bar{X}$	O	I	$\bar{X}$
0	4.41	4.41	4.41	3.30	3.43	3.36
30	5.22	5.05	5.13	4.37	4.09	4.23
60	5.58	5.52	5.55	4.72	4.58	4.65
90	5.67	5.40	5.54	4.67	4.68	4.67
120	5.81	5.63	5.72	4.94	4.62	4.78
$\bar{X}$	5.34	5.20	4.46	4.40	4.28	4.34

O and I are noninoculated and inoculated, respectively.

Table 3. Statistical analyses for soybean study, 1985.

	Marshall County		NWES		Norman County
	Yield	Trifoliate N	Yield	Trifoliate N	Yield
I	*	NS	*	NS	NS
N	NS	**	**	**	*
N lin	NS	**	**	**	NS
N quad	NS	**	NS	**	**
I*N	NS	NS	NS	NS	NS
	16.7	4.5	7.5	5.6	9.2

I and N are inoculation and nitrogen rate, respectively.
**, * and NS are 0.01, 0.05, and > 0.20 significance levels, respectively.

AVAILABILILTY OF RESIDUAL NITRATE-N TO CORN

Lamberton, 1985

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 1985. 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 and 1983-84 can be found in University of Minnesota Agr. Exp. Stn. Misc. Pub 2 (revised) - 1983 (pp. 78-81) and 1985 (pp. 46-51), respectively.

In 1985, 125 lb N/A as anhydrous ammonia was applied to an isolated 6-row strip between the plots so that crop response to the residual N could be compared to this annual application. Weeds and insects were controlled adequately on all plots by pesticides. All plots have been moldboard plowed each fall.

RESULTS

Corn yields shown in Table 1 were good due to the favorable growing conditions (above normal rainfall). Grain yields from all of the previous N treatments were excellent considering that N had not been applied since 1979 but were below the yield of 145.8 bu/A obtained from the 6-row strip where N was applied in 1985. Grain yields were significantly increased over the 18- and 100-lb treatments by the residual N remaining from the 400-lb N treatment. Grain N concentration, although quite low, was also increased by the 400-lb treatment but was markedly less than the 1.25% N found in the grain from the 6-row strip. Silage yields were increased significantly (P=93% level) by the 400-lb treatment. As a result of higher yields and N concentrations, N removed in the grain and total N uptake in the silage were both increased significantly by the 400-lb treatment over all other treatments. Final population and N concentrations in the fodder and leaf at silking were not affected by the residual N. Results from the 200-lb organic N rate (soybean meal) were similar to the 200-lb rate applied as urea.

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

Table 1. Corn production and N utilization in 1985 as influenced by residual NO_3-N from annual N applications from 1973-1979 at Lamberton.

Annual N rate	Final population	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	22.1	2.54	.44	4.57	64.4	101.9	1.01	48.8
100	21.6	2.58	.45	4.82	68.1	106.2	1.01	50.8
200	22.2	2.45	.45	4.83	69.1	109.1	1.01	52.0
400	23.5	2.57	.50	5.69	86.5	124.5	1.08	63.4
Signif. Level (%): 1/	42	06	81	93	99	95	97	97
BLSD (.05) :					12.4	16.6	0.05	9.8
CV (%) :	7.3	12.2	6.8	8.6	8.3	7.1	2.4	8.7
200 org.	22.5	2.30	.40	5.10	70.3	113.7	1.01	54.2

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

Tile lines flowed from April thru mid-July and from September thru early November. Flow was highest in April, May, and September. Tile flow averaged 15.3 acre-inches for the 6-month flow period. Average flow-weighted NO_3-N concentrations ranged from 12.2 to 25.4 mg/L (Table 2). Average concentrations remained approximately the same as in 1984 except with the 400-lb rate which dropped from 33.0 mg/L.

Nitrate-N losses in the tile discharge were again quite sizeable (Table 2). The large flow volumes coupled with concentrations between 12 and 25 mg/L resulted in losses ranging from 44 lb/A with the 18-lb treatment to 100 lb/A with the 400-lb rate. These data indicate: (1) relatively high losses of NO_3^- even when no N fertilizer has been applied over the last 15 years, (2) little residual N is now being lost thru the tile lines with rates of 200 lb/A or less, and (3) substantial amounts of residual NO_3^- are still being lost to the tile lines six years after the last 400-lb N application.

Table 2. Tile line flow, average NO_3-N concentrations, and total NO_3-N losses into the tile lines in 1985 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	15.94	12.2	44.0
100	14.56	13.9	45.9
200	13.31	16.2	48.7
400	17.31	25.4	99.5
200 org.	15.53	14.8	52.0

Residual NO_3-N remaining in the soil profile from the two high N rates is shown in Table 3. With the exception of the slight accumulation between 1 and 3' in the 200-lb treatment most of the NO_3^- was below 6-feet in both treatments. Nitrate-N concentrations were highest between 6 and 10 feet deep. Nitrates at these depths have little chance of being moved up into the profile for crop uptake and, thus, are extremely susceptible to leaching down into the groundwater.

SUMMARY - 1985

Residual N still remained from the 400-lb annual treatment applied from 1973-79. As a result grain yield, N concentration, and N removal in the grain were significantly increased. At the same time, more than twice as much NO_3-N was lost from the tile lines with this treatment. At the end of the 1985 season, little NO_3^- remained in the soil above the tile lines. Most of the NO_3^- had been moved to the 5 to 15' depth.

Table 3. Residual NO_3-N in the 0-20' soil profile in October, 1985 as influenced by previous N application at Lamberton.

Profile depth	Annual N rate (lb/A)[1/]	
	200	400
feet	ppm	
0-1	2.3	4.5
1-2	7.3	1.6
2-3	7.1	2.3
3-4	1.6	1.8
4-5	2.4	5.3
5-6	4.2	9.4
6-7	6.2	13.0
7-8	7.5	13.0
8-9	9.9	11.6
9-10	7.0	11.6
10-11		10.1
11-12		9.2
12-13		6.7
13-14		7.5
14-15		6.9
15-16		5.7
16-17		3.9
17-18		2.1
18-19		2.0
19-20		No sample
Total lb NO_3-N in 10-foot profile	222	296

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

13-YEAR TILE DRAIN SUMMARY

Total NO_3-N losses via tile discharge water are presented in Table 4 for the fertilized period (1973-79) and for the residual period (1980-85). Due to higher precipitation in the last 6 years, approximately three-quarters of the 13-year tile flow occurred in the 6-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 44% of the fertilizer applied at the 200- and 400-lb N/A rates (the recommended rate is 140 lb N/A) were lost from the soil thru the tile lines during this 13-year period.

Table 4. Summary of NO_3-N losses thru tile discharge from 1973-85 at Lamberton.

Total Applied N (1973-79)[1/]	Nitrate-N Lost Thru Tiles[2/]			Percent of applied N lost
	1973-79	1980-85	1973-85	
lb N/A	lb NO_3-N/A			%
126	80	131	211	--
700	161	184	345	23
1400	299	287	586	29
2800	639	737	1376	44

1/ Does not include the 40-lb rate applied in 1984.
2/ 20.8 acre-inches tile drainage in 1973-79, 56.6 acre-inches in 1980-85.

WEST CENTRAL EXPERIMENT STATION - MORRIS

WEATHER SUMMARY - 1985

Month	Period	Precipitation 1985	Precipitation 100-yr. av.	Precipitation Dev. from av.	Temperature 1985	Temperature 100-yr. av.	Temperature Dev. from av.	Soil Temperature (10 cm depth) 1985	Soil Temperature (10 cm depth) 10-yr. av.
January	1-31	0.28	0.68	-0.40	5.1	8.0	-2.9	14.8	20.7
February	1-28	0.47	0.67	-0.20	10.1	12.8	-2.7	14.1	23.9
March	1-31	2.74	1.13	+1.61	33.4	26.7	+6.7	31.2	29.2
April	1-10	0	0.57	-0.57	37.9	38.0	-0.1	36.7	
	11-20	0.03	0.64	-0.61	53.9	44.4	+9.5	43.2	
	21-30	2.10	1.05	+1.05	52.8	48.3	+4.5	42.0	
Total or av.		2.13	2.26	-0.13	48.1	43.6	+4.5	42.3	41.4
May	1-10	0.87	0.77	+0.10	61.2	52.0	+9.2	52.4	
	11-20	3.00	0.95	+2.05	58.3	55.8	+2.5	56.3	
	21-31	2.87	1.25	+1.62	62.4	60.0	+2.4	58.8	
Total or av.		6.74	2.97	+3.77	60.7	56.1	+4.6	55.8	57.1
June	1-10	T	1.29	-1.29	59.7	63.0	-3.3	57.7	
	11-20	2.29	1.30	+0.99	61.0	66.3	-5.3	59.9	
	21-30	0.71	1.37	-0.66	64.7	68.1	-3.4	57.5	
Total or av.		3.00	3.96	-0.96	61.8	65.8	-4.0	58.3	69.3
July	1-10	0.12	1.44	-1.32	71.0	70.1	+0.9	70.5	
	11-20	0.22	1.06	-0.84	68.6	71.4	-2.8	70.9	
	21-31	2.14	1.01	+1.13	65.9	71.4	-5.5	69.9	
Total or av.		2.48	3.51	-1.03	68.4	70.9	-2.5	70.4	76.7
August	1-10	0.80	1.04	-0.24	68.2	70.4	-2.2	69.1	
	11-20	1.65	0.93	+0.72	59.9	69.0	-9.1	62.5	
	21-31	2.17	1.04	+1.13	63.2	66.9	-3.7	63.3	
Total or av.		4.62	3.01	+1.61	63.8	68.7	-4.9	64.7	73.9
September	1-30	3.25	2.20	+1.05	55.7	59.0	-3.3	56.8	61.5
October	1-31	1.58	1.74	-0.16	43.2	47.2	-4.0	42.0	47.8
November	1-30	1.62	0.97	+0.65	19.2	29.7	-10.5	30.6	33.6
December	1-31	1.00	0.68	+0.32	4.1	15.2	-11.1	23.7	23.4
April-August Growing Season		18.97	15.71	+3.26	60.6	61.0	-0.4	58.3	63.8
January-December Annual		29.91	23.78	+6.13	39.6	42.0	-2.4	42.1	46.7

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

Morris, 1985

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-(1982-85). 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 6, 1985, @ 24,300 seeds/acre. Counter was applied @ 12 lbs/acre (1.8 lbs/acre active ingredient) in the row to the entire area at planting. The fertilized plots received 120 + 50 + 50 + 10 (N + P_2O_5 + K_2O + Zn) lbs/acre on November 16, 1984. Lasso @ 3 lbs/acre and Bladex @ 2.2 lbs/acre were broadcast on May 8. Silage samples were taken by hand on September 26 and the grain harvest was taken with a plot combine on October 14.

II. Soil Sampling and Analysis

A. 1985 Measurements

Only three nutrients (P, K and Zn) were measured in the plow layer samples in the fall of 1985 (Table 1). The levels of the LH treatments are approaching the fertilized check levels. The SB and LB are generally higher than the fertilized check except for Zn where all treatments are significantly less.

Table 1. Soil test values in the 0 to 8-inch zone for P, K, Zn and pH in a Tara soil 15 years (Fall 1985) after the application of high rates of manure.

	Elements				
Treatment	P Bray	P Olsen	K	Zn	pH
	- - -	lbs/acre	- - -	ppm	
CK	14	10	272	0.6	7.7
FE	48	35	303	4.9	7.0
SB	125	104	666	2.1	7.5
LB	152	187	591	2.7	6.9
LH	101	81	389	3.2	7.3
Signif. level (%)	>99	>99	>99	>99	88
BLSD (.05)	52	57	75	1.1	0.7
CV (%)	31.9	37.4	9.6	23.3	4.5

III. Plant Tissue Analysis

The nutrient concentrations in the ear leaves at silking in 1985 are given in Table 2. There are significant effects on many elements. The LH treatment was in the deficient range in N and was also significantly less than the fertilized check in N, Fe and Zn. SB and LB were significantly less than the fertilized check in Mg and Zn.

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

Table 2. Summary of analysis of corn leaves at silking - 1985.

Treatment	Elements									
	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	- - - - -		%	- - - - -		- - - -		ppm	- - - -	
CK	2.00	0.21	1.71	0.55	0.37	90.3	16.7	5.6	101.0	5.7
FE	2.99	0.32	1.93	0.50	0.33	128.5	32.2	5.2	83.1	5.7
SB	2.81	0.34	2.11	0.49	0.22	129.4	16.4	6.4	126.7	6.0
LB	2.62	0.43	2.22	0.47	0.22	131.3	19.3	5.5	88.1	5.7
LH	2.21	0.34	2.06	0.45	0.26	108.6	23.2	5.7	93.8	5.7
Signif. level (%)	>99	>99	>99	99	>99	>99	>99	20	84	2
BLSD (.05)	0.44	0.07	0.14	0.05	0.07	18.4	6.2	NS	42.9	NS
CV (%)	9.1	11.4	3.9	5.0	13.4	8.3	15.5	20.1	20.2	12.5

IV. Yield Measurements (Table 3)

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

B. Silage - None of the treatments were significantly different from the fertilized check.

Table 3. Summary of plant measurements - 1985.

Treatment	Early plant height	Early plant (10) dry weight	Grain		Silage		
			Moisture at harvest	Yield @ 15.5% M	Dry matter at harvest	Silage yield (D.M.)	Ear wt. as a % of silage wt.
	inches	- grams -	- % -	-Bu/A-	- % -	-lb/A-	- % -
CK	19.0	35.4	46.2	43.0	41.0	8766	53.8
FE	23.5	64.9	35.0	124.9	42.8	15875	54.6
SB	25.4	92.5	35.3	113.9	44.7	14983	57.6
LB	24.0	71.6	36.6	105.9	41.0	13197	58.9
LH	23.7	74.4	37.8	97.0	46.6	13287	57.1
Signif. level (%)	98	98	>99	>99	87	97	87
BLSD (.05)	3.3	28.6	3.8	19.0	5.1	4314	5.0
CV (%)	7.4	21.5	5.4	10.9	5.5	16.3	4.1

V. Summary

The last manure treatments were applied in 1970 and 1971. The LH treatment has had a significantly lower grain yield than the fertilized check the last two years, probably due to lower available nitrogen in the soil. The other two manures are slightly lower yielding than the fertilized checks.

MANURE RATE STUDY

Morris, 1985

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-(1982-85). 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 6, 1985, @ 24,300 seeds/acre. Counter was applied @ 12 lbs/acre (1.8 lbs/acre active ingredient) in the row to the entire area at planting. The fertilized plots received 120 + 50 + 50 + 10 (N + P_2O_5 + K_2O + Zn) lbs/acre on November 16, 1984. Lasso @ 3 lbs/acre and Bladex @ 2.2 lbs/acre were applied broadcast on May 8. Silage samples were taken by hand on September 26 and the grain harvest was taken with a plot combine on October 14.

II. Soil Sampling and Analysis

A. 1985 Measurements

Only three nutrients (P, K and Zn) were measured in the plow layer samples in the fall of 1985 (Table 1). The levels of all nutrients of the LB1 treatment were slightly below the fertilized check. The remainder of the treatments continued to have P and K levels significantly greater than the fertilized check, with the SB3 treatment having the highest levels. The Zn level of the fertilized check was significantly greater than all treatments except SB2 and SB3.

Table 1. Effect of two types of beef cattle manure and commercial fertilizer on P, K, Zn and pH values of a Tara Soil (0-8") - Fall 1985.

Treatment	Elements			pH
	Bray P	K	Zn	
	- lbs/acre -		ppm	
CK	10	279	0.6	7.3
FE	29	299	3.6	7.3
SB1	110	607	2.3	7.6
SB2	322	1172	4.5	7.0
SB3	462	1657	6.7	6.8
LB1	22	287	0.7	7.6
LB2	68	344	1.3	7.6
LB3	164	479	2.1	6.5
Signif. level (%)	99	99	99	96
BLSD (.05)	28	138	1.1	0.9
CV (%)	11.9	13.5	25.6	5.8

III. Plant Tissue Analysis

The nutrient concentrations in the ear leaves at silking in 1985 are given in Table 2. Significant effects were measured on all elements except Ca, Cu and Mn. The treatments which showed high soil tests of P and K also showed high levels of P and K in the leaf tissue. The N level of LB1 was in the deficient range. Solid beef manure generally decreased the levels of Mg, Cu and Mn as the rate was increased. Liquid beef manure decreased Ca, Mg, Mn and B and increased Fe as the rate increased.

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

Table 2. Summary of analysis of corn leaves at silking - 1985.

Treatment	Elements									
	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	- - - - - - - - % - - - - - - - -					- - - - - - - - ppm - - - - - -				
CK	1.97	0.20	1.54	0.51	0.36	85.6	15.2	3.4	87.5	5.8
FE	2.92	0.28	1.73	0.51	0.34	107.1	26.1	3.9	107.9	4.9
SB1	2.72	0.29	1.95	0.45	0.25	133.5	17.3	4.6	105.6	4.9
SB2	2.79	0.35	2.12	0.47	0.21	148.0	14.4	3.8	96.6	5.1
SB3	2.96	0.41	2.13	0.46	0.18	140.2	16.8	3.4	98.5	4.8
LB1	2.25	0.27	1.70	0.53	0.33	91.3	15.1	3.5	105.2	6.0
LB2	2.45	0.28	1.84	0.49	0.26	104.1	16.2	4.3	101.3	5.1
LB3	2.70	0.35	1.98	0.44	0.23	129.9	16.0	4.4	88.2	4.6
Signif. level (%)	>99	>99	>99	57	>99	>99	>99	68	8	98
BLSD (.05)	0.39	0.04	0.23	NS	0.07	21.5	13.2	NS	NS	0.8
CV (%)	8.6	7.9	7.1	10.8	14.3	10.8	10.4	18.6	22.8	8.3

IV. Yield Measurements (Table 3)

A. Grain - No treatments were significantly less in yield than the fertilized check in 1985, but the LB1 and LB2 were both significantly less than the SB2 treatment. In 1984 LB1 and LB2 were both less than the fertilized check.

B. Silage - The LB1 treatment yielded significantly less than the fertilized check.

Table 3. Summary of plant measurements - 1985.

Treatment	Early plant height	Early plant (10) dry weight	Grain		Silage		
			Moisture at harvest	Yield @ 15.5% M	Dry matter at harvest	Silage yield (D.M.)	Ear Wt. as a % of silage wt.
	inches	- grams -	- % -	- Bu/A -	- % -	lbs/A	- % -
CK	19.5	42.9	40.8	65.5	45.0	8660	57.7
FE	22.9	70.0	38.9	121.3	41.1	16297	58.1
SB1	25.3	99.5	35.2	125.6	45.0	17706	58.1
SB2	29.6	111.6	33.0	149.0	43.3	18278	61.1
SB3	26.0	69.6	36.2	136.0	42.1	18161	60.4
LB1	21.5	57.9	40.2	87.3	41.4	12571	60.7
LB2	23.2	72.0	37.4	94.5	45.8	15492	62.3
LB3	24.3	79.6	35.4	118.7	41.8	16625	57.9
Signif. level (%)	99	91	95	99	66	>99	29
BLSD (.05)	4.4	54.1	5.6	41.5	NS	3177	NS
CV (%)	10.0	33.5	7.4	19.9	6.7	12.1	6.5

V. Summary

The 1985 season was the seventh since manure had been applied. The LB1 and LB2 treatments appear to no longer be adequate for grain yields, as compared to other treatments.

CONTINUOUS CORN SILAGE
Morris, 1985
S. D. Evans

I. Experimental Description

In 1965 an experiment was initiated on a McIntosh silt loam to determine the effect of removal of continuous corn silage and fertilizer on corn 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. 1985 Operations

In 1985 the variety was Dekalb T950 and was planted @ 24,300 seeds/acre. Counter was applied @ 12 lbs/acre at planting on May 23. Lasso @ 3 lbs/acre and Bladex @ 2.2 lbs/acre were applied broadcast on May 23. Silage yields were taken on October 8 and grain yields on October 28. Following harvest, plow layer soil samples were taken from each plot.

III. Silage Yields - Dry matter, tons/acre

Treatment	1985 Yield	1966-85 Yield
Silage, low fertility	4.20	5.60
Silage, high fertility	5.22	6.10
Grain, low fertility	4.66	5.65
Grain, high fertility	5.70	5.98

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

	1985 Yield	1966-85 Yield
Grain, low fertility	78.9	89.9
Grain, high fertility	96.6	94.1

V. Check Yields

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

	1985 Yield	1966-85 Yield
Grain (0 + 0 + 0)	31.3	45.7
Silage (0 + 0 + 0)	2.02	3.59

VI. Soil Test Results

Treatment	pH	Bray P	Olsen P	Exch. K	Zinc
		- - - lbs/acre		- - -	ppm
Silage, low fertility	8.1	23	26	261	2.1
Silage, high fertility	8.1	55	41	292	2.0
Grain, low fertility	8.1	29	17	332	2.2
Grain, high fertility	8.1	58	48	397	2.2
Check	8.1	9	7	280	1.9

VII. Discussion

A. In 1985 a severe soil surface crust decreased stands, however, the trends of past years continued. 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 20-year average yields show very little difference between silage and grain plots, but there is a slight advantage for the higher fertility level.

C. Soil test results show a large difference in soil P and K levels due to fertilizer treatment. The P levels on plots receiving only 50 lbs/acre of P_2O_5 annually are in the medium range. Soil K levels are considerably higher where only the grain has been removed compared to removing corn silage.

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

SOIL TEST LAB COMPARISON

Morris, 1985

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 1980-84 trials were summarized previously (Soil Series 109 and Misc. Publ. 2-1982 to 1985).

In the fall of 1984 soil samples from the plow layer and 0-2 foot zone (corn only) were taken from all plots except the check. The soil from the four replications was combined to make two samples (plow layer and 0-2 foot) from each treatment. The samples were dried thoroughly, mixed, subdivided and sent to the appropriate laboratory. Recommendations were requested from five laboratories for corn at a yield goal of 130 Bu/A and spring wheat at a yield goal of 65 Bu/A. Analyses requested were (1) a complete analysis on the plow layer samples and (2) a nitrate-N analysis and recommendation on the 0-2 foot samples for treatments to be planted to wheat. After receiving the soil tests and recommendations (Tables 1 and 2), the fertilizer treatments were calculated with an adjustment for soil buildup with Harris Labs (Lab C). Harris Labs gave no indication that the 0-2 foot sample was used for the nitrogen recommendation on wheat. Labs will be

Table 1. Soil test results and the suggested fertilizer program for wheat in 1985.

	Soil Test Results				
Test	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	7.7	7.5	7.8	7.9	7.6
P (Bray 1), ppm	-	23H	-	13	21
(NaHCO3), ppm	15(H)	-	14	13	16
K, ppm	125(H)	149M	183	155	147
O.M., %	4.4	4.0H	4.1	4.0	M
Ca, ppm	3750	2060M	4544	3760	-
Mg, ppm	570	573VH	644	510	-
Na, ppm	12	-	18	72	-
S, ppm	3L	4L	3	9	-
Fe, ppm	14.1H	20.0H	18.1	13.0	-
Mn, ppm	9.1VH	15.0H	12.4	8.8	-
Zn, ppm	1.45H	2.1M	2.1	1.7	2.0
Cu, ppm	.60H	1.0M	0.8	0.66	-
B, ppm	-	1.0M	0.7	3.3	-
ENR (lb/A)	-	89	-	-	-
Nitrate-N (lb/A)	96	-	11	38	50
C.E.C. (meq/100 g)	23.8	15.5	28.6	24	-
Soluble salts (mmhos/cm)	.35	-	.19	-	-

	Suggested Fertilizer Program[1]				
Nutrient	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
	- - - - - - - -	- - - - - - - -	lb/A	- - - - - - - -	- - - - - - - -
Nitrogen	56	120	98	76	70
Phosphorus (P_2O_5)	41	35	50	45	0
Potassium (K_2O)	51	115	130[2]	95	30
Sulfur	0	12	15	20	0
Zinc	0	1.5	0	5	0
Boron	0	0	0-1	0	0
Iron	0	0	0	3	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.

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

labeled as follows: Lab A = Agvise, B = A & L, C = Harris, D = Eco-gri (Tests for treatment D were analyzed by Willmar Testing Lab, Willmar, MN from 1980-83. Tests in the fall of 1984 for the 1985 crop were by Eco-Agri Testing Laboratories, Willmar, MN), and E = U of M.

Table 2. Soil test results and the suggested fertilizer program for corn in 1985.

	Soil Test Results				
Test	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	8.0	7.9	8.0	8.1	7.9
P (Bray 1), ppm	-	11.0L	-	6.0	5
(NaHCO3), ppm	8(L)	-	8.0	11	8
K, ppm	109(H)	120M	131	118	112
O.M., %	3.5	3.7H	3.5	3.9	M
Ca, ppm	4650	2730H	5143	3920	-
Mg, ppm	555	476VH	524	625	-
Na, ppm	11	-	16	72	-
S, ppm	3L	4L	3	9.0	-
Fe, ppm	11.4H	14M	14.5	12	-
Mn, ppm	7.0VH	10M	8.8	6.92	-
Zn, ppm	1.26H	1.7M	1.3	1.4	1.4
Cu, ppm	.62H	1.0M	0.8	.66	-
B, ppm	-	0.9M	0.7	3.4	-
ENR (lb/A)	-	85	-	-	-
Nitrate-N (lb/A)	-	-	-	-	-
C.E.C (meq/100 g)	28.2	17.9	30.5	25	-
Soluble salts (mmhos/cm)	.36	-	.19	-	-

	Suggested Fertilizer Program[1]				
Nutrient	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
	- - - - - - - -	- - - - - - - -	lb/A - - - - - - - -	- - - - - - - -	- - - - - - - -
Nitrogen	132	150	185	165	120
Phosphorus (P_2O_5)	98	85	108[2]	105	90
Potassium (K_2O)	59	130	243[2]	170	40
Sulfur	0	15	20	20	0
Zinc	0	2.5	3	8	0
Copper	0	0	0	4	0
Manganese	0	1.0	0	0	0
Boron	0	0	0-1	0	0
Iron	0	0	0	3	0

[1] All values indicate pounds of nutrient suggested per acre for a yield goal of 130 bushels per acre for corn.
[2] Value include maintenance plus 1/2 of suggested buildup.

General

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

Wheat

The fertilizer was applied by hand on November 7, 1984. All plots were then moldboard plowed. In the spring the plots were field cultivated and dragged. On April 30, 1985, the plots were seeded to Era wheat @ 1 3/4 Bu/A. Bromate was applied @ 1 pt/A on June 4. The plots were harvested with a plot combine on August 15.

Corn

The fertilizer was applied by hand on November 8, 1984. All plots were then moldboard plowed. In the spring the plots were field cultivated and dragged. On May 2, 1985, the plots were planted to Dekalb-Pfizer T950 @ 24,300 seeds/acre. Counter was applied at planting @ 12 lbs/acre. Lasso @

3 lbs/A and Bladex @ 2.2 lbs/A were applied broadcast on May 2. The plots were harvested on October 14 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 A & L, Harris and Eco-Agri labs suggested applying sulfur. A & L and Eco-Agri recommended zinc, Eco-Agri also recommended iron and Harris recommended boron. There were no significant differences between labs in plant lodging, plant height, grain yield or grain moisture (Table 3).
U of M had the lowest fertilizer cost ($19.80) and the highest return over fertilizer ($225.90), while Harris had the highest fertilizer cost ($52.47) and the lowest return over fertilizer ($168.73) (Table 4).

Table 3. Effect of fertilizer recommendations on various plant measurements - 1985.

	Wheat				Corn	
Lab	Plant Lodging	Plant Height at Harvest	Grain Yield	Grain Moisture	Grain Yield	Grain Moisture
	-Score[1]-	-inches-	Bu/A	%	Bu/A	%
A (Agvise)	3.5	34.5	62.7	14.6	114.2	39.6
B (A & L)	4.0	35.8	63.9	14.4	106.0	39.1
C (Harris)	4.3	35.5	63.2	14.3	100.8	40.7
D (Eco-Agri)[2]	3.3	35.3	67.9	14.5	100.3	41.2
E (UM)	3.0	34.5	70.2	14.3	107.3	41.6
Check	1.0	29.8	39.8	14.3	66.8	43.2
Signif. level (%)	98	>99	>99	21	>99	94
BLSD (.05)	1.9	2.8	9.8	NS	13.8	3.2
CV (%)	36.6	5.3	10.9	3.3	9.6	4.5

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

Table 4. Economic return over fertilizer costs - 1985.

	Wheat				Corn			
Lab	Value of Crop @ $3.50/Bu	Fertilizer Cost[1]	Return over Fertilizer	Return over Check	Value of Crop @ $2.07/Bu	Fertilizer Cost	Return over Fertilizer	Return over Check
	$/A							
A (Agvise)	219.45	27.15	192.30	53.00	236.39	58.16	178.23	39.95
B (A & L)	223.65	50.77	172.88	33.58	219.42	72.05	147.37	9.09
C (Harris)	221.20	52.47	168.73	29.43	208.66	99.08	109.58	-28.70
D (Eco-Agri)[2]	237.65	45.28	192.37	53.07	207.62	87.94	119.68	-18.60
E (UM)	245.70	19.80	225.90	86.60	222.11	51.70	170.41	32.13
Check	139.30	0	139.30	-	138.28	0	138.28	-

[1] Values used ($/lb) were: N = $0.24, P_2O_5 = $0.21, K_2O = $0.10, S = $0.21, Zn = $0.40, Mn = $1.05, B = $2.30, Fe = $0.63.
[2] Tested by Willmar 1980-83.

Results and Discussion of the Corn Trial

The soil tests and fertilizer recommendations are shown in Table 2. Once again recommendations varied for N, P, K and micro-nutrients. Sulfur was recommended by A & L, Harris, and Eco-Agri. Also recommended were: manganese by A & L, boron by Harris and iron by Eco-Agri.

Table 3 shows a significant difference between Agvise and Eco-Agri in grain yield. There are no significant differences in corn grain moisture between labs.

Fertilizer costs ranged from $51.70 (U of M) to $99.08 (Harris) (Table 4). Economic return over fertilizer had a range of $109.58 (Harris) to $178.23 (Agvise).

Five-Year Summary

The combined average return per year for 1980-85 shows a range of $39.46 (A & L) to $80.94 (U of M) over the check (Table 5). For wheat, Harris shows the smallest return over the check, while U of M shows the greatest. For corn, Harris and A & L are showing negative returns over the check, while after six years, U of M has returned $101.64 over the check. The extremely high rates of N and K by A & L, Harris and Eco-Agri are not increasing yields and result in a much higher fertilizer cost. In addition it appears that the recommendations of some labs for sulfur and micronutrients are not resulting in significantly higher yields over those which do not; consequently, economic returns over fertilizer are less.

Table 5. Six-year summary of yields and economic returns 1980-1985.

	Wheat[1]				Corn[2]				
Lab	Total 6-year Yield	Total 6-year Fertilizer Cost	Economic Return over Fertilizer	Return over Check	Total 6-year Yield	Total 6-year Fertilizer Cost	Economic Return over Fertilizer	Return over Check	Combined Average Return per Year
A (Agvise)	374.7	164.52	1302.93	305.23	687.1	308.69	1447.40	98.54	67.30
B (A & L)	384.3	255.00	1250.25	252.55	669.4	372.08	1333.08	-15.78	39.46
C (Harris)	382.6	287.63	1211.17	213.47	685.0	425.71	1332.59	-16.27	32.87
D (Eco-Agri)[3]	370.5	206.83	1241.22	243.52	678.2	379.04	1361.34	12.48	42.67
E (UM)	387.3	132.43	1381.67	383.97	679.4	255.42	1450.50	101.64	80.94
Check	254.4	0	997.70	-	525.4	0	1348.86	-	-

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

EFFECTS OF NITROGEN AND PHOSPHORUS APPLICATION METHODS ON SPRING WHEAT - 1985

Morris, 1985

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 fifth 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

Initial soil sample results by rep are given in Table 1. The broadcast 0-46-0 was applied by hand on May 3, 1985. 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. On May 3 the plots were field cultivated and drug. The study was seeded to Era wheat @ 1 3/4 Bu/acre.

Whole plant samples were collected on July 30 and were used to calculate forage yield and N and P uptake. The plots were harvested on August 15 with a plot combine.

Table 1. Soil test results spring 1985.

Rep	P Soil Test Olson	P Soil Test Bray	Exch. K	Soil pH	NO_3-N[1]
	- - lb/A	- -	-lb/A-		-lb/A-
1	11	15	237	7.8	12.8
2	6	7	290	8.1	
3	7	10	248	8.1	12.4
4	20	5	276	8.2	
Mean	11	9	263	-	12.6

[1] Nitrate samples (0-2') are an average of reps 1-2 and 3-4.

Yield and Nutrient Uptake

The nutrient uptake and yield results are given in Table 2. There are no large placement or P rate effects. The major significant difference is between the check vs. the other treatments. It also appears that surface placement of nitrogen (treatments 8, 9 and 11) was inferior to the other treatments in dry matter yield and grain yield. There appears to be no consistent advantage of any placement method. The response to P is small or non-existent indicated by a dry matter yield of 7467 lbs/acre and a grain yield of 68.4 bu/acre for treatment 10 where only N was applied.

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

Table 2. The effect of N and P application 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	4480	0.234	10.5	1.18	53.5	36.6	12.3
2	Dual NP, Knife	AA,APP	100	20	7167	0.221	15.9	1.64	117.9	68.9	14.0
3	Dual NP, Knife	AA,APP	100	40	7559	0.189	14.3	1.43	107.9	71.5	13.8
4	N Knife, P BCST	AA,TSP	100	20	7574	0.179	13.7	1.36	103.2	71.3	13.8
5	N Knife, P BCST	AA,TSP	100	40	8075	0.179	14.5	1.36	109.1	70.6	14.1
6	N Knife, NP1 Drill[2]	AA,UR,TSP	100	20	7657	0.194	14.9	1.52	116.5	70.7	13.7
7	N Knife, NP2 Drill[3]	AA,UR,TSP	100	40	7395	0.191	14.2	1.43	105.3	70.5	14.2
8	N & P BCST	UR,TSP	100	20	7043	0.188	13.5	1.27	89.5	66.8	13.2
9	N & P BCST	UR,TSP	100	40	7081	0.188	13.5	1.22	87.1	70.6	13.0
10	N Knife	AA	100	0	7467	0.180	13.3	1.48	110.0	68.4	13.4
11	N BCST	UR	100	0	6739	0.188	12.9	1.39	93.5	66.4	13.5
Signif. level (%)					>99	90	44	>99	>99	>99	91
BLSD (.05)					1136	0.050	NS	0.21	21.5	7.0	1.6
CV (%)					11.1	13.5	21.1	9.9	15.1	7.7	6.0

[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 + 20 P_2O_5 at seeding with drill.

[3] NP2 Drill = 10 N + 40 P_2O_5 at seeding with drill.

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

Morris, 1985

S. D. Evans

With the increase in reduced tillage systems, many new types of fertilizer placement devices have been developed to overcome the adverse effects of plant residues on operation of fertilizer placement disks or knives outside the seed opener area. One of these devices is a knife mounted inside the double disk opener on minimum tillage row crop planters. This device supposedly places the liquid fertilizer 1/2 to 3/4 inch to the side and 1/2 to 1 inch below the seed. The close proximity to the seed may cause seedling damage at high starter rates. This study was set up to examine the effect of two liquid fertilizers (10-34-0 and 7-22-5) at three rates (10, 20, and 30 gal/A) with two seed placements (the device described above and a 2" x 2" placement with a single disk opener).

Experimental Procedures

The study was located on a Tara silt loam planted to corn in 1984 and moldboard plowed in the fall. Nitrogen as anhydrous ammonia was applied with a field cultivator in the spring of 1985 to provide 120 lbs/A of N. The area was field cultivated a second time in preparation for planting. The soil tests were: pH = 7.9, O.M. = High, Olsen P = 22 lbs/A, and exchangeable K = 237 lbs/A.

A randomized complete block experiment with four replications was used. Treatments consisted of two liquid starters (10-34-0 and 7-22-5), three rates (10, 20, and 30 gal/A), and two placement methods (near the seed and 2" to the side and 2" below the seed) plus no starter checks with each placement device.

Corn (Pioneer 3906) was planted in 30" rows with a Hiniker minimum tillage planter with Kinze planter units at 24,300 plants per acre on May 30. The liquid materials were applied with a John Blue squeeze pump near the seed (NSd) or 2" x 2" with a Hiniker single disk opener. Counter was applied at 13 lbs/A for corn rootworm control. Chemical weed control consisted of 3 qt. of Lasso and 2.2 qt. of Bladex applied on May 30. The fertilizer pump drive chain came off when planting the 7-22-5, NSd, 10-gal treatment requiring replanting this treatment to get on the proper fertilizer. This treatment was not used in the early emergence measurements.

Plant counts to obtain emergence rate and final stand were taken every two days from 2 rows each 40' long for 10 days beginning on the 11th day after planting. Harvest population was taken on the same area. Grain yield was determined by harvesting each plot with a modified JD 3300 combine.

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

Days after planting	Avg. Soil temperature (2")	Precipitation
	- °F -	- inches -
1	59	2.53
2	60	trace
3	54	0
4	54	0
5	52	trace
6	52	0
7	58	0
8	56	0
9	63	0
10	64	0
11	62	trace
12	60	0.88
13	56	0.63
14	60	0

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

Results and Discussion

The experiment was planted late in the season because of wet soil conditions. The evening of the day the corn was planted a heavy rain of 2.53" fell (Table 1). This left the area saturated and possibly diluted the fertilizer bands eliminating any possibility of salt damage. The next significant rain was recorded on the 12th and 13th day after planting. Temperatures at the 2" depth were above 50°F for the entire period.

Salt values (Table 2) ranged from 11.6 lbs/A at the low rate of 10-34-0 to 39.6 lbs/A at the high of 7-22-5. The 20- and 30-gal rates of both materials exceed the maximum N + K_2O guideline in Minnesota of 15-20 lbs/A.

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

Application rate	Liquid fertilizer 10-34-0	7-22-5
gal/A	- lb N + K_2O -	
10	11.6	13.2
20	23.2	26.4
30	34.8	39.6

Emergence rate was significantly affected by placement (Table 3) with the NSd treatments emerging before the 2" x 2" treatments. Analysis of material and rate of material did not affect emergence rate.

There was no significant differences on emerged population.

Table 3. Influence of liquid starter fertilizer material, application rate, and placement on emergence rate, emerged population, and early plant height of corn.

Material	Treatment Knife	Rate	Days after planting 11	13	15	18	20	Emerged Population (6-19-85)
		gal/A	- % of final stand -					ppA x 10^{-3}
Check	NSd	0	35	72	91	98	100	20.6
Check	2" x 2"	0	31	68	88	96	100	20.6
10-34-0	NSd	10	55	86	98	100	100	22.5
10-34-0	2" x 2"	10	33	69	91	97	100	20.9
7-22-5	NSd	10[1]	-	-	-	-	-	- -
7-22-5	2" x 2"	10	22	70	86	96	100	20.5
10-34-0	NSd	20	53	86	97	100	100	22.4
10-34-0	2" x 2"	20	25	64	88	97	100	19.4
7-22-5	NSd	20	38	79	96	100	100	20.7
7-22-5	2" x 2"	20	30	64	90	96	100	21.5
10-34-0	NSd	30	58	83	89	100	100	20.8
10-34-0	2" x 2"	30	33	69	89	100	100	20.8
7-22-5	NSd	30	37	79	93	99	100	21.3
7-22-5	2" x 2"	30	34	69	85	96	100	19.1
Significance level (%)			>99	99	95	46	0	73
BLSD (.05)			9	9	13	NS	NS	NS
CV (%)			25	13	6	4	0	8

[1] Mistake made in planting this treatment so early stand counts not valid.

The NSd treatments were significantly taller than the 2" x 2" treatments as measured on July 1 (Table 4). The only material x rate combination showing a decrease in height with increasing rate was the 2" x 2" placement with 10-34.0. The height was 14.7" at 10-gal, decrease to 13.8" at 20-gal, and decreased to 12.8" at the 30-gal rate.

Table 4. Plant height on 7-1-85 as affected by liquid starter material, application rate, and placement.

Placement Method	Rate	Material 10-34-0		7-22-5
	gal/A	- height (in.) -		
NSd	0	- -	12.6	- -
NSd	10	15.2		14.6
NSd	20	16.0		13.8
NSd	30	15.8		12.8
2" x 2"	0	- -	11.7	- -
2" x 2"	10	14.7		12.6
2" x 2"	20	15.2		13.4
2" x 2"	30	15.8		14.2

Grain yield was significantly affected by treatment (Table 5). The NSd treatments averaged 72.2 bu/A and the 2" x 2" treatments 65.4 bu/A. The two materials were significantly different in yield: 10-34-0 = 72.6 bu/A and 7-22-5 = 64.5 bu/A. There was a significant effect of starter (68.8 bu/A) vs. no starter (57.6 bu/A). There was no significant effect of rate on yield.

There were some significant treatment effects on grain moisture (Table 5). One major effect was starter (38.2%) vs. no starter (44.6%). The other major effect was 10-34-0 = 36.6% vs. 7-22-5 = 39.8%.

Table 5. Influence of liquid starter fertilizer material, application rate, and placement on harvest population, grain moisture, and corn grain yield.

Material	Treatment Knife	Rate	Harvest Population	Grain Moisture	Grain Yield
		gal/A	- ppA x 10^{-3} -	- % -	bu/A
Check	NSd	0	20.1	43.5	60.3
Check	2" x 2"	0	20.3	45.8	54.8
10-34-0	NSd	10	21.8	37.4	71.6
10-34-0	2" x 2"	10	20.5	36.4	73.5
7-22-5	NSd	10[1]	22.8	40.3	69.3
7-22-5	2" x 2"	10	20.6	42.2	58.6
10-34-0	NSd	20	22.5	35.1	82.0
10-34-0	2" x 2"	20	19.5	38.9	64.1
7-22-5	NSd	20	20.1	37.9	63.9
7-22-5	2" x 2"	20	21.0	40.8	62.6
10-34-0	NSd	30	22.0	35.1	77.8
10-34-0	2" x 2"	30	20.5	39.8	66.9
7-22-5	NSd	30	21.8	36.7	68.9
7-22-5	2" x 2"	30	19.7	38.0	66.6
Significance level (%)			95	>99	>99
BLSD (.05)			2.8	3.4	9.5
CV (%)			7.2	6.2	9.8

[1] Mistake made in planting this treatment so early stand counts not valid.

ALFALFA FERTILITY-MANAGEMENT STUDY

Morris, 1985

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

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 a split-split plot with four replications. The main plots were cutting schedule. The first split was P and K fertilizer and the second split was variety. In 1983 the area was harvested but no yields were taken and no fertilizer applied. In 1984 and 1985 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 June 6, July 1, July 30, and September 6. The 3-cut schedule was harvested on June 12, July 12, and August 20. Yields were taken with a small flail chopper, weighed and a moisture sample collected from each plot. Samples of the Answer variety were saved for chemical analysis. Soil samples were taken of the 0 to 2-inch and 2- to 8-inch zones in early September.

Results and Discussion

After two crop years no significant difference in total seasonal yield has occurred between the two varieties used (Tables 1 and 2). There were some significant differences between varieties for individual cuttings (Table 4), but the no variety was consistently higher yielding and the maximum difference was 0.1 ton/acre. In 1985 the 3-cut schedule significantly outyielded the 4-cut schedule (Table 3). The addition of P fertilizer has increased yields significantly in both years, while the addition of K fertilizer has not affected yields (Tables 1 and 2).

Table 1. Effect of cutting schedules, P and K fertilization and varieties on alfalfa yields at Morris in 1985.

Fertilizer Rate		1/2 Bud (4 cuttings) Variety			1/10 Bloom (3 cuttings) Variety			Average over Fertilizer
P_2O_5	K_2O	Vernal	Answer	Average	Vernal	Answer	Average	
- - lb/A - -		- - - - - - - - - - Dry Matter (T/A) - - - - - - - - - - - - - - - - - -						
0	200	2.81	2.70	2.75	3.51	3.41	3.46	3.11
50	200	4.47	4.53	4.50	5.19	5.32	5.25	4.88
100	200	4.54	4.91	4.73	5.57	5.67	5.62	5.17
50	0	4.25	4.55	4.40	5.04	5.00	5.02	4.71
50	100	3.89	4.03	3.96	5.32	5.16	5.24	4.60
50	200	4.65	4.58	4.62	5.02	5.17	5.09	4.85
50	300	4.43	4.61	4.52	5.39	5.23	5.31	4.92
50	400	4.68	4.75	4.71	5.30	5.20	5.25	4.98
Average		4.21	4.33	4.27	5.04	5.02	5.03	4.65

CV =5.3%

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

Statistical analysis of the soil tests 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 tests, respectively (Tables 7 and 8). Fertilizer did not affect soil tests in the 2- to 8-inch zone. All P and K soil tests were lower than one year ago except the K soil test on plots receiving 400 lbs/acre of K_2O annually.

Table 2. Effect of P and K fertilization and variety on alfalfa yields at Morris in 1985.

Fertilizer Rate		Varieties	
P_2O_5	K_2O	Vernal	Answer
- - lb/A - -		Dry Matter (T/A)	
0	200	3.16	3.05
50	200	4.83	4.93
100	200	5.06	5.29
50	0	4.64	4.77
50	100	4.60	4.59
50	200	4.83	4.87
50	300	4.91	4.92
50	400	4.99	4.98
Average		4.63	4.67

CV = 5.3%

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)	.54	93
PK Treatment (PK)	.65	99
CS x PK	.18	27
Variety (V)	.03	71
CS x V	.07	88
PK x V	.07	35
CS x PK x V	.11	35

[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	99	>99	>99	>99	>99	>99	>99
Variety (V)	>99	96	91	42	74	>99	80
PK x V	95	4	61	41	19	46	4

[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.

Variable	3-cut Schedule 1st	2nd	3rd	4-cut Schedule 1st	2nd	3rd	4th
	- - - - Signif. level (%)[1] - - - -						
PK Treatment (PK)	>99	>99	>99	98	>99	>99	>99
Variety (V)	14	22	86	91	38	55	49
PK x V	83	27	74	94	61	88	30

[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 1985.

Variable	Soil Tests (lbs/acre) Bray P 0-2"	Bray P 2-8"	Olsen P 0-2"	Olsen P 2-8"	Exch. K 0-2"	Exch. K 2-8"
	- - - - - - - Probability[1] (%) - - - - - - - -					
Cutting Schedule (CS)	88	20	92	15	1	28
PK Treatment (PK)	>99	68	>99	62	>99	80
CS x PK	46	59	18	41	26	57

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

Table 7. Effect of P rate on Answer only on soil test P of the 0-2 inch soil zone in September 1985.

Fertilizer Rate P_2O_5	K_2O	Bray P	Olsen P
- lbs/acre -		- - lbs/acre - -	
0	200	9	5
50	200	20	17
100	200	40	33

Table 8. Effect of K rate on Answer only on soil test K of the 0-2 inch soil zone in September 1985.

Fertilizer Rate P_2O_5	K_2O	Exch. K
- lbs/acre -		lbs/acre
50	0	228
50	100	279
50	200	346
50	300	416
50	400	756

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

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

Morris, 1985

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

EXPERIMENTAL PROCEDURES

The experimental site is located in west central Minnesota on a Pachic Udic Haploboroll (Tara, silt loam) soil. The experimental disign is a split-plot with tillage as main plots, N rates as subplots, and hybrids as sub-subplots. There are four replications.

Treatments are summarized in Table 1. The site was too wet in the fall of 1984 to apply ammonia and carry out the tillage operations. The nitrogen was applied as anhydrous ammonia on May 10. The moldboard plow and chisel plow treatments were carried out on May 20. The moldboard plow plots were disked twice and field cultivated once before planting. The chisel plow plots were disked once before chiseling and disked once after chiseling. The plots were planted on May 24 with a Hiniker planter with Kinze units. The planted population was 30,100 seeds/acre.

Weed control was obtained by Alachlor (Lasso) 3 lbs/A + Cyanazine (Bladex) 2.2 lbs/A applied preemergence on May 25. There was excellent weed control. Row fertilizer was applied at planting (9.4 gal/A of 7.4-25-0). The moldboard , chisel, and no till treatments were not cultivated. The ridge till plots were cultivated twice (June 24 and July 8) to form ridges.

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

Silage yields were taken by hand on October 1 from one 20-foot border row of each plot. The ears and stover were weighed separately and samples were saved for moisture and chemical analysis.

Grain yields were taken on October 21 with a modified JD 3300 combine. The two center rows of each plot 30 feet long were harvested and weighed on the combine. A grain sample was saved for moisture and chemical analysis.

RESULTS AND DISCUSSION

Heavy rains (2.53 inches on May 30) and cool temperatures (minimum daily temperatures 6.3^{o} F below normal the first 14 days after planting) resulted in some herbicide damage from the Lasso + Bladex. Very few plants were lost, but there was some tissue damage.

Yields

The grain and silage yields were quite low (Table 3) due to the late planting and cool season. There were significant effects of tillage, nitrogen, and hybrid on yield (Tables 2 and 3). The chisel treatment was superior in both grain and silage yield. The grain yields of the other 3 treatments were not different. Silage yields of moldboard and ridge till were low while no till was intermediate. The grain yields reached a maximum at 120 N while silage yields peaked at 80 N. Pioneer 3906 outyielded Dekalb XL8 in both grain and silage yields.

Moisture Stress

Moisture stress was measured on August 7th and 8th. There was a relatively low level of moisture stress at that time. The evaporative demand was relatively high under clear, dry conditions. There was no measurable effect of tillage on moisture stress (Table 6). There was a consistent difference in moisture stress due to hybrid. Pioneer 3906 showed lower stress than Dekalb XL8 (Table 7). This is consistent with the 1984 findings, although there was a significant tillage effect in that year.

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

Table 1. Treatment summary at Morris, MN, 1985.

Treatment	
Tillage:	Spring moldboard plow Spring chisel plow Ridge till No till
N Rate:	0, 40, 80, 120, and 160 lbs/A applied May 10,1985 prior to tillage as anhydrous ammonia
Hybrid:	Pioneer 3906 Dekalb XL 8

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

Variable	Residue Cover After Planting	Emerged Population	Tassel Date	Silk Date	Grain Yield	Silage Yield	Harvest Index[2]
	- - - - - - - - - - - - - - Significance level[1](%) - - - - - - - - - - - - - -						
Tillage (T)	>99	99	91	91	99	98	95
Nitrogen (N)	80	52	>99	>99	>99	>99	>99
T x N	86	65	78	79	58	8	73
Hybrid (H)	97	>99	10	21	>99	>99	>99
T x H	60	92	97	96	7	12	95
N x H	95	42	38	26	44	82	98
T x N x H	90	1	52	54	18	31	88

[1] Harvest index is defined as ear dry matter as a percent of the total dry matter.
[2] Probability that differences are not due to chance.

Table 3. Main effects of tillage, N rate, and hybrid on grain yield, silage yield, and harvest index.

Tillage	N Rate	Hybrid	Grain Yield	Silage Yield	Harvest Index
	- lb/A -		- bu/A -	- lbs/A -	- % -
Moldboard			68.4	9856	46.8
Chisel			79.3	11352	45.1
Ridge till			69.3	9690	45.7
No till			65.8	10199	43.7
BLSD (.05)			6.6	1099	2.3
	0		38.8	7291	42.0
	40		72.2	9806	45.2
	80		77.6	11272	46.4
	120		82.9	11416	46.5
	160		82.9	11587	46.5
	BLSD (.05)		4.3	746	2.4
		P 3906	78.8	10949	46.8
		D XL8	62.7	9599	43.8
CV (%)			12.7	15.3	9.4

Table 4. The effect of tillage and hybrid on residue cover, emerged population, and harvest index.

Tillage	Residue Cover[1] After Planting		Emerged Population		Tassel Date		Harvest Index	
	P 3906	D XL8	P 3906	D XL8	P 3906	D XL8	P 3906	D XL8
	- - - % - - -		- ppA x 10^{-3} -		days after 8/1		- - - % - - -	
Moldboard	10.1	9.2	24.2	22.0	5.2	4.7	46.7	46.8
Chisel	37.5	43.0	25.4	24.3	3.9	4.0	46.6	43.6
Ridge till	64.1	70.9	24.6	22.0	4.6	4.6	48.2	43.2
No till	70.8	74.2	24.4	23.6	4.8	5.0	45.8	41.6

[1] Only 40 N and 120 N rates were counted.

Table 5. The effect of nitrogen and hybrid on residue cover and harvest index.

N Rate	Residue Cover[1] After Planting		Harvest Index	
	P 3906	D XL8	P 3906	D XL8
- lbs/A -	- - - % - - - -		- - - - % - - - -	
0	-	-	45.7	38.4
40	42.8	49.9	47.3	43.1
80	-	-	46.6	46.1
120	48.4	48.8	47.5	45.5
160	-	-	47.1	45.8

Table 6. The effect of tillage on moisture stress at Morris, MN, 1985 (n=8).

Date	Time	Tillage				Significance[1] Level
		Moldboard	Chisel	Ridge till	No till	
		- - - - - - - - - - (-bars) - - - - - - - - - - -				- - - % - -
8/7/85	1400	7.85	7.90	7.05	7.20	52
8/8/85	0800	1.77	2.05	1.81	2.17	50
8/8/85	1330	4.78	4.74	4.70	4.55	6

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

Table 7. The effect of corn hybrid on moisture stress at Morris, MN, 1985 (n=8).

Date	Time	Hybrid		Significance[1] Level
		Pioneer 3906	Dekalb XL8	
		- - - - - - (-bars) - - - - - -		- - - % - -
8/7/85	1400	6.81	8.12	99
8/8/85	0800	1.65	2.25	99
8/8/85	1330	4.44	4.95	91

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

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

George Rehm, Mike O'Leary, Greg Cremers, Brian Anderson

Background and Justification:

In Minnesota, there is potential for a requirement for the use of fertilizer boron (B) in the production of both corn and alfalfa. The potential for a response of B is highest where these crops are grown on sandy soils with a low organic matter content.

The need for the addition of B to a fertilizer program has been the subject of previous studies but the results have not been conclusive. Annual applications of B did increase the yield of an alfalfa-grass mixture in northeastern Minnesota. Broadcast applications of B increased corn yield but had little effect on production of alfalfa in north-central Minnesota. At this experimental site, excessively high rates of fertilizer B reduced the yield of both corn and alfalfa. At the Becker Experimental Field, the application of fertilizer B had no effect on yield.

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

In past studies, the B used in the fertilizer program has been broadcast and incorporated before planting. Perhaps some of the B applied in this way was lost and this might explain some of the erratic responses noted to date. This study was designed to evaluate the effect of rate of applied B as well as frequency of application on production of both alfalfa and corn grown on an irrigated sandy soil.

Experimental Procedures:

This study was conducted at the Irrigation Research Center at Staples, Minnesota. The soil is classified as a Hubbard sandy loam. Relevant soil properties are listed in Table 1.

Trials were conducted with both corn and alfalfa. Prior to treatment application, soil samples were taken from each corn plot at depths of 0-6, 6-12, 12-24, and 24-36 inches (Table 2). Samples were collected in early November from the same depths to monitor changes in the B concentration in the soil. The hot water soluble procedure was used to extract B from the soil.

Four rates of B (0, 1, 2, 4 lb./acre) in either single or split application were broadcast to an established stand of alfalfa. When split applications were used, 1/2 was applied in early spring and 1/2 after the second cutting. Adequate S (as gypsum) and K (as 0-0-60) were applied to all plots. Three cuttings were taken starting in early June and whole plant samples were taken from each plot at each cutting. A total of 11.45 inches of irrigation water was applied during the growing season.

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

pH	7.0
P, lb./acre (Bray & Kurtz #1)	89
K, lb./acre (1 N NH_4 $C_2H_3O_2$)	206
Mg, lb./acre	340
S, ppm	4
B, ppm	.24
O.M., %	2.4

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

Table 2. Boron concentration in corn experimental area with depth as influenced by rate and frequency of application.

Treatment	Depth	Sampling Time Spring	Fall
	inches	ppm B	
control	0-6	.28	.23
	6-12	.20	.20
	12-24	.13	.13
	24-36	.10	.10
1 lb.B/acre	0-6	.23	.30
	6-12	.20	.28
	12-24	.15	.13
	24-36	.10	.10
2 lb. B/acre	0-6	.23	.30
	6-12	.20	.35
	12-24	.13	.18
	24-36	.10	.10
.5 + .5 lb. B/acre (split)	0-6	.23	.30
	6-12	.20	.33
	12-24	.13	.15
	24-36	.10	.10
1 + 1 lb. B/acre (split)	0-6	.25	.43
	6-12	.20	.55
	12-24	.10	.13
	24-36	.10	.10

Three rates of B (0, 1, 2 lb./acre) in either single or split application were broadcast for corn. Single applications were applied before planting. For split applications, 1/2 was applied before planting and 1/2 was applied at the 8-leaf stage. All plots received broadcast S (gypsum) and K (0-0-60). The N rate for all treatments was 200 lb./acre with 1/2 half applied before planting and 1/2 applied at the 8-leaf stage. In addition, all plots received a starter (8-10-41) at a rate of 100 lb./acre.

Other management practices needed to achieve high yields in the area were used. A total of 8.70 inches of irrigation was water applied during the growing season.

Ear leaf samples were collected at silking, dried and analyzed for B. Both grain and stover yields were recorded. Stover samples were analyzed for B to calculate B removal by the corn crop.

Results and Discussion:

In 1985, neither rate nor frequency of B applied had a significant influence on alfalfa yield (Table 3). This was true for individual cuttings as well as for total yield. Apparently the inherent B in the soil as well as the B released from the mineralization of organic matter during the growing season was sufficient to meet the B needs of this crop.

As was the situation for alfalfa, neither rate nor frequency of B applied had a significant effect on both the grain and stover yield of corn (Table 4). Again, the soil was able to supply the needed B during the 1985 growing season. Yields were hindered by cool temperatures and were lower than anticipated. Perhaps a response to fertilizer B could be achieved at higher yield levels.

The B concentration in the mature stover was not significantly affected by treatment. The high CV associated with this measurement illustrates the problem with sample collection and analysis of samples of mature corn stover. As would be expected, B uptake by the crop was not significantly influenced by treatment.

The B concentration in the ear leaf tissue was affected by treatment (Table 4). Compared to the control, use of B increased the concentration in this tissue. The highest concentration resulted from the situation where 2 lb. B/acre was split into 2 equal applications. These data would indicate that split applicatinos may be useful under irrigated conditions in situations where soil B is more limiting than at this experimental site.

The concentration of boron in the soil was also influenced by the treatment applied (Table 2). Compared to the control, the concentration in the 0-6 and 6-12 inch levels was increased when B was applied. The major changes occurred in the 6-12 inch depth. Greatest changes were measured when the 2 lb. B/acre rate was applied in 2 equal increments.

Compared to values recorded before B was applied, there was little or no change in B concentration in the 12-24 and 24-36 inch depths. It should be noted that the percentage of fine textured materials in the soil increases at the 12-24 inch depth. This fine textured material apparently prevents leaching of fertilizer B through the profile.

The amount of irrigation water used was higher than the normal amount that would be used. Based on data from one year it would appear that leaching of applied B would be a minor concern for these irrigated soils.

Table 3. Effect of rate and frequency of boron application on the yield of alfalfa.

Treatment	Cutting 1	2	3	Total
	---------ton dry matter/acre-------			
control	2.1	1.2	1.3	4.6
1 lb. B/acre (single)	1.8	1.1	1.3	4.2
2 lb. B/acre (single)	2.0	1.1	1.3	4.4
4 lb. B/acre (single)	1.8	1.1	1.3	4.2
.5 + .5 lb. B/acre (split)	2.0	1.2	1.3	4.5
1 + 1 lb. B/acre (split)	1.9	1.1	1.3	4.3
2 + 2 lb. B/acre (split)	2.1	1.2	1.3	4.6

Table 4. Effect of rate and frequency of boron application on the stover and grain yield of corn, B concentration in ear leaf and stover and B uptake by corn.

Treatment	Yield Grain	Yield Stover	B Conc. Ear leaf	B Conc. Stover	B Uptake
	bu./acre	ton D.M./acre	-------ppm B-----		lb./acre
control	136.4	6.17	8.1	5.2	.064
1 lb.B/acre (single)	143.4	6.02	9.3	6.1	.073
2 lb.B/acre (single)	140.6	6.34	9.8	5.0	.063
.5 + .5 lb.B/acre (split)	141.7	6.18	9.6	5.8	.072
1 + 1 lb.B/acre (split)	142.7	6.03	11.7	6.0	.072
CV: %	3.8	6.3	6.2	18.2	17.7
BLSD (.10)	NS	NS	.8	NS	NS

CORN - SOYBEAN ROTATION

H. Meredith, Mel Wiens and Mike O'Leary

The corn-soybean rotation experiment initiated in 1981 at the Staples Station to evaluate corn yield under a regime of continuous corn and corn following soybean continues.

Objective: To determine potential corn and soybean yields under intensive management.

Discussion: Moisture and nutritional requirements are frequently the two most limiting features of crop production on these typically coarse textured soils. Other management practices as early planting, population, seed selection, pest control, etc. frequently limit yields. This study is an application of the best management practices available to the commercial farmer variation in yield from year to year are attributed to growing conditions rather than changing management. All treatments have four replications.

1985 Management Practices

Date of Planting: Corn - April 26
Soybeans - May 21

Population: Corn - 29,900 seeds/A
Soybeans - 57 lbs/A (9 seeds/ft)

Herbicide: Lasso @ 4 lbs/A

Insecticide: Corn-Counter @ 6 lbs/A

Fertilizer: Corn - 9-11-72-11 Sulfur @ 100 lbs/A 180 lbs at planting N as urea applied on 6/4, 7/8, and 8/2 in 60 lb increments
Soybeans - 17-10-30 @ 142 lbs/A at planting

Harvest: Corn forage 9/26
Corn grain 10/15
Soybeans 9/26

Water Use: 5/3-9/19 19.27 in. total
Irrigation 6.5 in.
6/21-8/8 8.85 in. or .18 in/day

Variety Corn: Pioneer 3881 90 day (relative maturity)
Pioneer 3906 95 day
Pioneer 3953 80 day
Soybean: Clay

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

Table 1 contains yield and corresponding features associated with corn production in 1986.

Table 1. Corn Yield and Related Information Pertaining to Corn Production at the Staples Station in 1986

Treatment	Yield Bu/A	Harvest Population (X1000)	% Moisture	Grain Yield T/A(DM)	Stover Yield T/A(DM)	Grain Stover Ratio	Silage Tons/A (DM)
(1) C-C 3881	125.4	27.0	29.8	2.97	2.04	.60	5.01
(2) C-C 3906	123.9	23.3	31.0	2.94	2.55	.54	5.49
(4) SB-C 3881	122.7	24.7	30.3	2.91	2.49	.54	5.40
(7) CC-3953	115.1	26.7	20.3	2.73	2.00	.58	4.72
Sig Level	91	88	99	91	91	81	98
BLSD (.05)	9.6	NS	2.06	.23	.63	NS	.53
C.V. ½	4.3	8.7	4.8	4.3	15.10	7.5	6.0

Table 2. Nutrient Removal in Corn Grain - lbs/A

Treatment	N	P_2O_5	K_2O	Ca	Mg	MN	Zn	Cu	B
(1)	98.0	43.7	31.1	.18	8.5	.031	.13	.004	.016
(2)	95.1	41.4	27.1	.24	8.8	.035	.12	.005	.016
(4)	94.7	43.6	29.8	.16	8.5	.030	.13	.004	.014
(7)	79.9	35.5	24.8	.20	7.2	.025	.14	.005	.012

Table 3. Nutrient Removal in Corn Stover - lbs/A

Treatment	N	P_2O_5	K_2O	Ca	Mg	MN	Zn	Cu	B
(1)	13.5	8.03	129.2	15.2	7.08	.20	.13	.019	.029
(2)	30.9	12.32	139.8	20.4	9.43	.23	.12	.021	.037
(4)	24.0	10.19	128.8	16.7	8.09	.22	.11	.022	.031
(7)	17.7	7.15	108.0	14.5	7.73	.13	.10	.011	.025

Table 4. Total Nutrient Removal in Corn Grain and Stover - lbs/A

Treatment	N	P_2O_5	K_2O	Ca	Mg	MN	Zn	Cu	B
(1)	111.5	51.7	159.4	15.4	15.6	.23	.27	.023	.046
(2)	126.0	53.8	166.9	20.6	18.2	.27	.24	.026	.053
(4)	118.7	53.8	158.6	16.9	16.6	.25	.24	.026	.046
(7)	97.6	42.6	132.8	14.7	14.9	.16	.24	.016	.037

Table 5. Leaf Tissue Analyses of Corn at Silking

	Percent						PPM			
Treatment	N	S	P	K	Ca	Mg	MN	Zn	Cu	B
(1)	3.18	.22	.31	2.5	.66	.28	88	31	5.5	5.2
(2)	3.14	.23	.30	2.5	.70	.29	68	26	5.4	5.2
(4)	3.06	.22	.31	2.5	.68	.28	92	27	5.5	4.5
(7)	3.14	.21	.31	2.7	.71	.25	64	28	5.2	5.0

Table 6. Analyses of Corn Grain

	Percent					PPM			
Treatment	N	P	K	Ca	Mg	MN	Zn	Cu	B
(1)	1.65	.32	.42	.003	.14	5.3	22.5	.70	2.7
(2)	1.62	.31	.38	.004	.15	6.0	21.3	.87	2.7
(4)	1.63	.32	.43	.003	.14	5.2	22.6	.66	2.5
(7)	1.46	.28	.38	.004	.13	4.7	25.2	.84	2.3

Table 7. Analyses of Corn Stover

	Percent					PPM			
Treatment	N	P	K	Ca	Mg	MN	Zn	Cu	B
(1)	1.11	.22	1.33	.15	.15	22.8	26.4	2.31	4.6
(2)	1.15	.21	1.26	.19	.17	24.3	22.2	2.37	4.8
(4)	1.10	.22	1.22	.16	.15	23.3	22.6	2.42	4.2
(7)	1.04	.20	1.18	.16	.16	16.9	25.2	1.69	4.0

Table 8. Leaf Analyses/Soybean Leaves at Initiation of Blossom, Staples Station

Percent					PPM			
S	P	K	Ca	Mg	MN	Zn	Cu	B
.29	.51	2.6	1.2	.46	112	50	4.6	40

Yield of clay soybeans averaged 36.4 bu/A. However, the yield from plots planted to soybeans the previous year was 34.2 bu/A while yield following corn the previous year was 37.7 and 37.4 as averages from four replications. There appears to be a slight yield increase in soybean yields where corn is grown as an inter crop.

Table 9. Summary of Corn Yields of the Corn-Soybean Rotation Plots, Staples Station 1982-1985

	Corn Yields - Bu/A				
Treatment	1982	1983	1984	1985	Ave.
C-C	168 1/	135.2 1/	130.5 1/	125.4 4/	139.8
C-C	166 2/	150.4 2/	127.7 2/	123.9 2/	142.0
SB-C	170 1/	148.2 2/	139.6 1/	122.7 4/	145.1
SB-C	168 1/	147.3 1/	137.4 1/	---	150.9
C-C	--	155.0 2/	131.8 1/	115.1 3/	134.0

1/ Pioneer 3978 (85 day RM)
2/ Pioneer 3906 (95 day RM)
3/ Pioneer 3953 (80 day RM)
4/ Pioneer 3881 (90 day RM)

Table 10. Summary of Soybean Yields of the Corn Soybean Rotation Plots, Staples Station 1982-1985

Soybean Yields Bu/A				
1982	1983	1984	1985	Ave.
47.0	47.0	37.6	36.4	42.0

LUPIN BEAN STUDY

H. L. Meredith, Mel Wiens and Mike O'Leary

Lupinus Alba (white lupin), an herb cultivated from ancient times, is ideally suited for well drained, slightly acidic soils. A seemingly low fertility requirement, cold tolerance, relatively high yields, high palatibility and high protein content all tend to confirm the desirability of this ancient crop.

A lupin experiment was initiated in the spring of 1984 to determine the feasibility of lupinus as a seed and forage crop. Potential yield and fertility requirements are of high interest.

Early planting is essential to permit blossom and pod set prior to the onset of high summer temperatures. This crop should be planted with the earliest spring crops or about the same time as oats.

Yield from two years field experience appears in Table 1.

Table 1. Ultra Lupin Yields at the Staples Station 1984 and 1985. Yields are Based on 13.5 Percent Moisture Basis.

Treatment	Yield, bu/Acre 1984	Yield, bu/Acre 1985	Forage Dry Matter 1985 (Lbs/A)
No fertilizer	39.1 1/	71.4 2/	9108
100# 8-32-16 3/	39.4	64.1	9719
25# sulfur	43.2	71.2	7667
300# K_2O	40.5	63.8	7996
PKS 4/	39.4	68.8	8595
NPKS 4/	41.5	64.9	8317

1/ 30-inch rows

2/ 6-inch graindrill

3/ Changed to 160# N in 1985, split applications

4/ 60# N and 60# P_2O_5 where indicated

There were no significant differences in yield as a result of any fertility treatments. The more variable yield in 1985 was attributed to plant count differential.

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

Yield data in Table 1 were taken from the same plots, therefore, lupins were grown two years on the same plots. A variety trial at another location on the station resulted in higher yields and demonstrates the yield capability of this crop.

Table 2. Yield of Lupin Varieties, Staples Station, 1985. Yields Adjusted to 13.5 Percent Moisture.

Variety	Yields, Bu/Acre
Kiev	83.7
Ultra	94.7
Hamburg	45.9
Multilupin	33.1

Plant population on these plots, especially Kiev and Ultra, was excellent. Neither the Hamburg nor Multilupin would be recommended. These varieties are "forage" varieties but are coarse, woody, and require a longer growing season than the Kiev or Ultra.

Lupins are susceptible to root disease. Seeding rates of 180 pounds per acre are highly recommended.

Table 3. Soil Test Data Staples Station from Site Used for Lupin Production, 1985.

Treatment	Soil Texture	Organic Matter	Soil pH	Bray P Lbs/A	K Lbs/A	Mg Lbs/A	S PPM	Zn PPM
(1) No Fert	LS	1.4	6.3	44	81	292	1	0.4
(2) 100# 8-32-16	LS	1.5	7.0	52	129	281	3	0.4
(3) 25# Sulfur	LS	1.6	6.9	52	93	297	2	0.6
(4) 300# K_2O	LS	1.5	6.7	45	223	299	2	0.6
(5) K+S + 60# P_2O_5	LS	1.3	6.8	62	229	280	2	0.4
(6) P_2O_5+K+S+60# N	LS	1.6	6.7	60	155	264	2	0.5

Table 4. Tissue Values of Lupin Grown on the Staples Site, 1985. Samples Taken at the Bloom Stage.

Treatment	N	S	P	K	Ca	Mg	Mn	Zn	Cu	B
	(%)						(PPM)			
1	5.36	.28	.36	1.33	1.04	.22	.94	17.1	3.64	17.8
2	5.29	.29	.41	1.74	.88	.22	1.00	17.5	3.09	12.6
3	5.27	.30	.39	1.47	.99	.24	.95	21.3	3.46	15.2
4	5.27	.29	.35	1.71	.91	.18	.91	15.3	2.71	12.1
5	5.47	.29	.35	1.66	.96	.18	.88	12.4	2.44	12.8
6	5.25	.28	.38	1.74	.96	.22	1.01	16.3	3.04	13.8

Table 5. Nutrient Content of Lupin Beans, Staples Station, 1985.

Treatment	N	S	P	K	Ca	Mg	Mn	Zn	Cu	B	Al	Fe	Na
				(%)					(PPM)				
1	5.36	.23	.41	1.03	.22	.18	1.4	39.3	4.7	13.0	8.5	28.1	52.7
2	5.35	.23	.44	1.10	.23	.19	1.3	36.6	3.9	10.5	6.6	26.4	43.4
3	5.65	.30	.43	1.17	.23	.19	1.2	41.4	4.9	12.4	6.3	27.0	51.7
4	5.57	.26	.42	1.17	.23	.18	1.6	39.9	4.8	11.4	6.6	28.6	54.3
5	5.67	.29	.44	1.24	.23	.20	1.1	35.6	4.1	9.3	13.6	34.3	52.0
6	5.59	.31	.43	1.20	.24	.19	1.4	39.5	4.2	12.0	10.0	28.1	61.8
Ave.	5.53												

Table 6. Nutrient Content of Lupin Forage, Staples Station, 1985.

Treatment	N	S	P	K	Ca	Mg	Mn	Zn	Cu	B
				(%)					(PPM)	
1	2.63	.12	.20	1.06	.59	.22	1.4	21	2.8	13.8
2	2.58	.12	.20	1.21	.56	.22	1.3	19	2.4	11.4
3	2.25	.15	.17	1.26	.62	.22	1.1	19	2.7	13.2
4	2.50	.12	.17	1.51	.60	.20	1.4	19	2.6	12.6
5	2.58	.14	.19	1.45	.49	.19	1.0	17	2.4	10.2
6	2.72	.16	.21	1.46	.59	.21	1.3	22	2.2	11.8

Table 7. Lupin Bean Nutrient Removal, Staples Station, 1985.

Treatment	N	S	P	K	Ca	Mg	Mn	Zn	Cu	B
					(Lbs/A)					
1	200	8.5	15.3	38.3	8.4	6.6	5.3	.14	.017	.05
2	180	7.6	14.5	36.9	7.6	6.3	4.2	.12	.013	.04
3	210	11.0	15.9	43.4	8.7	6.9	4.5	.15	.018	.05
4	185	8.7	13.9	38.6	7.6	6.0	5.2	.13	.016	.04
5	202	10.5	15.8	44.6	8.2	7.1	4.0	.12	.014	.03
6	189	10.3	14.6	40.8	8.2	6.4	4.7	.13	.014	.04

Table 8. Lupin Forage Nutrient Removal, Staples Station, 1985.

Treatment	N	S	P	K	Ca	Mg	Mn	Zn	Cu	B
					(Lbs/A)					
1	238	10.6	17.8	98	53	20	12.8	.19	.026	.12
2	250	11.2	19.6	118	53	21	12.7	.18	.023	.11
3	175	11.4	13.8	97	48	17	8.4	.15	.021	.10
4	197	9.9	13.6	122	48	16	10.9	.15	.021	.10
5	220	12.3	16.3	125	42	16	9.1	.14	.020	.09
6	220	13.1	16.9	122	50	18	10.7	.18	.019	.10

Summary. Lupins appear to offer great potential as an alternate protein source where growing soybeans is not practical. The protein content is about 35 percent. Soybeans require heat treatment to deactivate the trypsin inhibitors and ureases which decrease digestibility of the dietary protein; lupins can be fed directly on the farm without heat treatment.

It is noted that yields such as the 94.5 bushel per acre yield obtained in 1985 would contain about 270 pounds of nitrogen. It is absolutely essential that lupin be carefully inoculated with Rhizobium lupini when planting to ensure adequate nitrogen fixation. Seemingly this bacteria is capable of excellent survival in a soil environment which is slightly acidic. A pH of 5.7 to 7.0 appears to be ideally suited for the growth of lupins. Strains are being developed for growth on higher pH soils. Iron and possibly Zinc deficiency appear to be common problems when grown on high pH soils, (above pH 8.0).

No response to fertility treatments was noted. However, additional studies must be conducted to more adequately describe the nutritional requirements of this crop.

Cold tolerance, relatively early maturing varieties, low to moderate nutrient requirements and on-farm usage are all factors which may be appealing qualities for many heretofore marginal soybean growing areas. Consideration of the lupin as a potential forage crop should not be overlooked.

Lupins have been shown to substitute 100 percent for soybean meal on a protein equivalent basis to obtain the same rate of daily gain. Lupins have also been substituted up to 30 percent in nonruminant rations. Pet ration also offer a strong potential for the use of lupins.

Snacks, macaroni, or pasta preparations, flour, etc. are also being test marketed through health-food stores. The high protein and fiber are especially attractive to the health-conscious user. The lupin, when prepared directly like other bean dishes, does not cause intestinal flatulence as some other beans.

Finally, it might be stated this ancient seed may fill a broad-based modern need.

Triticale Studies

H. Meredith, Melvin Wiens and Mike O'Leary

Triticale is a cross between durum wheat and rye. Triticum for wheat and secale for rye, hence the name. Although triticale is an old crop (first reported in 1876) improvements are destined to make the old crop better.

The early severe cold temperatures in the fall of 1984 convinced many growers that the crop does not have sufficient winter hardiness. Both winter and spring varieties are available.

In the fall of 1984 trial plots were established at the Staples Station which included triticale varieties I-18, 239, and double crop, a variety developed especially for forage production.

All three varieties winter killed. These varieties were replanted at the Staples Station in the fall of 1985. Excellent growth was observed prior to heavy snowfall. Unless unusual weather conditions prevail in the spring of 1986, a crop should be forthcoming.

A spring variety, Nutricale, was established and excellent yields were obtained in 1985. This variety will also be planted in 1986. Nitrogen treatments are to be established on all of the varieties to determine optimum yield levels.

Table 1 lists the chemical data for triticale forage (whole plant) grown at Staples in 1985.

Table 1. Chemical Data of Double-Crop Triticale, a Forage Variety. Whole Plant Data, Late Dough Stage, Staples Station, 1985.

Sample	N	S	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	- - - - - Percent - - - - - - - -						- - - - - - - - - - PPM - - - - - - - - - -						
1	1.49	.10	.25	1.6	.28	.11	41	77	17	84	34	2.0	2.4
2	1.56	.13	.28	1.8	.30	.12	38	100	27	62	52	2.7	2.4

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Well Water Analyses

H. Meredith and Melvin Wiens

For several years the irrigation wells on the Staples Station have been monitored to determine any changes in the water quality.

The data from water samples taken in 1984 appear in Table 1.

Table 1. Analysis of Well Water, Staples Station, Sampled Fall 1984.

No.	SO_4-S PPM	Total Alkalinity mg/L $CaCO_3$	Specific Conductance Micromhos @25°C
I	2.5	131	240
II	11.7	112	350
III	7.3	133	--
IV	2.1	133	--
V	9.9	126	350
VI	11.7	108	335
VII	9.9	120	345
VIII	1.0	141	255
IX	0.8	139	245

Table 2. Water Sample Results From Water Samples Obtained in 1985, Staples Station.

No.	SO_4-S PPM	Total Alkalinity mg/L $CaCO_3$	K	Ca	Mg	Na	Mn	B
			PPM					
C-1	3.6	237	1.5	74	21	2	.2	.02
C-2	3.7	230	1.4	75	22	2	.2	.02
D-1	2.5	231	1.1	71	21	2	.3	.01
D-2	2.4	244	1.6	71	20	2	.3	.02
SWP-1	0.5	117	1.1	28	9	.8	.01	--
SWP-2	0.6	96	.6	27	9	.5	.01	--

Note: Phosphorus, Zinc, Copper, and other elements were essentially too low to determine.

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SOUTHERN EXPERIMENT STATION - WASECA

WEATHER DATA - 1985

Month	Period	Precipitation 1985	Precipitation Normal 1/	Avg. Air Temp. 1985	Avg. Air Temp. Normal 1/	Growing Degree Days 1985	Growing Degree Days Normal 1/
		----inches-----		------°F-------			
January	1-31	0.69	0.84	8.1	10.0		
February	1-29	0.24	0.99	13.7	16.4		
March	1-31	5.61	1.99	35.4	27.6		
April	1-30	3.33	2.64	49.9	44.7		
May	1-10	0.20		63.6		147.0	
	11-20	1.01		60.5		119.0	
	21-31	0.60		64.1		159.5	
	Total	1.81	3.76	62.7	57.7	425.5	334
June	1-10	0.17		63.6		138.5	
	11-20	1.80		59.9		105.5	
	21-30	0.59		67.9		177.0	
	Total	2.56	4.48	63.8	67.1	421.0	518
July	1-10	0.09		71.7		206.0	
	11-20	0.19		71.3		211.5	
	21-31	2.23		67.3		190.5	
	Total	2.51	4.02	70.1	71.2	608.0	641
August	1-10	0.18		68.3		183.5	
	11-20	2.41		61.0		124.5	
	21-31	2.62		63.5		149.0	
	Total	5.21	3.99	64.3	68.8	457.0	579
September	1-30	5.40	3.36	59.0	59.8	335.5	311
October	1-31	2.71	2.08	46.0	48.9	0.0	38
November	1-30	1.84	1.43	23.0	32.5		
December	1-31	2.04	1.02	4.7	18.0		
Year	Jan-Dec	33.95	30.60	41.7	43.6	2247.0	2421
Growing Season	May-Sep	17.49	19.61	64.0	64.9	2247.0	2383

1/ 30-year normal from 1951 - 1980.

Notes:

1) Highest temperature on June 9 -- 102°.
2) Rainfall for the May-June period was 47% below normal and was 6th driest May-June period since records began in 1914.
3) Rainfall for May-July period was 44% below normal and also was 6th driest May-July period on record.
4) Highest 24-hour precipitation on July 25 -- 1.57".
5) Last spring frost -- April 10.
6) First fall frost -- September 26.
7) Solar radiation recorded for May and July set record highs. Only 3 cloudy days in July.

ROTATION NITROGEN STUDY

Waseca, 1985

G. W. Randall, P. L. Kelly, 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 purposes 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 1985, 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 1984 after receiving a broadcast application of 0 + 50 + 150 lb $N+P_2O_5+K_2O$/A.

Each corn plot was split lengthwise and two corn hybrids (Pioneer 3732 and Pioneer 3906) were planted in 30" rows at 29900 ppA on May 1. Furadan was applied to all corn plots at 1 lb/A to control rootworms. Wheat ("Wheaton") was planted on April 30. Hardin soybeans were planted in 15" rows on May 13.

Weeds were chemically controlled along with one cultivation of the corn. A combination of 3½ qt Lasso plus 3½ lb Bladex/A was applied preemergence to corn. Soybeans received 3½ 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 1984 harvest and again in the spring prior to N application, soil samples were taken to a depth of 5' from the 0 and 160-lb N treatments which were applied to the continuous corn (grain) and continuous corn (silage) rotations. Soil samples were also taken from the 0-lb N treatments in the plots where soybeans, wheat, and corn following soybeans were the 1984 crops. Two cores were taken/plot, divided into 1-foot increments, composited/rep, dried, crushed, and analyzed for NO_3-N by the Univerity of Minnesota Soil Testing Laboratory.

RESULTS

Nitrate-N remaining in the soil profile after the 1984 crop which was available to the 1985 corn, is presented in Table 1. When no fertilizer N was applied in 1984 (except the blanket 50-lb rate to wheat) very little difference in residual NO_3-N appeared among the five crop sequences.

Samples taken from these 0-N plots the following spring showed slight increases in NO_3-N compared to the fall sampling. Again, differences among the crop sequences were minimal. Approximately 40% of the residual NO_3-N was found in the top foot of the 5-foot profile with all five crops. When the 160-lb rate of N was applied to continuous corn (grain and silage), a substantial amount of residual N was found throughout the 5-foot profile in the fall. Samples taken the following April from these same plots showed approximately a 50% decline in NO_3-N throughout the profile. Reasons for this decrease are thought to be due to either denitrification or leaching.

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

Table 1. Effect of time, crop, and N rate applied to corn in the crop sequence on residual NO_3-N remaining in the 0-5' profile in the fall of 1984 and the beginning of the 1985 growing season.

	October, 1984					April, 1985			
	1984 Crop								
Profile depth	Corn (grain)	Corn (silage)	Soybeans	Wheat	Corn after Soybeans	Corn grain	Corn silage	Soybeans	Wheat
feet	lb NO_3-N/foot								
	0 lb N/A								
0-1	33	ND[1/]	37	48	28	30	44	51	37
1-2	12		14	15	11	26	17	24	28
2-3	10		12	11	9	14	10	15	19
3-4	11		15	10	13	13	16	15	14
4-5	12		17	11	16	13	13	14	9
Total(lb NO_3-N/5')	77		95	95	77	96	100	119	107
	160 lb N/A								
0-1	61	68				37	56		
1-2	67	67				22	34		
2-3	57	59				24	27		
3-4	60	67				21	26		
4-5	52	61				21	25		
Total(lb NO_3-N/5')	297	322				125	168		

1/ Not determined

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

Grain yield

Corn yields were excellent in 1985 considering the moisture stress encountered in July. As in previous years crop sequence had a substantial effect on corn yield. Yields following soybeans or wheat were significantly higher (15 to 24 bu/A) than when following corn (either for grain or silage) when averaged over N rates and hybrids. Second year corn yields following soybeans were intermediate between continuous corn and corn after soybeans or wheat. When averaged over N rates and hybrids corn yields following wheat were significantly higher than when following soybeans. Yields were economically maximized with the 160-lb N rate when averaged over crop sequence and hybrids. Contrary to 1984, yields were significantly higher with P3732. The lower yields with P3906 more than likely could be attributed to the dry, stress conditions during the pollination of this hybrid. P3732 which pollinated 5 days later (July 22) was aided by 1.57" of rain on July 25.

Closer examination of the interactions reveals additional information. The sequence x N rate interaction was highly significant (P=99% level) when averaged across hybrids. For the CC(g), CC(s), C-Sb, C-W, and Sb-C-C systems, highest yields were obtained statistically at the 120, 120, 120, 80, and 160-lb N rates, respectively, and were economically maximized at the 160, 160, 160, 80, and 160-lb rates, respectively. Yield responses of 68.2, 51.5, 60.2, 48.8, and 92.6 bu/A were obtained with the maximum economic rate of N for each of the respective crop sequences. Yields with the 0-16 N rate were lowest with the CC(g) and Sb-C-C systems, intermediate with the CC(s) and C-Sb systems, and highest with the C-W system. These data indicate that the higher amounts of plant residue incorporated from the 1984 CC(g) and Sb-C-C systems probably immobilized greater amounts of N than from the lower residue crop systems.

Contrary to 1984, the sequence x hybrid interaction was not significant indicating that the two hybrids behaved identically across all sequences. On the other hand, a highly significant N rate x hybrid interaction was found. At the 0-lb N rate only a 3.9 bu/A advantage was shown for P3732. As the N rates increased, yield advantages for P3732 increased up to a maximum of 16.2 bu/A at the 200-lb rate when averaged over sequences. No three-factor interaction was found.

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

Table 2. Corn grain yield, leaf N, grain N, grain N removed, and grain moisture as influenced by previous crop, N-rate and hybrid at Waseca, 1985.

Previous Crop	Hybrid	N-rate (lb/A) 0	40	80	120	160	200
		Yield (bu/A)					
Cont. Corn (grain)	3906	85.0	111.0	133.4	140.5	148.9	149.8
	3732	89.9	120.3	145.8	159.8	162.3	162.9
Cont. Corn (silage)	3906	95.8	120.4	141.8	147.5	146.5	147.4
	3732	109.2	128.5	149.9	152.9	161.5	164.3
Soybeans	3906	102.2	132.7	145.8	152.8	158.9	156.9
	3732	109.6	146.5	164.5	170.5	173.3	173.6
Wheat	3906	125.6	148.7	164.0	157.0	159.7	164.1
	3732	116.6	158.3	175.8	176.3	177.6	173.8
Corn after soybeans	3906	78.9	116.2	148.4	154.6	164.6	153.4
	3732	81.8	121.3	152.9	168.6	181.1	177.7
		Leaf N (%)					
Cont. Corn (grain)	3906	1.58	1.68	2.18	2.41	2.61	2.61
	3732	1.33	1.55	2.08	2.35	2.52	2.57
Cont. Corn (silage)	3906	1.44	1.85	2.21	2.44	2.47	2.57
	3732	1.33	1.77	2.11	2.42	2.61	2.59
Soybeans	3906	1.48	2.12	2.35	2.45	2.55	2.66
	3732	1.44	1.99	2.31	2.50	2.60	2.70
Wheat	3906	1.69	2.13	2.37	2.45	2.73	2.78
	3732	1.86	2.22	2.45	2.70	2.73	2.76
Corn after soybeans	3906	1.24	1.51	2.13	2.32	2.63	2.69
	3732	1.30	1.58	2.09	2.39	2.66	2.58
		Grain N (%)					
Cont. Corn (grain)	3906	1.27	1.24	1.43	1.57	1.56	1.63
	3732	1.10	1.04	1.19	1.35	1.36	1.37
Cont. Corn (silage)	3906	1.28	1.30	1.45	1.55	1.58	1.63
	3732	1.12	1.12	1.21	1.39	1.37	1.40
Soybeans	3906	1.26	1.31	1.41	1.55	1.55	1.54
	3732	1.07	1.10	1.20	1.32	1.33	1.32
Wheat	3906	1.27	1.47	1.49	1.53	1.57	1.59
	3732	1.12	1.27	1.27	1.29	1.33	1.34
Corn after soybeans	3906	1.21	1.23	1.38	1.53	1.57	1.62
	3732	1.05	1.02	1.18	1.25	1.35	1.37
		Grain N Removed (lb/A)					
Cont. Corn (grain)	3906	51.5	65.0	89.9	104.0	110.3	115.2
	3732	47.1	59.0	82.0	102.1	104.7	105.3
Cont. Corn (silage)	3906	58.1	73.7	97.2	108.3	109.5	113.4
	3732	57.7	68.5	86.0	100.0	105.0	108.3
Soybeans	3906	60.8	82.2	97.3	112.1	116.7	113.9
	3732	55.4	76.1	93.8	106.5	109.5	108.7
Wheat	3906	76.0	103.5	115.4	113.8	118.2	123.4
	3732	62.2	94.7	105.9	107.1	111.6	109.8
Corn after soybeans	3906	45.2	68.1	96.8	111.8	122.0	117.7
	3732	40.8	58.5	85.5	99.9	115.6	115.0
		Grain Moisture (%)					
Cont. Corn (grain)	3906	25.3	24.0	24.5	25.0	24.8	24.8
	3732	31.0	29.5	29.5	29.9	29.6	29.6
Cont. Corn (silage)	3906	25.4	24.2	24.4	24.6	25.1	24.6
	3732	30.7	30.0	29.6	30.0	30.2	29.7
Soybeans	3906	24.8	24.3	24.2	24.9	24.5	24.3
	3732	30.8	29.2	28.6	29.5	29.1	29.6
Wheat	3906	25.0	24.8	24.7	25.2	25.0	25.5
	3732	30.5	29.6	29.2	29.8	29.1	29.5
Corn after soybeans	3906	24.9	23.8	24.4	24.6	24.6	24.8
	3732	30.8	29.2	29.0	28.3	28.7	29.2

Table 3. Main factor and two-factor interaction averages for corn yield, moisture, N, and grain N removal and leaf N in 1985

Source		Grain Yield	Grain Moisture	Grain N	Grain N removed	Leaf N
		bu/A	------- %	-------	lb/A	%
MAIN FACTORS						
Sequence						
Cont. corn (grain)		134.1	27.3	1.34	86.3	2.12
Cont. corn (silage)		138.8	27.4	1.37	90.5	2.15
Sb-C		149.0	27.0	1.33	94.4	2.26
Wht-C		158.1	27.3	1.38	103.5	2.41
Sb-C-C*		141.6	26.8	1.31	89.8	2.09
Signif. Level (%):		99	64	90	99	99
BLSD(.10)	:	8.7	---	.05	6.6	.08
BLSD(.05)	:	10.2	---	---	7.8	.09
N Rate (lb/A)						
0		99.5	27.9	1.17	55.5	1.47
40		130.4	26.8	1.21	75.0	1.84
80		152.2	26.8	1.32	95.0	2.23
120		158.1	27.2	1.43	106.6	2.44
160		163.4	27.1	1.46	112.3	2.61
200		162.4	27.1	1.48	113.1	2.65
Signif. Level (%):		99	99	99	99	99
BLSD(.10)	:	3.4	.3	.02	2.4	.04
BLSD(.05)	:	4.0	.3	.02	2.7	.05
Hybrid						
P 3906		138.4	24.7	1.45	96.4	2.21
P 3732		150.2	29.6	1.24	89.4	2.20
Signif. Level (%):		99	99	99	99	36
INTERACTIONS						
Sequence x N Rate						
CC(g)	0	87.4	28.1	1.18	49.3	1.46
	40	115.6	26.7	1.14	62.0	1.61
	80	139.6	27.0	1.31	85.9	2.13
	120	150.2	27.5	1.46	103.0	2.38
	160	155.6	27.2	1.46	107.5	2.57
	200	156.4	27.2	1.50	110.2	2.59
CC(s)	0	102.5	28.0	1.20	57.9	1.38
	40	124.4	27.1	1.21	71.1	1.81
	80	145.8	27.0	1.33	91.6	2.16
	120	150.2	27.3	1.47	104.1	2.43
	160	154.0	27.7	1.48	107.3	2.54
	200	155.9	27.2	1.51	110.8	2.58
Sb-C	0	105.9	27.8	1.16	58.1	1.46
	40	139.6	26.8	1.20	79.1	2.06
	80	155.2	26.4	1.31	95.6	2.33
	120	161.7	27.2	1.43	109.3	2.48
	160	166.1	26.8	1.44	113.1	2.57
	200	165.2	26.9	1.43	111.3	2.68
Wht-C	0	121.1	27.7	1.20	69.1	1.78
	40	153.5	27.2	1.37	99.1	2.17
	80	169.9	27.0	1.38	110.6	2.41
	120	166.6	27.5	1.41	110.5	2.57
	160	168.6	27.0	1.45	114.9	2.73
	200	169.0	27.5	1.46	116.6	2.77