TWENTY-NINE YEARS OF FIELD EXPERIMENTATION WITH NITROGEN SOURCE, PLACEMENT, AND TIME OF APPLICATION TO A WEBSTER LOAM AT THE SOUTHWEST EXPERIMENT STATION LAMBERTON, MN[1]

D.J. Fuchs, J.A. Staricka and W.W. Nelson[2]

Abstract: Corn yields may be affected by different nitrogen management systems. This study was conducted to determine if differences exist between nitrogen forms (urea or ammonium nitrate), amounts ranging from 0 to 160 pounds N/Ac, and their time of application (fall or spring) and placement (surface, moldboard plow incorporation or sidedress) on corn yields. The effects were examined on continuous corn with 30-inch rows in a Webster clay loam. In 1988, there was little difference between the various treatments because of the drought. When precipitation is not limiting, corn yields respond the greatest to N rate with a slight advantage to spring application with little difference between N forms.

(Annual reports of this experiment have been included in most of the University of Minnesota Soil Science Department "Blue Books" and much of this information will not be included here).

The fertilizer treatments have now been applied annually to the same plot area for 29 years. Each plot is 20' by 77.5' with the four replications arranged in a randomized block. After ear corn removal and stalk cutting, the fall treatments are broadcast on their respective plots and the entire area is then moldboard plowed to approximately 12 inches deep. The fall surface treatments are then broadcast with no further working of the plow area. Spring treatments are broadcast before seedbed preparations in late April or early May. The corn is planted in 30-inch rows at a plant population of 26,000 plants/A, using a band starter fertilizer of 8-24-12 at a rate of 180#/A over the entire experimental area, thus supplying an additional 14 #N/A to all plots. Sidedress treatments are broadcast in June and incorporated during cultivation.

1988 results: The 1988 yields from this experiment are given in Table 1. The one-way analysis of variance (Table 2) indicates a no significant treatment effect. The Tukey HSD for yield ($p = 0.05$) is 29.5 bu/ac. Last year the LSD ($p = 0.05$) was 12.7 bu/ac. The drought dramatically increased the variability of the treatments.

Also included in Table 1 are the 28-yr averages. (In 1976, no yields were obtained due to drought, thus only 28 years of data exist). Figure 1 provides a 3 dimensional perspective of the 28-yr average yields versus time of application and N-rate. (Note: Missing 3-D bars are because of incomplete experiment design, not because of obscurity). The results of 1988 do not follow previous 28 year average trends, where greatest yield response is to increasing N-rates, because of the drought. There is a moderate response to delayed application time, with the exception of the fall surface treatments. Normally, there is little difference in yield between ammonium nitrate and urea treatments.

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[1] Funding provided by Agricultural Experiment Station

[2] Junior Scientist, Graduate Student and Superintendent - University of Minnesota, Southwest Experiment Station, respectively.

Table 1. Influence of nitrogen form, rate, and time of application on grain yield on a Webster loam, Southwest Experiment Station, Lamberton, MN 1988.

------ Nitrogen Treatment ------			---------- 1988 ----------					
Rate	Form	Time	Rep. 1	Rep. 2	Rep. 3	Rep. 4	Avg.	28 yr. Avg.
#N/Ac			---------- Bu/Ac @ 15.5 % moisture ----------					
--	Check	----	51.2	40.0	30.8	48.0	42.5	65.0
40	Ammonium Nitrate	Fall	71.0	54.3	72.2	58.6	64.0	83.0
40	Urea	Fall	51.3	56.5	53.0	59.9	55.2	87.0
40	Ammonium Nitrate	Fall Surface	64.4	47.4	77.8	70.2	65.0	81.0
40	Urea	Fall Surface	50.1	46.5	54.4	67.1	54.5	86.0
80	Ammonium Nitrate	Fall	48.6	65.3	63.6	35.1	53.2	103.0
80	Urea	Fall	54.2	65.4	61.2	70.5	62.8	103.0
160	Ammonium Nitrate	Fall	48.9	61.5	90.1	45.1	61.4	110.0
160	Urea	Fall	53.4	49.4	68.9	49.9	55.4	112.0
40	Ammonium Nitrate	Spring	49.6	52.8	59.1	53.4	53.7	94.0
40	Urea	Spring	46.1	51.4	54.8	65.1	54.4	93.0
80	Ammonium Nitrate	Spring	80.6	63.9	61.2	74.3	70.0	107.0
80	Urea	Spring	65.2	73.7	54.3	81.2	68.6	108.0
40	Ammonium Nitrate	Side Dress	63.2	36.4	77.6	48.8	56.5	97.0
40	Urea	Side Dress	50.2	39.5	66.6	68.7	56.3	97.0
80	Ammonium Nitrate	Side Dress	58.4	54.2	86.1	76.0	68.7	103.0
80	Urea	Side Dress	72.3	73.2	59.2	56.7	65.4	111.0
160	Ammonium Nitrate	Side Dress	70.7	62.4	76.3	60.9	67.6	115.0
	Average						59.7	98.0
	Tukey (p = 0.05)						29.5	

Table 2. One-way analysis of variance.

Source	DF	Sum of Squares	Mean Square	F-Value	P value
Block	3	886.7	295.6	2.47	0.07241
Treatment	17	3639.0	214.0	1.79	0.05641
Error	54	4322	80.0		
Total	71	21311			

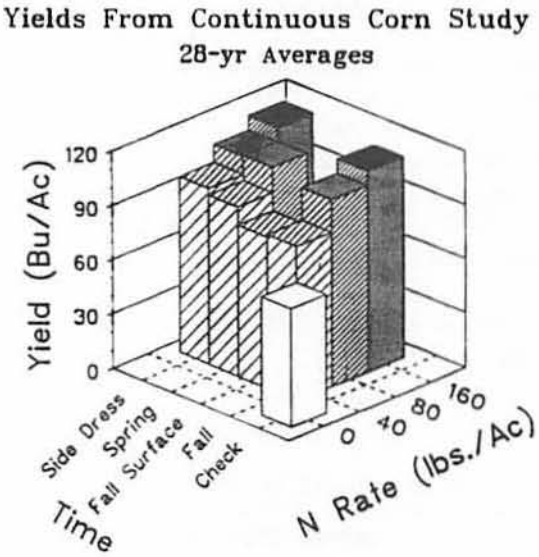

Figure 1

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

J.A. Staricka, D.J. Fuchs, M. Lindstrom, W.W. Nelson, and J.B. Swan[2]

Abstract: Field data is needed to evaluate crop growth simulation models. The objective of this is to determine the interactive effect of tillage and soil erosion level on corn yields. Continuous corn is grown under conventional (fall moldboard plow) or ridge tillage on sites which have been slightly, moderately, or severely eroded. In 1987, neither tillage nor erosion had a significant effect on yield. In 1988, ridge tillage yields were significantly greater at $p = 0.01$ than conventional tillage on all various erosion classes for the first time in four years. Corn yields decrease with increasing erosion for both tillages.

Introduction: This experiment is part of RRF project NC-174, Soil Productivity and Erosion. The objectives of this study are "To asses the effect of erosion-modified soil physical properties on potential productivity of selected soils under rainfed conditions, with emphasis on evaluation of physically-based simulation models." The experiment was started in 1984. Detailed results from 1985 and 1986 were presented in the "1987 Bluebook".

Methods and Materials: Plots for this study were located in areas of a field which had been slightly (SLT), moderately (MOD), and severely (SEV) eroded. The soil type for the slight and moderately eroded areas is a Ves (fine-silty, mixed mesic Typic Hapludalf). The soil type on the severely eroded area is a Storden (fine-loamy, mixed (calcareous), mesic Typic Udorthent). Two tillage systems were used on the field: CONVentional (fall moldboard plow) and RIDGE-tillage.

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

Stand counts were recorded in June of both years (1987 and 1988) and are listed in Table 3. Leaf numbers for 1987, but not for 1988, and are provided in Table 4. Tasseling and silking information is provided in Table 5.

Grain yields are given in Table 6. Analysis of variance, using a spilt plot design (erosion class = whole plots, tillage = split plots) for each year is furnished in Tables 7 and 8.

Summary of results: Precipitation was the major yield limiting factor in 1988. The lack of adequate moisture resulted in significant differences in corn yields among the various erosion classes. The slightly eroded areas had greater yields than the severely eroded areas, probably because of the poor soil water holding capability and runoff potential of these soils. In 1987 there were no significant differences among the various slopes, probably because moisture was not a limiting factor. Which may also explain why there was no significant difference in tillages in 1987 also. In 1988, ridge tillage had significantly higher yields than the conventional tillage for the first time in four years.

Acknowledgements: The Southwest Experiment Station would like to thank the John Deere Company for providing the JD 7000 Conservation ridge tillage.

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[1] Funding provided by the USDA - CSRS and the Agricultural Experiment Station.

[2] Graduate Student, Junior Scientist - U of MN, Southwest Experiment Station; Soil Scientist - USDA-ARS, Morris, MN 56267; Superintendent - U of MN, Southwest Experiment Station; Professor - U of MN, Soil Science Dept., St. Paul, MN 55108, respectively.

Table 1. Applied Fertilizer.

Time	Plots[1]	N	P_2O_5	K_2O	Comments
		---- # / Ac ----			
Fall 1986	All	39	100	100	
Spring 1987	All	220	--	--	4/20/87
Spring 1987	SEV	7	20	7	(starter)
Fall 1987	SEV		75		
Spring 1988	All	150	--	--	4/29/88
Spring 1988	All	7	20	7	(starter)

1/ Erosion levels: SLT = Slight, MOD = Moderate, SEV = Severe

Table 2. Management Information.

Item	Type	Rate	Date
	1987		
Secondary Tillage[1]	Disk	Twice	Spring
Insecticide	Counter	1.0 #/Ac	4/21/88
Seed	Pioneer 3732	26,000 p/Ac	" "
Herbicides	Lasso	3.0 #/Ac	4/22/87
	Bladex	2.0 #/Ac	" "
	1988		
Secondary Tillage[1]	Disk/Digger		4/22/89
Insecticide	Furadan	1.0 #/Ac	4/29/88
Seed	Pioneer 3732	26,000 p/Ac	" "
Herbicides	Eradicane	2.5 #/Ac	4/22/88
	Bladex	1.5 #/Ac	" "

1/ Secondary tillage performed on conventional (moldboard plow) plots only.

Table 3. Stand Counts.[1]

	1987			1988		
Treatment[2]	CONV	RIDGE	Avg.	CONV	RIDGE	Avg.
	plants (thousands) / Ac					
SLT	22.9	19.0	20.9	22.9	20.8	21.9
MOD	19.2	16.1	17.6	21.6	18.9	20.3
SEV	22.0	17.9	19.9	21.9	21.8	21.9
Avg	21.4	17.7	19.5	22.1	20.5	21.4

1/ Measurements taken on 6/1/87 and 6/30/88.
2/ Erosion levels: SLT = Slight, MOD = Moderate, SEV = Severe
Tillage systems: CONV = Conventional (moldboard plow), RIDGE = ridge tillage.

Table 4. 1987 Leaf Numbers.[1]

Treatment[2]	CONV	RIDGE	Avg.
	----- Leaf Number -----		
SLT	5.17	5.35	5.26
MOD	3.06	5.27	4.17
SEV	5.25	5.59	5.42
Avg	4.49	5.40	4.95

1/ Measurements taken on 6/1/87, no measurements for 1988.
2/ Erosion levels: SLT = Slight, MOD = Moderate, SEV = Severe
Tillage systems: CONV = Conventional (moldboard plow), RIDGE = ridge tillage.

Table 5. Phenology

Erosion Class	50% Tassel CONV	50% Tassel RIDGE	50% Silk CONV	50% Silk RIDGE
	----------July, 1987----------			
SLT	7	4	10	6
MOD	15	7[1]	16	10[1]
SEV	9	7	10	10
	----------July, 1988----------			
SLT	8	8	12	13
MOD	7	8	12	15
SEV	7	7	12	13

1/ Dry soil conditions at planting resulted in differential emergence. Reps 1 and 2 of this treatment had a larger proportion of delayed plants.

Table 6. Grain Yield.

Treatment[1]		Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Avg.
		---------- Bu / Ac @ 15.5% moisture ----------						
---------- 1987 ----------								
SLT	CONV	134.1	146.3	137.1	148.6	---	---	141.5
SLT	RIDGE	136.6	139.2	133.2	120.1	---	---	132.3
MOD	CONV	135.3	136.9	128.0	151.6	---	---	138.0
MOD	RIDGE	129.2	109.7	129.6	119.9	---	---	122.1
SEV	CONV	121.2	121.3	159.4	119.2	---	---	130.3
SEV	RIDGE	144.1	133.8	130.9	122.4	---	---	132.8
---------- 1988 ----------								
SLT	CONV	61.9	47.0	55.1	38.4	50.7	46.5	49.9
SLT	RIDGE	50.1	71.2	64.1	51.9	52.8	50.2	56.7
MOD	CONV	59.4	39.5	48.9	31.3	33.8	48.7	43.6
MOD	RIDGE	52.7	57.3	50.1	48.0	43.4	61.4	52.2
SEV	CONV	38.5	48.0	22.1	18.1	44.7	58.7	38.4
SEV	RIDGE	55.9	51.9	36.1	37.3	50.9	52.4	47.4

1/ Erosion levels: SLT = Slight, MOD = Moderate, SEV = Severe
Tillage systems: CONV = Conventional (moldboard plow), RIDGE = ridge tillage.

Table 7. Analysis of variance for 1987 yields.

Source	DF	SS	MS	F	P-value
Rep	3	131.5	43.82	0.34	0.7953
Erosion	2	208.8	104.4	0.84	0.4848
ERROR1	6	765.3	127.5	--	--
Tillage	1	339.8	339.8	2.19	0.1735
Erosion*Tillage	2	346.6	173.3	1.11	0.3695
ERROR2	9	1400	155.5	--	--

Table 8. Analysis of variance for 1988 yields.

Source	DF	SS	MS	F	P-value
Rep	5	1131.0	226.3	2.03	0.1592
Erosion	2	654.6	327.3	2.94	0.09915
ERROR1	10	1114.0	111.4	--	--
Tillage	1	595.4	595.4	10.80	0.005003
Erosion*Tillage	2	8.6	4.3	0.08	0.9253
ERROR2	9	1400	155.5	--	--

MANAGEMENT OF SLOPES USING VARIOUS TILLAGES, TILLAGE AND ROW DIRECTION AT THE SOUTHWEST EXPERIMENT STATION[1]

J.A. Staricka, D.J. Fuchs, M. Lindstrom, W.W. Nelson, and J.B. Swan[2]

Abstract: Field research is needed to evaluate soil movement under different crop production practices and its consequent effect on crop growth. This study was conducted to examine soil movement and crop yields on three different slope percentages (1%, 4%, and 8%), with various tillages (ridge tillage, moldboard plow, and chisel), and tillage and planting directions (up and down the slope, or contour to the slope) in a corn - soybean rotation. In 1988, tillage was the only significant treatment on corn yields ($p = 0.05$). In all years, slope position and/or planting direction had significant effect on yields ($p = 0.05$).

Materials: This study began in the fall of 1985 to examine soil movement on three different slope percentages (1%, 4%, and 8%), using various tillages (ridge tillage, moldboard plow, and chisel), and tillage and planting directions (up and down the slope, or contour to the slope) in a corn and soybean rotation. Yields are measured every year and soil movement is being monitored.

Fertilizer information is provided in Table 1.

Additional management information is provided in Table 2.

Results: Analysis of variance of the yields for the three years on the various slopes are provided in Tables 3-5 (1986), 9-11 (1987) and 15-17 (1988). Yield averages and standard deviations of all treatment combinations are presented after the analysis of variance tables for each respective year.

In 1988, ridge tillage treatment had significantly higher corn yields than moldboard and chisel plow on all three slope percentages (Table 15-17). Even though, early in the growing season (June and July), the ridge tillage treatments showed on the 8 percent slopes severe K deficiency and were visually underdeveloped in comparison to the other tillages. The above normal precipitation in August may have helped it through the critical growth stage more than the other tillage treatments because of its delayed growth.

In 1988, position on the 8 percent slope was also a significant factor ($p = 0.001$) with highest yields occurring on the top portion of the slope.

In 1987, the 8 percent slope position (top, middle and bottom) and its interaction with row direction were the significant treatments ($p = 0.005$). The greatest yields occurred on the top portion of the slope (summit and shoulder).

In 1986, row direction and slope position on the 8 percent slope were the only significant treatments ($p = 0.05$) with highest yields on the middle part of the slope (backslope).

Acknowledgements: The Southwest Experiment Station would like to thank the John Deere Company for providing the JD 7000 Conservation ridge tillage.

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[1] Funding provided by the USDA - CSRS and the Agricultural Experiment Station.

[2] Graduate Student, Junior Scientist - U of MN, Southwest Experiment Station; Soil Scientist - USDA-ARS, Morris, MN 56267; Superintendent - U of MN, Southwest Experiment Station; Professor - U of MN, Soil Science Dept., St. Paul, MN 55108, respectively.

Table 1. Applied Fertilizer.

Time	Plots	N	P_2O_5	K_2O	Comments
		---- # / Ac ----			
Fall 1985				50	
Spring 1986		7	21	7	(starter)
Spring 1986		125			6/12/86 (sidedress)
(no fertilizer for 1987 growing season)					
Spring 1988		125	--	--	6/4/88 (sidedress)
Spring 1988		7	21	7	(starter)

Table 2. Management Information.

Item	Type	Rate	Date
---------- 1986 ----------			
Secondary Tillage[1]	Digger	Twice	5/5
Seed	Pioneer 3732	26,500 ppa	5/5
Herbicides	Lasso	2.5 lbs/ac	5/7
	Bladex	1.5 lbs/ac	5/7
---------- 1987 ----------			
Secondary Tillage[1]	Disk	Twice	4/30
Seed	Corsoy 79	160,000 ppa	5/2
Herbicides	Lasso	3.0 lbs/ac	5/4
	Amiben	2.5 lbs/ac	5/4
---------- 1988 ----------			
Secondary Tillage[1]	Digger	Twice	4/20
Seed	Pioneer 3732	26,000 ppa	5/4
Herbicides	Lasso	3.0 lbs/ac	5/4
	Bladex	1.5 #/Ac	5/4

1/ No secondary tillage on ridge tillage plots.

Table 3. 1986 analysis of variance for the 1 percent slope. (Note: Analyzed as a randomized block design.)

Source	DF	SS	MS	F	P-value
Rep	1	4.201	4.201	(0.195)	(0.6704)
Tillage	2	1.865	0.9325	0.0445	0.9578
ERROR1	8	172.2	21.53	---	

Table 4. 1986 analysis of variance for the 4 percent slope. (Note: Analyzed as a split plot design.)

Source	DF	SS	MS	F	P-value
Rep	1	291.2	291.2	(15.55)	(0.1581)
Row[1]	1	207.7	207.7	11.09	0.1857
ERROR1	1	18.73	18.73	---	
Tillage	2	27.63	13.82	0.4858	0.7556
Row*Tillage	2	4.756	2.378	0.1300	0.8790
ERROR2	16	292.7	18.29	---	

1/ Row = Row direction (up and down, or contour to the slope).

Table 5. 1986 analysis of variance for the 8 percent slope. (Note: Analyzed as a split-split plot design.)

Source	DF	SS	MS	F	P-value
Rep	2	410.9	205.5	(8.509)	(0.1052)
Row	1	1281.0	1281.0	53.04	0.01834
ERROR1	2	48.29	24.15	---	
Tillage	2	23.74	11.87	0.1523	0.8612
Row*Tillage	2	355.1	177.6	2.279	0.1647
ERROR2	8	623.5	77.94	---	
Position[1]	2	665.2	332.6	6.302	0.002905
Row*Position	2	307.0	153.5	2.908	0.06051
Tillage*Position	4	224.8	56.2	0.0805	0.9881
Row*Tillage*Position	4	16.99	4.247	0.9881	0.08047
ERROR3	78	4117.0	52.78	---	

1/ Position = slope position (top, middle and bottom).

Table 6 (A-B). 1986 Corn Yields on the 1 Percent Slope.

6A.

	Avg	s[1]
Overall	178.8	3.8

1/ s = Standard deviation.

6B.

Tillage	Avg	s
Chisel	178.4	4.7
Moldboard	178.7	3.7
Ridge	179.3	3.0

Table 7 (A-D). 1986 Corn Yields on the 4 Percent Slope.

7A.

	Avg	s
Overall	179.3	4.9

7B.

Tillage	Avg	s
Chisel	179.6	4.3
Moldboard	180.4	4.2
Ridge	177.8	6.2

7C.

Row Dir.	Avg	s
Up & Down	182.2	4.7
Contour	176.3	5.0

7D.

Till[1]	Row Dir.	Avg	s
CH	Up & Down	183.8	5.1
CH	Contour	176.9	3.2
MP	Up & Down	182.6	3.5
MP	Contour	176.6	5.0
RT	Up & Down	180.2	5.6
RT	Contour	175.4	6.7

1/ CH = CHisel plow, MP = Moldboard Plow
RT = Ridge Tillage.

Table 8 (A-H). 1986 Corn Yields on the 8 Percent Slope.

8A.

	Avg	s
Overall	168.8	7.6

8B.

Tillage	Avg	s
Chisel	169.4	8.7
Moldboard	168.9	3.7
Ridge	168.3	6.9

8C.

Row Direction	Avg	s
Up & Down	172.3	7.8
Contour	165.4	7.4

8D.

Slope Position	Avg	s
Top	167.9	5.6
Mid	172.2	6.2
Bottom	166.4	7.6

8E.

Tillage	Row Dir.	Avg	s
Chisel	Up & Down	175.1	7.3
Chisel	Contour	163.7	10.1
Moldboard	Up & Down	172.2	8.3
Moldboard	Contour	165.5	6.0
Ridge	Up & Down	169.5	7.7
Ridge	Contour	167.0	6.1

8F.

Tillage	Slope Pos.	Avg	s
Chisel	Top	169.8	7.4
Chisel	Mid	173.4	7.0
Chisel	Bottom	165.0	7.9
Moldboard	Top	168.6	6.0
Moldboard	Mid	172.6	7.4
Moldboard	Bottom	165.6	5.1
Ridge	Top	165.5	3.3
Ridge	Mid	170.7	4.2
Ridge	Bottom	168.5	9.7

8G.

Row Dir.	Slope Pos.	Avg	s
Up & Down	Top	169.0	6.2
Up & Down	Mid	177.2	4.5
Up & Down	Bottom	170.6	8.1
Contour	Top	166.8	4.9
Contour	Mid	167.2	7.9
Contour	Bottom	162.1	7.0

8H.

Till	Row Dir.	Slope Pos.	Avg	s
CH	Up & Down	Top	173.1	8.4
CH	Up & Down	Mid	180.3	2.3
CH	Up & Down	Bottom	171.8	6.6
CH	Contour	Top	166.4	6.4
CH	Contour	Mid	166.4	11.7
CH	Contour	Bottom	158.2	9.2
MP	Up & Down	Top	169.5	6.8
MP	Up & Down	Mid	178.2	7.4
MP	Up & Down	Bottom	169.1	7.1
MP	Contour	Top	167.6	5.1
MP	Contour	Mid	167.0	7.3
MP	Contour	Bottom	162.0	3.1
RT	Up & Down	Top	164.4	3.4
RT	Up & Down	Mid	173.1	3.7
RT	Up & Down	Bottom	171.0	10.5
RT	Contour	Top	166.5	3.2
RT	Contour	Mid	168.3	4.6
RT	Contour	Bottom	166.0	8.8

Table 9. 1987 analysis of variance for the 1 percent slope. (Note: Analyzed as a randomized block design.)

Source	DF	SS	MS	F	P-value
Rep	1	0.9219	0.9219	(0.2329)	(0.6423)
Tillage	2	5.302	2.651	0.6698	0.5383
ERROR1	8	31.67	3.958		

Table 10. 1987 analysis of variance for the 4 percent slope. (Note: Analyzed as a split plot design.)

Source	DF	SS	MS	F	P-value
Rep	1	2.75	2.75	0.0663	(0.8396)
Row	1	9.305	9.305	0.2243	0.7184
ERROR1	1	41.49	41.49	---	
Tillage	2	54.78	27.39	2.715	0.09659
Row*Tillage	2	10.47	5.236	0.5189	0.6048
ERROR2	16	161.5	10.09		

Table 11. 1987 analysis of variance for the 8 percent slope. (Note: Analyzed as a split-split plot design.)

Source	DF	SS	MS	F	P-value
Rep	2	477.9	239.0	(2.528)	(0.2834)
Row	1	31.45	31.45	0.3327	0.6223
ERROR1	2	189.1	94.54	---	
Tillage	2	24.82	12.41	0.3437	0.7191
Row*Tillage	2	8.481	4.241	0.1174	0.8907
ERROR2	8	288.9	36.11	---	
Position	2	243.8	121.9	8.203	5.844e-4
Row*Position	2	171.8	85.9	5.781	4.559e-3
Tillage*Position	4	42.36	10.59	0.7127	0.5857
Row*Tillage*Position	4	35.73	8.931	0.601	0.6630
ERROR3	78	1159.0	14.86	---	

Table 12 (A-B). 1987 Soybean Yields on the 1 Percent Slope.

12A.

	Avg	s
Overall	51.3	1.9

12B.

Tillage	Avg	s
Chisel	52.0	2.2
Moldboard	50.4	2.1
Ridge	51.4	1.2

Table 13 (A-D). 1987 Soybean Yields on the 4 Percent Slope.

13A.

	Avg	s
Overall	46.2	3.5

13B.

Tillage	Avg	s
Chisel	46.7	2.1
Moldboard	44.2	3.6
Ridge	47.8	3.8

13C.

Row Dir.	Avg	s
Up & Down	46.9	3.3
Contour	45.6	3.7

13D.

Till	Row Dir.	Avg	s
CH	Up & Down	46.4	2.8
CH	Contour	47.1	1.5
MP	Up & Down	45.3	3.8
MP	Contour	43.0	3.5
RT	Up & Down	48.8	3.1
RT	Contour	46.7	4.7

Table 14 (A-H). 1987 Soybean Yields on the 8 Percent Slope.

14A.

	Avg	s
Overall	36.9	5.0

14B.

Tillage	Avg	s
Chisel	36.2	4.0
Moldboard	37.3	4.4
Ridge	37.0	6.3

14C.

Row Direction	Avg	s
Up & Down	36.3	5.3
Contour	37.4	4.7

14D.

Slope Position	Avg	s
Top	38.5	5.0
Mid	37.2	5.3
Bottom	34.9	4.0

14E.

Tillage	Row Dir.	Avg	s
Chisel	Up & Down	35.3	3.8
Chisel	Contour	37.1	4.1
Moldboard	Up & Down	36.9	4.7
Moldboard	Contour	37.7	4.2
Ridge	Up & Down	36.7	7.0
Ridge	Contour	37.4	5.8

14F.

Tillage	Slope Pos.	Avg	s
Chisel	Top	37.6	5.2
Chisel	Mid	36.3	3.8
Chisel	Bottom	34.7	2.2
Moldboard	Top	38.6	4.3
Moldboard	Mid	38.7	3.8
Moldboard	Bottom	34.6	4.1
Ridge	Top	39.3	5.7
Ridge	Mid	36.5	7.5
Ridge	Bottom	35.3	5.3

14G.

Row Dir.	Slope Pos.	Avg	s
Up & Down	Top	36.2	4.8
Up & Down	Mid	37.6	6.4
Up & Down	Bottom	35.2	4.4
Contour	Top	40.8	4.2
Contour	Mid	36.8	4.1
Contour	Bottom	34.5	3.6

14H.

Till	Row Dir.	Slope Pos.	Avg	s
CH	Up & Down	Top	34.8	4.6
CH	Up & Down	Mid	36.7	4.5
CH	Up & Down	Bottom	34.4	1.9
CH	Contour	Top	40.4	4.4
CH	Contour	Mid	36.0	3.5
CH	Contour	Bottom	35.0	2.5
MP	Up & Down	Top	37.3	4.8
MP	Up & Down	Mid	39.1	3.5
MP	Up & Down	Bottom	34.4	5.1
MP	Contour	Top	39.9	3.8
MP	Contour	Mid	38.4	4.4
MP	Contour	Bottom	34.8	3.4
RT	Up & Down	Top	36.5	5.5
RT	Up & Down	Mid	36.9	10.1
RT	Up & Down	Bottom	36.8	5.7
RT	Contour	Top	42.2	4.7
RT	Contour	Mid	36.0	4.8
RT	Contour	Bottom	33.9	4.9

Table 15. 1988 analysis of variance for the 1 percent slope. (Note: Analyzed as a randomized block design.)

Source	DF	SS	MS	F	P-value
Rep	1	294.0	294.0	(4.374)	(0.06986)
Tillage	2	830.3	415.1	6.172	0.02388
ERROR1	8	537.8	67.22	---	

Table 16. 1988 analysis of variance for the 4 percent slope. (Note: Analyzed as a split plot design.)

Source	DF	SS	MS	F	P-value
Rep	1	539.6	539.6	(1.280)	(0.4608)
Row	1	55.81	55.81	0.132	0.7779
ERROR1	1	421.7	421.7	---	
Tillage	2	2091.0	1046.0	12.83	4.73e-4
Row*Tillage	2	123.9	61.94	0.760	0.4839
ERROR2	16	1304.0	81.51	---	

Table 17. 1988 analysis of variance for the 8 percent slope. (Note: Analyzed as a split-split plot design.)

Source	DF	SS	MS	F	P-value
Rep	2	4328.0	2164.0	(3.757)	(0.2102)
Row	1	552.2	552.2	0.959	0.4308
ERROR1	2	1152.0	576.0	---	
Tillage	2	2622.0	1311.0	6.992	0.01754
Row*Tillage	2	958.8	479.4	2.557	0.1385
ERROR2	8	1500.0	187.5	---	
Position	2	6529.0	3264.0	18.174	3.318e-7
Row*Position	2	605.2	302.6	1.685	0.1922
Tillage*Position	4	785.6	196.4	1.094	0.3657
Row*Tillage*Position	4	1120.0	280.1	1.560	0.1934
ERROR3	78	14010.0	179.6	---	

Table 18 (A-B). 1988 Corn Yields on the 1 Percent Slope.

18A.

	Avg	s
Overall	36.5	12.3

18B.

Tillage	Avg	s
Chisel	36.5	7.4
Moldboard	26.4	14.3
Ridge	46.7	4.1

Table 19 (A-D). 1988 Corn Yields on the 4 Percent Slope.

19A.

	Avg	s
Overall	25.5	14.0

19B.

Tillage	Avg	s
Chisel	27.2	17.3
Moldboard	13.3	5.3
Ridge	35.9	4.8

19C.

Row Dir.	Avg	s
Up & Down	27.0	16.4
Contour	23.9	11.8

19D.

Till	Row Dir.	Avg	s
CH	Up & Down	32.0	22.4
CH	Contour	22.5	11.5
MP	Up & Down	13.1	6.9
MP	Contour	13.4	4.3
RT	Up & Down	36.0	5.9
RT	Contour	36.0	4.4

Table 20 (A-H). 1988 Corn Yields on the 8 Percent Slope.

20A.

	Avg	s
Overall	35.2	17.9

20B.

Tillage	Avg	s
Chisel	31.7	19.8
Moldboard	31.8	17.3
Ridge	42.2	14.5

20C.

Row Direction	Avg	s
Up & Down	37.5	16.9
Contour	32.9	18.7

20D.

Slope Position	Avg	s
Top	42.0	13.0
Mid	39.3	20.0
Bottom	24.3	14.8

20E.

Tillage	Row Dir.	Avg	s
Chisel	Up & Down	29.7	17.8
Chisel	Contour	33.6	21.8
Moldboard	Up & Down	36.4	13.8
Moldboard	Contour	27.1	19.5
Ridge	Up & Down	46.2	15.3
Ridge	Contour	38.1	12.9

20F.

Tillage	Slope Pos.	Avg	s
Chisel	Top	39.3	12.9
Chisel	Mid	38.1	25.5
Chisel	Bottom	17.5	9.8
Moldboard	Top	36.7	13.1
Moldboard	Mid	38.3	20.1
Moldboard	Bottom	20.3	12.8
Ridge	Top	50.0	9.8
Ridge	Mid	41.4	14.4
Ridge	Bottom	35.1	15.7

20G.

Row Dir.	Slope Pos.	Avg	s
Up & Down	Top	47.1	10.7
Up & Down	Mid	38.6	14.9
Up & Down	Bottom	26.6	18.0
Contour	Top	36.9	13.4
Contour	Mid	39.9	24.5
Contour	Bottom	22.0	10.8

20H.

Till	Row Dir.	Slope Pos.	Avg	s
CH	Up & Down	Top	45.5	5.8
CH	Up & Down	Mid	33.1	15.5
CH	Up & Down	Bottom	10.7	7.9
CH	Contour	Top	33.2	15.5
CH	Contour	Mid	43.2	33.7
CH	Contour	Bottom	24.4	5.9
MP	Up & Down	Top	41.2	11.2
MP	Up & Down	Mid	42.3	13.0
MP	Up & Down	Bottom	25.9	12.2
MP	Contour	Top	32.2	14.3
MP	Contour	Mid	34.2	26.1
MP	Contour	Bottom	14.8	11.6
RT	Up & Down	Top	54.8	10.6
RT	Up & Down	Mid	40.5	17.1
RT	Up & Down	Bottom	43.4	15.8
RT	Contour	Top	45.2	6.5
RT	Contour	Mid	42.4	12.8
RT	Contour	Bottom	26.8	11.3

WEST CENTRAL EXPERIMENT STATION
WEATHER SUMMARY - 1988

		Precipitation			Temperature			Soil Temperature (10 cm depth)	
Month	Period	1988	100-yr. av.	Dev. from av.	1988	100-yr. av.	Dev. from av.	1988	10 yr. av.
January	1-31	0.70	0.68	-0.05	5.6	8.0	+ 9.9	17.6	20.7
February	1-29	0.20	0.67	-0.35	9.2	12.8	+16.7	15.8	23.9
March	1-31	0.82	1.13	+0.44	30.1	26.7	+ 5.5	29.5	29.2
April	1-10	0.44	0.57	-0.57	45.5	38.0	+ 5.5	38.9	
	11-20	0	0.64	-0.31	36.7	44.4	+11.0	41.3	
	21-30	0.13	1.05	-0.99	44.7	48.3	+ 6.3	44.5	
Total or av.		0.57	2.26	-1.87	43.6	43.6	+ 7.6	41.5	41.4
May	1-10	0.77	0.77	-0.65	63.2	52.0	+ 8.1	57.6	
	11-20	0.06	0.95	-0.59	60.6	55.8	+ 6.9	60.8	
	21-31	0.88	1.25	+1.19	69.5	60.0	+ 0.3	67.3	
Total or av.		1.71	2.97	- .05	64.3	56.1	+ 4.9	62.1	57.1
June	1-10	T	1.29	-1.13	73.2	63.0	+ 2.4	77.3	
	11-20	0.41	1.30	+0.40	73.7	66.3	+ 5.5	71.7	
	21-30	0.08	1.37	-1.36	74.7	68.1	- 1.3	80.4	
Total or av.		0.49	3.96	-2.09	73.9	65.8	+ 2.2	77.6	69.3
July	1-10	0.39	1.44	-0.75	75.7	70.1	- 1.4	81.5	
	11-20	1.25	1.06	-0.76	72.7	71.4	- 1.6	83.2	
	21-31	0.19	1.01	-0.19	75.6	71.4	+ 5.5	84.1	
Total or av.		1.83	3.51	-1.70	74.7	70.9	+ 1.1	83.0	76.7
August	1-10	2.56	1.04	-0.76	73.2	70.4	- 0.4	79.6	
	11-20	1.71	0.93	-0.26	76.4	69.0	- 1.6	77.3	
	21-31	0.36	1.04	-0.53	64.5	66.9	- 7.0	68.7	
Total or av.		4.63	3.01	-1.55	71.1	68.7	- 3.1	77.1	73.9
September	1-30	4.56	2.20	+0.69	58.2	59.0	0	63.0	61.5
October	1-31	0.46	1.74	-1.32	41.6	47.2	- 5.5	46.9	47.8
November	1-30	1.07	0.97	-0.15	27.7	29.7	+ 5.3	33.3	33.6
December	1-31	0.45	0.68	-0.01	16.3	15.2	+ 5.7	23.8	23.4
April-Aug. Growing Season		9.23	15.71	-7.26	65.6	61.0	+ 2.6	68.4	63.8
January-December Annual		23.78	23.78	-8.01	43.1	42.0	+ 4.2	47.7	46.7

CONTINUOUS CORN SILAGE
MORRIS, 1988[1]

S. D. Evans[2]

ABSTRACT: This long-term study addresses the effects of removal of continuous corn silage and corn grain on soil properties and yield. Results after 23 years show no yield differences due to the removal of silage versus grain. A significant difference in yields exists between high and low fertilizer levels.

OBJECTIVES

This is the 23rd year of a continuing study initiated in 1965 on a McIntosh silt loam soil. This study was initiated to determine the effects of removal of continuous corn silage and fertilizer rate on soil properties and yields. Silage and shelled corn yield samples were collected. Half of the plots received a fertilizer rate of 74+48+48 ($N+P_2O_5+K_2O$) in lbs./acre) and the other half a rate of 148+96+96.

MATERIALS AND METHODS

The experiment is set up as a latin square with 4 treatments: (1) silage, low fertility, (2) silage, high fertility, (3) grain, low fertility, and (4) grain, high fertility. The experimental area has been moldboard plowed each fall and tilled with a field cultivator prior to planting. In 1988 Dekalb 461 was seeded at 26,200 seeds/acre on April 25. Furadan 15G was applied in the row at planting at 10 lbs./acre (1.5 lbs./acre a.i.). The fertilizer was all applied the previous fall prior to plowing.

Lasso @ 3 lbs./acre a.i. + Bladex @ 2.2 lbs./acre a.i. were applied broadcast on April 27. Silage yields were taken on August 20 and grain yields on September 21. Yields were also taken as in past years on an adjacent unfertilized area where only the grain is removed. These check yields are an average from two measured areas.

RESULTS AND DISCUSSION

Grain and Silage Yields: Silage yields are given in Table 1. There was no significant difference in silage yields in 1988. Dry conditions reduced yields to about half of normal. The 23-year average shows no effect of silage versus grain but does show increased yields of high fertility over low fertility. Grain yields and an average of the two unfertilized checks adjacent to the experimental area are given in Table 2.

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[1] Funding provided by the West Cent. Expt. Sta. Univ. of Minnesota
[2] Professor, West Cent. Expt. Sta., Univ. of Minnesota.

Table 1. Effect of removal of continous silage or grain on silage yields.

Treatment	1988 Yield	1966-88 Yield
	- - - dry matter, tons/acre - - -	
Silage, Low fertility	4.09	5.42
Silage, High fertility	4.16	5.93
Grain, Low fertility	3.39	5.45
Grain, High fertility	3.39	5.80
Signif. levels (%):		
Treatment	72	>99
Year	--	>99
Treatment x Year	--	99
LSD, treatment (.05)	NS	0.16

Table 2. Effect of fertilizer level on grain and silage yields.

Treatment	1988 Yield	1966-88 Yield
	- - - - bu./acre @ 15.5% M. - - - -	
Grain, Low fertility	52.2	87.0
Grain, High fertility	39.8	91.8
Grain, Check	48.0	46.7
	- - - - dry matter, ton/acre - - -	
Silage, check	3.45	3.52

MANURE RATE STUDY
Morris, 1988[1]

S. D. Evans, P. R. Goodrich, G. L. Malzer and R. C. Munter[2]

ABSTRACT: This is the 16th year of a study initiated in 1972 to investigate the effect of application of three rates of solid and and three rates of liquid beef manure on corn growth and soil properties. Seven fall applications of manure were made from 1972 thru 1978 (application omitted in 1977). Residual effects of the seven applications has been measured from 1979-1988. Higher rates of manure did not result in higher yields during the application years, but the highest manure rate did indicate a measurable response to residual fertility in the post-application years. NO_3-N movement below the root zone of corn is much higher with the higher rates of manure.

Objectives

This study was initiated in 1972 to investigate the effect of application of three rates of solid and three rates of liquid beef manure on corn growth and soil properties. The manure treatments were compared to commercial fertilizer and check treatments. Seven fall applications of manure were made from 1972 thru 1978 (omitted in 1978). Fertilizer was applied to the commercial fertilizer treatment each year at the same rate. The treatments and abbreviations are as follows:

CHECK- CK - No fertilizer or manure
FERTILIZED - FE - 120 + 50 + 50 (N + P_2O_5 + K_2O) lbs/acre/year
SOLID BEEF MANURE, RATE 1 - SB1 - 33 tons/acre annually (wet weight), total application of 233 tons/acre
SOLID BEEF MANURE, RATE 2 - SB2 - 67 tons/acre annually (wet weight), total application of 467 tons/acre
SOLID BEEF MANURE, RATE 3 - SB3 - 100 tons/acre annually (wet weight), total application of 700 tons/acre
LIQUID BEEF MANURE, RATE 1 - LB1 - 4530 gallons/acre annually, total application of 31700 gallons/acre
LIQUID BEEF MANURE, RATE 2 - LB2 - 9060 gallons/acre annually, total application of 63400 gallons/acre
LIQUID BEEF MANURE, RATE 3 - LB3 - 13580 gallons/acre annually, total application of 95100 gallons/acre

Materials and Methods

Plots were fall plowed in 1987 and field cultivated on April 25 and then planted to Pioneer 3906 corn at 26,200 seeds/acre. Furadan 15G was applied at 10 lbs/acre (1.5 lbs/acre a.i.) in the row to the entire area at planting. Lasso @ 3 lbs/acre (a.i.) + Bladex @ 2.2 lbs/acre (a.i.) were broadcast on April 27. The fertilized plots had received an application of 120 + 50 + 50 the previous fall. On June 2 plant heights were recorded and 10 plants were harvested for dry weight determination. Plots were cultivated on June 3. Silage yields were calculated from two 10-foot rows hand harvested on August 31. Two 40-foot rows were harvested with a plot combine on September 21. Following harvest the plots were sampled to a depth of 4 feet in 1-foot increments. Two cores were combined for each plot and divided into two parts; one for N analysis and the other for moisture determination. The cores for N analysis were dried at 95°F.

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[1] Funding provided by the West Cent. Expt. Sta. Soil analysis provided by the Center for the Impacts of Agricultural Practices on Water Quality.

[2] Professor, West Cent. Expt. Sta. Assoc. Prof., Dept. of Soil Science, and Asst. Prof., Dept. of Soil Science, respectively, Univ. of Minnesota.

Results and Discussion

Plant and Yield Measurements: Early plant height, early dry weight, silage yields and grain yields are given in Table 1. Early plant height and dry weight were significantly taller and heavier for the solid beef manure treatments than for the liquid manure and fertilizer treatments. Even though the SB treatments early plant growth was greater, there was no difference in grain and silage yields. Extremely dry conditions reduced yields to about half of normal and probably overcame any early plant growth advantages.

Fall 1988 Soil Samples: The results of the NO_3-N analyses are given in Table 2. Levels in the manure treatments increased with rate. The CK, SB1, and LB1 had significantly lower NO3-N levels than the other treatments. All other manure treatments except SB3 are not different from the fertilizer treatment. Nitrates accumulated in the 2-, 3-, and 4-foot depths and were significantly higher than in the top foot.

Table 1. Summary of plant measurements - 1988.

			Grain		Silage		
Treatment	Early plant height	Early plant (10) dry wt.	Moisture at harvest	Yield at 15.5% moisture	Dry matter at harvest	Silage yield (D.M.)	Ear Wt. as a % of silage
	-in.-	grams	-%-	bu/acre	-%-	lbs/acre	-%-
CK	11.0	15.1	25.6	49.1	45.2	7265	51.2
FE	11.5	16.0	26.1	48.2	42.0	8173	48.5
SB1	14.5	27.4	24.3	52.7	44.3	9303	47.7
SB2	14.5	28.7	25.8	45.3	39.4	6468	41.5
SB3	16.2	34.5	27.4	43.6	41.8	6530	40.3
LB1	11.5	17.4	25.2	56.5	46.8	7024	49.8
LB2	12.5	21.1	25.2	49.7	47.4	9003	52.1
LB3	12.8	20.7	24.1	54.4	44.1	8331	50.9
Signif. Level(%)	>99	>99	59	8	>99	93	96
BLSD (.05)	1.3	5.9	NS	NS	3.3	NS	9.0
CV (%)	5.9	15.6	6.7	26.1	4.2	15.5	9.4

Table 2. Effect of two types of cattle manure and commercial fertilizer on the nitrate - nitrogen level of a Tara Soil profile - Fall 1988

Depth Increment	CK	FE	SB1	SB2	SB3	LB1	LB2	LB3	MEAN
- ft -	ppm NO_3 - N								
0-1	5.1	15.0	6.9	12.1	24.7	5.0	6.3	12.1	10.9
1-2	.9	49.6	13.0	16.2	77.5	2.7	20.7	43.8	28.0
2-3	.9	25.1	20.9	30.1	82.6	3.3	21.4	34.0	27.3
3-4	2.7	18.9	14.5	37.5	62.4	10.3	17.7	17.1	22.6
MEAN	2.4	27.2	13.8	24.0	61.8	5.3	16.5	26.7	

Signif. Levels (%)

Replication	- 95		
Treatment	- 95	BLSD (.05)	11.7
Depth	- >99	BLSD (.05)	8.9
Trt x depth	- 89		

RESIDUAL EFFECT OF HEAVY APPLICATIONS OF ANIMAL MANURES ON CORN GROWTH, YIELD, AND ON SOIL PROPERTIES[1]
Morris, 1988

S. D. Evans, P. R. Goodrich, G. L. Malzer, and R. C. Munter[2]

ABSTRACT: This study is continuing and 1988 was the 18th year. Nitrate movement and yield responses from two initial annual large applications of manure have been measured. Results over the 18 years show 1986 as the first year the fertilized check yielded significantly better than the manure treatments. Soil samples were taken to a depth of 18 feet in the fall of 1987. The fertilizer treatment had the most NO_3-N in the root zone. Below the root zone (4 feet) NO_3-N levels in the manure treatments exceeded the fertilizer treatment. Most of this manure fertilizer is 6 feet or deeper, therefore, below the root zone of corn and not available to the crop and susceptible to deeper movement to the groundwater.

This is the 18th year of a continuing study initiated to measure the residual effects of 1970 and 1971 applications of two types of manure on corn yields and soil nitrogen levels. The total manure applications were as follows: Solid Beef Manure-200 tons/acre (wet weight), Liquid Beef Manure- 36,000 gallons/acre, and Liquid Hog Manure-136,000 gallons/acre. The fertilized plots received the same amount of fertilizer annually (120 + 50 + 50 of N + P_2O_5 + K_2O in lbs/acre, respectively).

Planting and Harvesting Information

The study was seeded to Pioneer 3906 corn on April 25 at 26,200 seeds/acre. Furadan 15G was applied @ 10 lbs/acre (1.5 lbs/acre a.i.) in the row at seeding. The fertilized plots received 120 + 50 + 50 (N + P_2O_5 + K_2O) lbs/acre on October 26, 1987. The plots were moldboard plowed following fertilizer application. A Lasso and Bladex tank mix applied at 3.0 and 2.2 lbs/acre a.i. respectively was applied broadcast preemergence on April 27. Plots were cultivated on June 3. Silage yields were calculated from two 10-foot rows hand harvested on August 31. Grain yields were calculated from two 110-foot rows harvested with a plot combine on September 21.

Soil Sampling and Analysis

Two soil cores were taken from each plot in the fall of 1988 to a depth of 4 feet in one-foot increments. The two cores were combined and divided into two parts; one for N analysis and the other for moisture determination. The cores for N analysis were dried at 95°F. There was a significant difference between the fertilized check and all other treatments in NO_3-N levels (Table 1). The fertilized check has far more nitrates in the upper 4-foot profile than the other treatments. However, the manure treatments (Table 2) have far more nitrates deeper in the soil profile out of the rooting zone for corn, therefore, susceptible to deeper movement into the soil. NO_3-N levels (Table 1) increased with depth while NH_4-N levels decreased with depth.

Plant and Yield Measurements

Early plant height, early plant weight, silage yields, and grain yields are given in Table 3. Early plant height and early plant weight were significantly higher and heavier for the manure treatments over the fertilizer treatment. There were no differences between manure and fertilizer treatment yields. Due to extreme dry conditions yields were about half of normal.

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[1] Funding provided by the West Cent. Expt. Sta. Soil analysis provided by the Center for the Impacts of Agricultural Practices on Water Quality.

[2] Professor, West Cent. Expt. Sta., Assoc. Prof., Dept. of Agr. Eng., Assoc. Prof., Dept. of Soil Science, and Asst. Prof., Dept. of Soil Science, respectively, Univ. of Minnesota.

Table 1. Nitrate and ammonium nitrogen levels of Tara Soil 18 years (Fall 1988) after application of high rates of manure.

Depth Increment	Treatment: Check	Fertilized	Solid Beef Manure	Liquid Beef Manure	Liquid Hog Manure	Mean	Treatment: Check	Fertilized	Solid Beef Manure	Liquid Beef Manure	Liquid Hog Manure	Mean
	ppm NO_3-N						ppm NH_4-N					
0-1	3.0	7.3	4.2	5.4	2.6	4.5	4.6	4.9	2.2	5.0	5.8	4.5
1-2	1.5	24.3	2.7	3.9	1.7	6.8	2.7	3.0	2.3	3.4	2.7	2.8
2-3	.7	19.4	2.3	5.1	2.4	6.0	2.2	2.3	2.2	2.0	2.2	2.2
3-4	1.2	9.5	6.4	14.6	4.9	7.3	2.5	2.7	2.5	2.3	2.3	2.5
Mean	1.6	15.1	3.9	7.2	2.9		3.0	3.2	2.3	3.2	3.2	

Signif. Level (%)

Replication	- NS	Replication	- NS
Treatment	- 99	Treatment	- NS
Depth	- NS	Depth	- >99
Trt x Depth	- >99	Trt x Depth	- >99

BLSD (.05) 7.1

BLSD (.05) .4

Table 2. Calculated nitrate - nitrogen contents of various profile increments of a Tara soil in the fall of 1987.

Depth Increment	Treatments: Check	Fertilized	Solid Beef Manure	Liquid Beef Manure	Liquid Hog Manure
- ft. -	-NO_3-N, lbs/acre				
0-6	96	268	80	152	120
6-18	232	396	700	832	584
Total	328	664	780	984	704

Table 3. Summary of plant measurements - 1988.

Treatment	Early plant height	Early plant(10) dry wt.	Grain: Moisture at harvest	Grain: Yield at 15.5% moisture	Silage: Dry matter at harvest	Silage: Silage yield (D.M.)	Silage: Ear Wt. as a % of Silage
	- in. -	grams	-%-	bu/acre	-%-	lbs/acre	-%-
Check	9.7	13.0	24.9	45.1	43.6	6110	49.8
Fertilized	10.8	13.1	24.7	58.4	42.8	8581	52.2
Solid Beef Manure	13.8	22.6	24.5	48.6	41.1	6715	44.7
Liquid Beef Manure	13.5	25.1	24.6	50.5	45.9	7875	48.6
Liquid Hog Manure	12.5	19.0	25.4	52.8	47.7	7352	55.1
Signif. Level (%)	>99	>99	17	55	>99	85	88
BLSD (.05)	1.6	2.9	NS	NS	2.8	NS	NS
CV (%)	7.3	8.8	4.2	16.6	3.3	15.2	8.3

FOLIAR UAN CONCENTRATIONS ON HARD RED SPRING WHEAT[1]
Morris, 1988

S. D. Evans and G. A. Nelson[2]

ABSTRACT: Foliar application of 28% UAN to hard red spring wheat has the potential to burn leaf tissue and possibly adversely affect yield. This study addresses the use of four concentration rates of UAN and their effects on leaf burn and yield. Results of this one-year study indicate increasing rates of leaf burn occurred with increasing concentrations of 28% UAN. Yield was about 1/3 of normal due to extremely dry conditions.

There has been concern over leaf burn caused from 28% UAN on hard red spring wheat and its effects on yield. This study was set up to study the effects of leaf burn as related to N concentration in the spray and how much burn is permissible before yield decreases occur.

Experimental Procedure

The experiment was established on a Hamerly clay loam (Aeric Calciaquoll). A randomized complete block design with four replications was used. The entire plot area received 40 lbs N/acre as urea on April 11. In the fall of 1987 2-foot NO_3-N samples were taken and measured 80 lbs/acre/2 ft. Plot size was 8 ft x 45 ft. The 28% UAN treatments included: (1) 100% UAN, 0% water, (2) 50% UAN, 50% water, (3) 33% UAN, 67% water, and (4) 25% UAN, 75% water. The foliar N treatments were applied at 13.3-, 26.7-, 40.0-, and 53.3-gal/acre and 30 psi pressure for treatments 1, 2, 3, and 4, respectively. The treatments were applied at the 4-5 leaf stage (tiller) of the wheat to provide 40 lbs N/acre. Marshall wheat was seeded at 100 lbs/acre on April 12. Bronate (.25 lb/acre a.i.) and Hoelon (.25 lb/acre a.i.) were broadcast for weed control on May 24 and 26, respectively. Tilt was applied @ 4 oz/acre for disease control on June 2. The 28% UAN was applied on May 24 and leaf damage was recorded on May 27. Plant heights were taken on July 20 and plots were harvested with a plot combine on July 21. Samples of grain were taken for test weight and moisture.

Results and Discussion

Leaf damage on the 100% UAN and 50% UAN treatments was significantly greater than on the 33% UAN and 25% UAN treatments. Grain yield, test weight, grain moisture and plant height were not significantly (P=.05) affected by UAN concentration. The year 1988 was extremely dry and hot with wheat yields 1/3 or less than normal. This study will be repeated in 1989.

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[1] Funding provided by the West Cent. Expt. Sta., Univ. of Minnesota.
[2] Professor and Junior Scientist, West Cent. Expt. Sta.,, Univ. of Minnesota

Table 1. The effect of concentration rate of 28% UAN to provide 40 lbs N/acre on spring wheat applied at tillering.

Trt No.	Concentration	Leaf[1] Damage	Plant Height	Grain Moisture at Harvest	Test Weight	Grain Yield at 13% Moisture
			inches	- % -	lbs/bu	Bu/acre
1	100% UAN	3.75	16.8	15.4	53.7	17.5
2	50% UAN 50% H_2O	3.50	16.3	15.6	55.8	17.8
3	33% UAN 67% H_2O	2.50	16.0	15.6	55.3	16.7
4	25% UAN 75% H_2O	2.00	16.0	15.4	56.1	16.8
Signif. Level (%)		>99	31	59	90	43
BLSD (.05)		0.8	NS	NS	2.3	NS
CV (%)		16.3	6.2	1.1	2.3	7.6

[1] Leaf Damage 3 days after application: 1=0%, 2=1-25%, 3=26-50%, 4=51-75%, 5=76-100%, expressed as estimation of percentage of the top leaf tissue burned by fertilizer.

SOIL AND FOLIAR APPLIED NITROGEN FOR HARD RED SPRING WHEAT[1]
Morris, 1988

S. D. Evans and G. A. Nelson[2]

ABSTRACT: Recommendations for increasing protein content and yields for hard red spring wheat with foliar N applications in combination with various soil N applications have yet to be developed. This study addresses soil and foliar nitrogen combinations used to increase protein content and yield of spring wheat. Leaf tissue damage was significantly affected by rate of foliar N applied but damaged a significant portion of the leaves only at the 40 lbs N/acre rate. Yield results of this one-year study were inconclusive due to extreme drought. Average yields were under 8 bu/acre. This study will be repeated in 1989.

In the past few years there has been an increased interest in spring wheat protein levels. This study was initiated to look at 4 foliar nitrogen rates, applied at the 4-5 leaf stage of wheat, on 4 rates of nitrogen, for a total of 16 treatments.

Experimental Procedures

The experiment was established on a Hamerly clay loam (Aeric Calciaquoll). Plot size was 8 feet x 45 feet. NO_3-N soil tests taken the fall of 1987 indicated 80 lbs NO_3-N/acre was available for plant growth in the top 2 feet of soil. Nitrogen (urea) was applied to appropriate plots to equal 80, 120, 160 and 200 lbs N/acre on April 11. The plot area was then worked with a field cultivator to incorporate the urea and prepare a seedbed. The plots were seeded to Marshall wheat at 100 lbs/acre on April 12. The foliar N treatments were applied with a sprayer delivering a volume of 50 gal/acre at 30 psi pressure. The foliar fertilizer, 28% UAN, was applied at 4-5 leaf stage on May 23. Rates applied were 0, 10, 20, and 40 lbs N/acre across the 80, 120, 160, and 200 lbs N/acre soil nitrogen plots. Bromate @ .25 lbs/acre a.i. and Hoelon @ .25 lbs/acre a.i. were broadcast on May 24 and 26, respectively. Tilt was applied @ 4 oz/acre for disease control on June 2. Foliar leaf damage was recorded on May 26, three days after foliar N application. Plant heights were taken on July 20 and the plots were harvested with a plot combine on July 21. Samples of grain were taken for yield, moisture, and test weight determination.

Results and Discussion

There was no significant effect of the soil or foliar fertilizer treatments on plant height, bushel weight, moisture, or grain yield. Leaf damage was affected significantly by the foliar N application. As N rate increased, so did leaf damage, but there was no effect on yield. Leaf damage was significant on the 40 lbs N/acre foliar treatment. Severe drought conditions existed in 1988 with wheat averaging 7 1/2 bu/acre. Because of extremely poor yields and plot variability, protein analysis was not run. This study will be repeated in 1989.

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[1] Funding provided by the West Cent. Expt., Univ of. Minnesota.

[2] Professor and Junior Scientist, West Cent. Expt. Sta., Univ. of Minnesota.

Table 1. Effect of Soil and Foliar Nitrogen Rates on Spring Wheat.

Soil Applied Fertilizer	LFD[1] (0-5)	Ht.	Bu. Wt.	Moist.	Yield @ 13% Moist.	Foliar Fertilizer	LFD[1] (0-5)	Ht.	Bu.Wt.	Moist.	Yield @ 13% Moist.
lbs N/acre		-in-	lbs/bu	%	bu/acre	lbs N/acre		-in-	lbs/bu	%	bu/acre
80	1.6	10.2	58.2	12.1	7.4	0	1.0	10.1	58.2	12.1	7.8
120	1.6	9.8	58.1	11.9	6.5	10	1.0	10.1	58.2	12.1	7.9
160	1.5	10.4	58.3	12.2	9.1	20	1.4	10.1	58.3	12.1	7.7
200	1.4	9.7	58.5	12.0	7.2	40	2.7	9.9	58.4	12.1	6.8
Significance											
Level (%)	51	59	47	77	68		>99	3	15	22	15
BLSD	NS	NS	NS	NS	NS		0.2	NS	NS	NS	NS
CV (%)	22.7	13.7	1.1	2.0	42.3		22.7	13.7	1.1	2.0	42.3

[1] Leaf Damage 3 days after application 1 = 0%, 2 = 1-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-100%, expressed as estimation of percentage of the top leaf tissue burned by fertilizer.

USING SPLIT APPLICATIONS AND A NITRIFICATION INHIBITOR FOR CORN PRODUCTION ON AN IRRIGATED SANDY SOIL

Kendall Langseth, Denzil Cooper, and George Rehm[1]

ABSTRACT: Past research in Minnesota has shown that split applications and nitrification inhibitors are effective management tools for improving the yield of irrigated corn grown on sandy soils. This study was designed to determine if the use of these two practices would reduce the rate of fertilizer N needed for most profitable yield. In 1988, at the Irrigation Center at Staples, N rate (160 or 200 lb./acre), the use of a nitrification inhibitor (DCD) and split applications had no effect on grain yield of corn. The NO_3-N in the root zone at the end of the growing season was significantly affected by N rate, but not by nitrification inhibitor use or split applications.

Efficient use of nitrogen fertilizers is essential for profitable corn production on irrigated sandy soils. Split applications and the use of nitrification inhibitors are two management tools that can be easily used to provide for the efficient use of fertilizer N. The importance of these two management tools has been documented in past research. There was, however, a need to determine if the use of these management options would allow for the use of lower rates of fertilizer N without any reduction in yield. Therefore, this trial was conducted to determine the impact of split rates of fertilizer N and a nitrification inhibitor on the yield of corn when 2 rates of N (160, 200 lb./acre) were used.

EXPERIMENTAL PROCEDURES:

This study was conducted at the Irrigation Center at Staples. The soil was a Sverdrup sandy loam. Soil samples were collected prior to corn planting and the results are summarized in Table 1.

Three variables were incorporated into a complete factorial design with 4 replications. These variables were: 1) N rate (160, 200 lb./acre), 2) application frequency (single, split), and 3) use of an inhibitor (DCD). The variety, Agripro 270 (90 day relative maturity) was planted on May 5 at a population of 32,000 plants per acre. All treatments received a starter fertilizer to supply 40 lb. N, 13 lb. P_2O_5, 26 lb. K_2O and 13 lb. S per acre. The Dual/Bladex herbicide combination was applied preemergence at rates of 1.5 pint and 1.3 qt per acre respectively.

For single applications, the N was applied at the 5-6 leaf stage of development. For split applications, one half of the fertilizer N was applied at this stage with the remainder applied approximately 2 weeks prior to silking. Urea (46-0-0) was used to supply the N for all treatments.

Grain yields were harvested in mid-October and corrected to the 15.5% moisture level. Soil samples from 0-12, 12-24, and 24-36 inches were also collected at this time. These samples were dried and analyzed for nitrate-nitrogen (NO_3-N).

RESULTS AND DISCUSSION:

The influence of N rate, split application and use of a nitrification inhibitor on grain yield is summarized in Table 2. None of the variables used in the study had a significant effect on yield. The yield goal established for this study was 170 bu./acre. The lowest N rate used was adequate to meet this goal. Because of the weather, there was a very low potential for leaching of NO_3-N through the root zone. Therefore, a response to the use of either split applications or nitrification inhibitors would not be anticipated.

The yield of approximately 185 bu./acre was certainly higher than expected for the 1988 growing season. These high yields are a reflection of the good management practices used throughout the growing season.

[1] County Extension Agent, Wadena County; County Extension Agent, East Ottertail County; and Extension Specialist, respectively.

Table 1. Relevant soil test values for the experimental site.

pH	6.7
P (lb./acre)	75
K (lb./acre)	374
O.M. (%)	2.0
NO_3-N (lb./acre to 24 inches)	38

Table 2. Influence of N rate, frequency of N application, and use of a nitrification inhibitor on the yield of irrigated corn.

N Rate	Inhibitor used	Application Frequency single	split
lb./acre		- - bu./acre - -	
160	No	185	188
	Yes	175	191
200	No	187	185
	Yes	179	184

Results of the analysis of soil samples collected in mid-October at harvest are summarized in Tables 3, 4, 5, and 6. The amount of NO_3-N present in the 12-24 inch depth was not significantly affected by any of the variables used (Table 3). Concentrations of NO_3-N were relatively low and quite uniform at this depth.

The variables used also had no significant on the amount of NO_3-N found at the 12-24 and 24-36 depths (Tables 4 and 5). Amounts of NO_3-N found at these depths were low and quite variable. Except for the situation where 200 lb. N was applied with a split application and the inhibitor was used, total amounts of NO_3-N to a depth of 3 feet were relatively uniform (Table 6).

In general, the amount of NO_3-N measured to the 3 ft. depth in the fall was less than the amount found to the 2 ft. depth in early spring. This would indicate very efficient use of the applied N during the 1988 growing season.

Table 3. The influence of N rate, frequency of N application, and use of a nitrification inhibitor on the amount of NO_3-N at the depth of 0-12 inches.

N Rate	Inhibitor Used	Application Frequency single	split
lb./acre		- - bu. NO_3-N/acre - -	
160	No	16	14
	Yes	14	14
200	No	14	15
	Yes	14	15

Table 4. The influence of N rate, frequency of N application, and use of a nitrification inhibitor on the amount of NO_3-N at the depth of 12-24 inches.

N Rate	Inhibitor Used	Application Frequency single	split
lb./acre		- - lb.NO_3-N/acre - -	
160	No	7	7
	Yes	6	7
200	No	7	22
	Yes	14	8

Table 5. The influence of N rate, frequency of N application, and use of a nitrification inhibitor on the amount of NO_3-N at the depth of 24-36 inches.

N Rate	Inhibitor Used	Application Frequency single	split
lb./acre		- - - lb./acre - - -	
160	No	5	5
	Yes	4	6
200	No	6	13
	Yes	8	6

Table 6. The influence of N rate, frequency of N application, and use of a nitrification inhibitor on the amount of NO_3-N in the 0-36 inch root zone.

N Rate	Inhibitor Used	Application Frequency single	split
lb./acre		- - - lb./acre - - -	
160	No	28	27
	Yes	24	28
200	No	27	50
	Yes	37	30

INFLUENCE OF POTASSIUM AND SULFUR ON THE YIELD OF RED CLOVER

Greg Cremers, Andy Scobbie, and George Rehm[1/]

ABSTRACT: Red clover may substitute for alfalfa in many farming enterprises where high costs of some inputs may discourage alfalfa production. Relatively little is known about the fertilizer requirements of red clover. In this study, neither K nor S increased the yield of red clover seeded in August of 1987. An erratic stand may have contributed substantially to variable yields which, in turn, masked treatment effects.

Red clover has the ability to tolerate soils with a relatively low pH. Therefore, lower rates of lime may be needed for profitable production. This reduced requirement for lime makes red clover an attractive legume for many farm enterprises that use legumes in their crop rotations.

The fertilizer requirements for the most profitable production of red clover are not well established. Red clover can easily substitute for alfalfa in rotations where soils are sandy with medium to low soil test values for potassium. Therefore, this study was conducted to measure the effect of potassium and sulfur on the yield of red clover.

EXPERIMENTAL PROCEDURE:

This study was conducted at the Irrigation Center at Staples. The soil is classified as a Sverdrup sandy loam. Results of the soil test showed a pH of 6.2, a P level of 34 lb./acre and a K level of 109 lb./acre. The organic matter content was 2.4%.

Lime at a rate of 2 ton/acre was broadcast and incorporated in mid-summer of 1987. The red clover was seeded with a Brillion seeder in early August of 1987. A seeding rate of 10 lb./acre was used. The Arlington variety was used.

Six rates of K (0, 20, 40, 80, 160, 320) were combined with 3 rates of S (0, 25, 50) in a complete factorial. The treatments were incorporated into a randomized complete block design with 4 replications. The K was supplied as 0-0-60 and granular gypsum was used to supply the S. Treatments were topdressed to the established stand in mid-April.

First cutting yields were measured on June 17 and 2nd cutting yields were harvested on July 26. The harvest area was approximately 3 ft. x 18 ft.

RESULTS AND DISCUSSION:

In 1988, neither K nor S had a significant effect on the yield of red clover (Table 1). Therefore, only total yields are shown.

Because of the relatively low soil test for K (109 lb./acre) and the sandy soil a response to both K and S was anticipated. There was, however, a substantial amount of variability in yields (C.V. of approximately 15%). This variability may have masked any response to K and S. Treatments will be repeated and this study will be continued in 1989.

Table 1. Effect of rate of K and S on total yield of red clover during the 1988 growing season.

S	K Rate (lb./acre)					
Rate	0	20	40	80	160	320
lb./acre	- - - - - - - - ton D.M./acre - - - - - - - -					
0	3.01	3.21	3.22	2.97	2.76	3.19
25	3.07	2.89	3.16	3.48	3.38	3.23
50	2.95	2.70	3.10	3.68	3.66	2.91

[1/] Assistant Scientist, Junior Scientist and Extension Specialist, respectively.

CORN-SOYBEAN ROTATION

H. Meredith, Mel Wiens, Greg Cremers, and Andy Scobbie[1/]

ABSTRACT: This study was initiated in 1981 following widespread complaints by farmers that they were unable to maintain consistently high corn yields under a regime of continuous corn. The study contains two relative maturity hybrids and one soybean variety. Continuous corn and corn following first-year and second-year soybeans are evaluated. Corn yields have not increased following soybeans compared to a continuous corn regime.

The 1988 growing season was likely the best year in the history of irrigated corn in Minnesota. Early season temperatures permitted the crop to develop rapidly to capitalize on the long day length. Adequate moisture was provided through sprinkler irrigation to mitigate the intense heat experienced during the summer.

Table 1. Corn Yield @ 15.5% Moisture, Bu/A, Staples 1988.

No.	Treatment	1981	1982	1983	1984	1985	1986	1987	1988	Ave.
1	Cont. corn[1/]	151	168	135	130	125	149	170	182	151
2	Cont. corn[2/]	151	166	150	128	124	180	181	180	158
3	SB_1, SB_2, corn		168		137		142			149
4	Corn, SB	151		148		123		155	178	151
5	Corn, SB		170		140		144			151
6	SB_1, SB_2, corn			147				173		157
7	SB_1, SB_2, corn			155	132	115[3/]			190	148

1/ Pioneer 3902, 90-day R.M. on all treatments except No. 2
2/ Pioneer 3790, 95-day R.M.
3/ Pioneer 3953, 80 day R.M.

Table 2. Soybean Yields, Bu/A, Staples 1988.

No.	1981	1982	1983	1984	1985[1/]	1986	1987	1988
3	39	47	47	38	36		54	43
4						49		
5							52	47
6						53		44
7							53	

1/ Soybean yields averaged through 1985

Table 3. Supportive Information Pertaining to Corn Yields, Staples 1988

No.	Treatment	Harvest Population (X 1000)	Kernel Moisture (%H_2O)	Grain Yield T/A DM	Silage Yield T/A DM	Stover Yield T/A DM	Grain/ Stover Ratio
1	Cont. corn	29.5	17.0	4.31	7.92	3.61	.544
2	Cont. corn	29.2	19.5	4.27	8.36	4.09	.510
4	2nd year corn	28.8	17.4	4.22	8.07	3.85	.523
7	SB_1-SB_2-corn	31.4	17.7	4.48	8.17	3.69	.548

1/ Regional Director, Tennessee Valley Authority, Research Plot Coordinator, Staples Irrigation Center, Asst. Scientist, Jr. Scientist, University of Minnesota, respectively.

Table 4. Nutrient Removal in Corn Grain, Staples 1988

No.	N	S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lbs/A										
1	144	9.8	27	34	.28	11.3	.26	.048	.29	.013	.032
2	137	9.8	26	30	.26	10.0	.19	.047	.24	.007	.027
4	142	9.5	26	34	.26	11.0	.25	.045	.27	.010	.031
7	148	10.5	26	35	.28	11.3	.31	.044	.33	.014	.032

Table 5. Nutrient Removal in Corn Silage (Grain & Stover), Staples 1988

No.	N	S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lbs/A										
1	194	17	31	212	49	27	7.0	.64	.56	.034	.117
2	209	18	36	243	54	30	7.7	.79	.67	.037	.126
4	190	16	30	234	50	27	6.8	.67	.66	.029	.113
7	196	17	31	243	61	29	9.3	.88	.99	.035	.116

Table 6. Whole Corn Plant Nutrient Concentration at Silage Harvest, Staples 1988

No.	N	S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%							ppm			
1	1.23	.10	.20	1.3	.31	.17	.045	40	36	2.1	7.4
2	1.25	.11	.21	1.4	.32	.18	.046	48	40	2.2	7.6
4	1.18	.10	.19	1.4	.31	.17	.042	42	41	1.8	7.0
7	1.20	.10	.19	1.5	.37	.18	.057	53	60	2.1	7.1

Table 7. Corn Leaf Tissue Concentration at Silking, Staples 1988

No.	N	S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%							ppm			
1	2.8	.23	.25	2.6	.66	.20	.10	89	71	4.7	6.5
2	2.8	.24	.27	2.6	.65	.22	.09	82	61	4.8	7.2
4	2.9	.24	.26	2.5	.67	.22	.10	84	59	4.6	6.0
7	2.9	.23	.25	2.6	.68	.22	.11	101	99	4.3	4.9

Table 8. Chemical Analysis of Corn Grain, Staples 1988

No.	N	S	P	K	Mg	Fe	Mn	Zn	Cu	B	Ca
	%					ppm					
1	1.68	.11	.31	.40	.13	30	5.6	33	1.5	3.8	32
2	1.62	.12	.30	.26	.12	23	5.6	28	1.5	3.2	30
4	1.67	.11	.30	.40	.13	29	5.3	32	1.5	3.6	31
7	1.65	.12	.30	.39	.13	35	4.9	37	1.6	3.5	31

Table 9. Soybean Whole Plant Concentration, Staples 1988

No.	N	S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%						ppm				
3	3.2	.22	.39	2.7	1.0	.38	.057	82	32	3.0	33
5	3.2	.22	.39	2.7	1.0	.39	.055	90	31	3.2	35
6	3.3	.22	.39	2.6	1.1	.37	.065	83	40	3.0	34

Table 10. Soybean Whole Plant Uptake, Staples 1988

No.	N	S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	Lbs/A										
3	176	12	22	149	56	21	3.1	.46	.18	.017	.18
5	168	12	20	142	52	21	3.0	.48	.16	.017	.18
7	196	13	23	153	67	22	3.9	.50	.24	.018	.20

Table 11. Concentration of Nutrients in Soybean Grain, Staples 1988

No.	N	S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%						ppm				
3	6.6	.37	.74	2.3	.18	.27	99	33	62	5.8	3.4
5	6.7	.37	.72	2.2	.17	.27	116	34	58	7.0	3.7
7	6.7	.38	.74	2.3	.17	.27	109	33	64	6.3	3.6

Table 12. Soybean Grain Nutrient Uptake, Staples 1988

No.	N	S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	Lbs/A										
3	147	8.3	16	51	3.9	6.0	.22	.07	.14	.013	.077
5	164	9.2	18	55	4.3	6.5	.28	.08	.14	.017	.090
7	152	8.5	17	51	3.8	6.1	.25	.07	.14	.014	.083

Table 13. Soybean Trifoliate Leaf Analysis (early pod set), Staples 1988

No.	N	S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%						ppm				
3	4.8	.36	.53	2.7	.92	.44	.034	110	59	3.5	41
5	4.8	.36	.53	2.7	.94	.44	.034	127	56	3.1	43
6	5.0	.36	.55	2.6	.89	.43	.031	110	53	3.5	41

LUPIN BEAN FERTILITY STUDY

H. Meredith, Mel Wiens, Greg Cremers, and Andy Scobbie[1/]

ABSTRACT: The revival of an old legume specie (Lupinis albus) dating to biblical times kindled a need for an understanding of the nutritional requirements of this plant. This plant has a built-in "survival" system, which enables it to alter the rhizosphere and solubilize needed nutrients. A study was undertaken to determine if the lupin plant would respond to nutrient addition when managed for high yield levels. A study was initiated in 1984 which included five elements most limiting for production of agricultural legumes on the irrigated sands in central Minnesota.

In 1988, two sites were planted to lupins (Lupinus albus) and fertilized with sulfur (100 lbs. S/A) phosphorus (60 lbs. P_2O_5/A), potassium (300 lbs K_2O/A), zinc (10 lbs Zn/A) and boron (2 lbs B/A). One site is a continuous fertilized site since initiation of the studies in 1984. The second site had not been seeded to lupins previously.

Table 1. Summary of Lupin Yields 1984 to date. Staples Station, Staples, MN. Yields are based on 13.5 percent moisture and 60 pound bushel weight.

		Yield bu/A							
No.	Treatment	1984	1985	1986		1987		1988	
1	No fertilizer	39.1	71.4	40.6[1/]	32.0[2/]	57.2[1/]	61.8[2/]	47.6[1/]	61.9
2	Sulfur	43.2	71.2	44.0	31.7	54.2	62.8	58.7	67.2
3	Potassium + S	40.5	63.8	40.6	43.3	49.9	61.9	50.9	61.1
4	Phosphorus + S+K	39.4	68.8	39.2	40.2	56.6	61.8	42.3	57.2
5	Zinc + S+K+P	39.4	64.1	41.8	37.4	47.2	56.3	42.8	58.0
6	Boron + Zn+S+K+P	41.5	64.9	33.8	32.8	54.8	60.8	52.0	52.3

1/ Old Fertility Site
2/ New Fertility Site

Because of the variability of yield within treatments, no significant differences in yield due to fertility treatments exist. The yield from the sulfur amended plots was highest in 1988 but upon application of statistical analysis, no significant differences were noted. the population was variable and weeds were a compounding factor.

Table 2. Nutrient Content of Lupin Beans, Staples 1988, Continuous Lupins

Treatment	N	S	P	K	Ca	Mg	Mn	Zn	Cu	B	Fe
No.	%							ppm			
1	6.2	.27	.43	1.1	.26	.20	.069	45	3.5	14	28
2	6.4	.29	.42	1.2	.26	.20	.067	45	3.5	15	28
3	6.3	.28	.43	1.2	.26	.20	.067	46	3.6	13	27
4	6.0	.28	.42	1.2	.27	.20	.061	41	2.7	13	26
5	6.1	.28	.48	1.4	.26	.22	.060	52	2.6	12	28
6	6.0	.29	.44	1.3	.26	.21	.062	53	2.9	26	27

1/ Regional Director, Tennessee Valley Authority, Research Plot Coordinator, Staples Irrigation Center, Asst. Scientist, Jr. Scientist, University of Minnesota, respectively.

Table 3. Nutrient Content of Lupin Beans, Staples 1988, first year lupin fertility

No.	N	S	P	K	Ca	Mg	Mn	Zn	Cu	B	Fe
	- - - - - -	- - -	- - -	%	- - -	- - -	- - -	- - -	- - ppm	- - -	- - -
1	5.6	.28	.49	1.2	.25	.20	.097	57	4.2	19	38
2	5.6	.28	.53	1.3	.26	.20	.094	60	4.1	19	34
3	5.4	.29	.56	1.4	.26	.20	.118	62	4.1	18	40
4	5.5	.28	.58	1.4	.27	.20	.105	59	4.1	18	36
5	5.5	.28	.58	1.4	.26	.20	.099	62	3.8	18	34
6	5.4	.30	.58	1.4	.27	.20	.102	60	3.4	26	35

LUPIN LIME, GYPSUM, AND SULFUR AMENDED STUDIES

H. Meredith, Mel Wiens Greg Cremers, and Andy Scobbie[1/]

ABSTRACT: Ground agricultural limestone, gypsum, and elemental sulfur were applied at various rates to determine if a change in soil pH would effect performance and uptake of nutrients for lupins.

Elemental sulfur, ground limestone, and gypsum were applied at various rates prior to planting of lupins to evaluate effect of soluble salts and soil pH on growth and uptake of selected nutrients.

Table 1. Nutrient Concentration of Lupin Beans Grown in Lime Amended Soils, Staples 1988.

Lime	N	S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
Lbs/A											
0	6.2	.26	.42	1.2	.26	.21	26	1/	44	6.9	17
500	6.2	.26	.43	1.2	.26	.22	26	1/	43	1/	17
1000	6.0	.26	.42	1.2	.27	.21	26	1/	44	5.6	18
2000	6.2	.27	.42	1.2	.27	.21	28	1/	44	7.7	17

1/ Data unreliable

Table 2. Nutrient Concentration of Lupin Beans Grown on Gypsum Amended Soils, Staples 1988.

Gypsum	N	S	P	K	Ca	Mg	Mn	Fe	Zn	Cu	B
Lbs/A	%							ppm			
0	6.0	.31	.41	1.1	.25	.20	.09	29	50	3.7	18
500	6.1	.34	.40	1.2	.27	.19	.10	29	50	3.8	18
1000	6.1	.36	.38	1.1	.27	.19	.10	29	50	3.8	17
2000	6.1	.26	.38	1.2	.27	.18	.10	28	51	3.6	18

Table 3. Nutrient Concentration of Lupin Beans Grown on Elemental Sulfur Amended Soil, Staples 1988.

Sulfur	N	S	P	K	Ca	Mg	Mn	Fe	Zn	Cu	B
Lbs/A	%							ppm			
0	6.0	.30	.44	1.2	.26	.20	.11	31	52	6.8	19
500	6.2	.31	.43	1.2	.26	.20	.11	28	52	4.4	20
1000	6.1	.33	.43	1.2	.27	.20	.12	29	53	7.8	19
2000	6.0	.32	.42	1.2	.27	.20	.11	29	54	4.7	20

1/ Regional Director, Tennessee Valley Authority, Research Plot Coordinator, Staples Irrigation Center, Assist. Scientist, Jr. Scientist, University of Minnesota, respectively.

Table 4. Yield and Test Weight of Lupins Grown on Lime, Gypsum and Sulfur Amended Soils, Staples 1988.

	Lime Amended		Gypsum Amended		Sulfur Amended	
Treatment	Yield Bu/A	Test wt lbs/bu	Yield Bu/A	Test wt lbs/bu	Yield Bu/A	Test wt lbs/bu
0	47.3	64.9	45.0	64.5	56.1	65.0
500	52.6	64.6	44.3	63.9	56.9	65.0
1000	57.3	64.7	38.9	64.2	52.5	64.7
2000	50.6	64.8	40.4	63.9	58.3	64.8

There were no significant differences in concentration of nutrients in the beans or in yield due to any of the amendments. There appeared to be an increase in sulfur in the beans with the gypsum and sulfur treatments.

ANALYSES OF LUPIN HULLS, DEHULLED, AND WHOLE LUPINS

H. L. Meredith[1/]

ABSTRACT: Lupins are a high protein supplement used in ruminant, swine, poultry, and human diets. The high fiber containing hull of the lupin finds use in baking flour. The dehulled lupin is higher in protein and lower in fiber than the whole lupin.

Three lupin samples - whole lupins, the hulls of lupins, and the dehulled lupins were analyzed for chemical constituents to better understand the chemical nature and the nutrient value of the hull vs. the dehulled cotyledon portion of the seed.

Table 1. Analyses of Whole Lupins, Lupin Hulls, and Dehulled Lupin Cotyledon.

Seed Part	N	S	P	K	Ca	Mg	Mn	Fe	Zn	Cu	B	Al	Na
	%							ppm					
Hulls	0.75	.038	.04	.52	.79	.07	.026	26	7.2	3.3	14	5.6	50
Dehulled	6.14	.333	.55	.14	.16	.20	.254	31	60	7.9	23	1.6	79
Whole seed	5.68	.315	.55	.14	.22	.19	.186	39	72	8.2	22	2.0	71

The hull is low in protein (less than 5%), lower in sulfur, phosphorus, magnesium, manganese, iron, zinc, copper, boron, and sodium. The hulls are higher in potassium, calcium, and aluminum.

1/ Regional Director, Tennessee Valley Authority

TRITICALE - RYE STUDIES

H. Meredith and Mel Wiens[1/]

ABSTRACT: When the Latin terms for wheat and rye - Triticum and Secale-are combined, the term Triticale results. Triticale is a product of the selection of the desirable characteristics of wheat and rye into one species. Triticales are largely self fertilized and breed true from one generation to the next. As new triticale varieties are being developed, the yield potantial under irrigation was evaluated.

Winter triticale and rye plots were fertilized to attain high yields under irrigation. High temperatures took their toll on the crop and yields were lowered.

Table 1. Yield of Rye and Triticale, Staples 1988

No.	Variety	Crop	Yield	Test Wt.	Straw Yield
			bu/A	lbs/bu	tons/A
1	Ind 6-6-2	Triticale	34.9	51.9	1.79
2	Ind 5-3-3	"	31.6	50.2	2.00
3	Mitzi Rye	Rye	55.3	60.2	2.04
4	Iowa 2-19-4	Triticale	35.9	56.1	1.68
6	Rymin	Rye	61.1	61.0	2.09
7	Ind 3-2-2	Triticale	40.1	54.7	2.06
8	Ind 2-2-4	"	45.9	55.0	2.00

1/ Regional Director, Tennessee Valley Authority, Research Plot Coordinator, Staples Irrigation Center, University of Minnesota, respectively.

WATER QUALITY STUDIES

H. Meredith and Mel Wiens[1/]

ABSTRACT: The Staples Station irrigation pumps lift water from an aquifer about 15 feet below the surface. The sand plain composed of coarse materials permits excessive internal drainage of the soil profile. Leaching of soluble nutrients occurs in the presence of excessive water. Water samples from pumping wells lends a tool to monitor the nutrient status of these wells.

Table 1. Nutrients in Irrigation Water, Staples 1988

Date	Location	NO^3	SO^4	P	K	Ca	Mg	Na	Zn	Cu	B	Mn
		ppm										
7/21	Well Farm Shop	0.43	33.5	T	.9	81	24	3.3	.03	T	T	T
7/21	2 Tower	9.5	27.0	T	2.1	85	26	3.4	T	T	T	T
7/21	Well B	5.1	6.0	T	1.0	95	25	2.1	T	T	T	.5
7/9	SW Lagoon	1.4	8.7	T	2.5	54	15	1.9	T	T	T	T
7/21	2 Tower	8.1	34.4	T	T	94	25	2.6	T	T	T	T
7/21	Single Tower	7.3	32.1	T	13.1	83	25	3.4	T	T	.02	.7
7/1	Well B	6.1	5.7	T	1.0	93	25	2.1	T	T	T	.02
7/7	SW Pit	1.5	5.6	T	1.8	53	15	1.9	T	T	T	T
6/24	2 Tower	9.8	33.3	T	2.3	89	24	2.6	T	T	T	.4
7/21	Well C	4.1	5.2	T	T	86	24	2.0	T	T	T	.5
7/21	Well D	3.4	6.7	T	.9	78	21	2.0	T	T	T	.3
7/21	Well A	11.0	12.4	T	1.1	92	25	2.6	T	T	T	T
6/24	Well D	3.7	7.1	T	1.3	79	22	1.8	.17	.31	T	.4

Table 2. Nutrients in irrigation water expressed in pounds per acre and on 12 inches of irrigation water, Staples 1988.

Location	NO_3-N	SO_4-S	$CaCO_3$ Equivalent
	Pounds/A		
Well Farm Shop	.2	30	593
2 Tower	5.6	24	582
Well B	3.2	5.4	667
SW Lagoon	.8	7.9	504
2 Tower	4.9	31.2	646
Single Tower	4.3	28.8	672
Well B	3.8	5.2	770
SW Pit	.8	5.2	478
2 Tower	26.4	30	616
Well C	11.0	4.6	743
Well D	9.2	6.0	667
Well A	30	11.2	672
Well D	10.0	6.5	689

1/ Regional Director, Tennessee Valley Authority, Research Plot Coordinator, Staples Irrigation Center, University of Minnesota, respectively.

SOUTHERN EXPERIMENT STATION
WASECA, MINNESOTA

WEATHER DATA - 1988

Month	Period	Precipitation 1988	Precipitation Normal 1/	Avg. Air Temp. 1988	Avg. Air Temp. Normal 1/	Growing Degree Days 1988	Growing Degree Days Normal 1/
		---- inches ----		------ °F -----			
January	1-31	2.44	0.84	7.0	10.0		
February	1-29	0.36	0.99	10.9	16.4		
March	1-31	1.34	1.99	33.0	27.6		
April	1-30	2.43	2.64	44.6	44.7		
May	1-10	1.62		62.6		138.0	
	11-20	.10		61.1		130.5	
	21-31	.27		70.9		211.5	
	Total	1.99	3.76	64.8	57.7	480.0	334
June	1-10	0.00		72.2		220.0	
	11-20	0.63		74.3		224.5	
	20-30	0.70		75.1		223.5	
	Total	1.35	4.48	73.9	67.1	668.0	518
July	1-10	0.23		74.8		230.0	
	11-20	0.19		74.3		225.5	
	21-31	0.19		74.5		261.5	
	Total	0.61	4.02	74.5	71.2	717.0	641
August	1-10	3.44		77.2		243.5	
	11-20	0.27		78.2		259.0	
	21-31	0.61		64.0		168.5	
	Total	4.32	3.99	73.1	68.8	671.0	579
September	1-30	5.34	3.36	62.1	59.8	412.5	311
October	1-31	0.32	2.08	43.0	48.9	18.5	38
November	1-30	3.98	1.43	32.4	32.5		
December	1-31	0.74	1.02	18.9	18.0		
Year	Jan-Dec	25.22	30.60	45.0	43.6	2970.0 2/	2421
Growing Season	May-Sep	13.61	19.61	69.7	64.9	2948.5	2383

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

Notes:
1) Highest temperature on August 1 -- 103°.
2) Highest 24-hour precipitation on August 3 -- 1.81".
3) Last spring frost -- April 28.
4) First fall frost -- October 3.
5) Warmest growing season in 74 years of records.
6) Driest year since 1976.
7) Driest May-July period in 74 years of records.

NITRATE LOSSES TO TILE DRAINAGE AS AFFECTED BY NITROGEN FERTILIZATION OF CORN IN A CORN-SOYBEAN ROTATION[1/]

Waseca, 1988

Gyles W. Randall, Gary L. Malzer and Brian W. Anderson[2/]

ABSTRACT: A study to determine the influence of time of N application and N-Serve on the uptake of N by corn and the loss of NO_3 to tile drainage was continued in 1988. Results from this second year were greatly affected by the hot and dry stress conditions. Yields were not consistently affected by N nor its time of application. Nitrogen efficiency was extremely poor. The majority of N uptake occurred prior to silking for all treatments. Tile lines flowed sporadically in late April and early May and averaged less than 1 acre-inch discharge. Even though NO_3-N concentrations averaged about 18 mg/L, NO_3-N losses were very low. Apparently soil mineralization was abundant because residual NO_3 remaining in the soil profile at the end of the season was quite high even when no N had been applied to corn. Accumulation of NO_3 in the top 2' was substantial (200 to 230 lb/A) where N had been applied as a split application.

Nitrogen (N) losses to tile drainage water have been directly linked to N additions, crop grown, and soil organic matter level. Research has been conducted on NO_3 losses to tile water in Minnesota since 1972. This research has focused primarily on the effects of rates and timing of fertilizer N application and tillage in a continuous corn system. The purpose of this study is to determine the influence of time of N application and the use of a nitrification inhibitor on NO_3 movement and accumulation in the soil, NO_3 losses via tile drainage, and yield and N uptake by corn grown in a rotation with soybeans.

EXPERIMENTAL PROCEDURES

Thirty-six individual tile line plots were installed on a poorly drained Webster clay loam at the Southern Experiment Station in 1976. Each 20 x 30' plot is completely surrounded by plastic sheeting to a depth of 6' to prevent lateral flow and contains a tile line (4' deep) 5 feet from one end. All tiles drain to collection pits where flow rates can be measured and water samples collected for analyses. After completing a research project in 1983 using this tile facility, the plots were cropped to corn with a blanket N rate in 1984 and 1985 to establish uniformity.

Beginning in 1986 corn was planted on one-half of the experimental site while soybeans were planted on the other half. Thirty two plots (16 with corn and 16 with soybeans) with the most uniform drainage were selected from the 36 for the primary study. The experimental design consists of a 4 x 4 Latin square where the rows and columns were based on the previous (1977-83) tile flow rates from each plot. The four basic N treatments (see Table 1) are applied to the corn phase each year with the residual effects measured in the soybean phase. Three additional N treatments were replicated four times around the edge of the core 16-tile-plot area and were planted to corn. These three treatments were analyzed along with the other four as a completely randomized design.

Anhydrous ammonia was applied at a rate of 135 lb/A for all N treatments while N-Serve was applied at 0.5 lb/A. Fall treatments were applied on October 21. Average soil temperature at the 4" depth on that date was 43°F with an average of 43°F over the following 10-day period. Spring preplant treatments were applied on April 18. The sidedress portion (60%) of the split treatments was applied at the V-7 stage on June 15.

No primary or secondary tillage was done on the soybean area that was planted to corn in 1988. The corn area, however, was fall chiseled and spring disked once prior to planting soybeans. Surface residue accumulation estimated by the line-transect method on June 2 showed an average of 18 and 30% for the areas that were planted to corn and soybeans, respectively, in 1987. Because of high soil P and K tests, no broadcast nor starter fertilizer was used.

1/ Partial funding provided by Dow Chemical U.S.A., Center for Agricultural Impacts on Water Quality, and Minnesota Agric. Exp. Stn.

2/ Professor, So. Exp. Stn.; Assoc. Prof. Dept. of Soil Science; Assistant Scientist, So. Exp. Stn., Waseca.

Corn (Pioneer 3737) was planted at 30,800 plants/acre on May 6 with a JD Max-Emerge planter equipped with waffle coulters. A corn rootworm insecticide was not used. Weeds were chemically controlled with a preemergence application of Lasso (3.5 lb/A) plus Bladex (3 lb/A).

Soybeans (Hardin) were planted in 13" rows at 3-4 beans per foot of row on May 19. Weeds were chemically controlled with a preemergence application of Lasso (3½ lb/A) plus Amiben (3 lb/A). Pursuit (imazethapyr) was applied on June 7 at 0.06 lb/A plus 0.25% v/v X-77 to plots 1, 5, 6, 11, 12, 13, 15 & 16 to determine if it could be found in tile drainage water.

Two plots within each of the corn and soybean areas were not planted and were fallowed all summer. These four fallow plot areas were located on those tile plots that showed greatest water flow variability (1977-83). The purposes of these plots were to simply check the NO_3-N concentrations in the tile water in a fallow system and to utilize all 36 of the tiled plots, even though these four historically showed the highest flow variability.

Stand counts were taken at the V-7 stage and plots were thinned to a uniform population. Eight randomly selected plants were removed from the center rows at silk initiation (July 19) and were chopped, dried, weighed and ground for total dry matter accumulation and analyzed for total N concentration. Stover and grain samples were taken at physiological maturity by hand harvesting 30' of row for stover yields and 60' of row for grain yields and moisture. Chemical analyses of whole plant, stover and grain samples were performed by the Research Analytical Laboratory, University of Minnesota.

Tile line flow rates were determined daily and were recorded when flow exceeded 10 ml/minute (0.01"/day). Samples were collected for NO_3-N analysis on an every-other-day basis. Periodic samples were collected for alachlor (Lasso) and cyanazine (Bladex) analyses.

Soil samples for NO_3-N analysis were taken in 1-foot increments to a depth of 8 feet from the fallow plots and selected corn and soybean plots on April 19. The same technique was used to sample all fallow and corn plots and selected soybean plots after harvest on October 14.

RESULTS AND DISCUSSION

Plant

Whole plant N concentration at the silking stage was greatly increased over the check by all of the N treatments with little difference among the six N treatments (Table 1). Dry matter accumulation at this stage was unaffected by N treatment. Stover N concentration at physiological maturity (PM) was increased consistently over the check by all N treatments. Stover yield at PM was higher for the three additional N treatments (even the control) than for the four primary N treatments. This unexpected result was noticed for all yield parameters at PM. It was probably due to "over" drainage in the small plots with the 25' tile spacing compared to the border plots without the close spacing in this very dry year. This phenomenon had never been encountered in 11 previous years of experiments at this tile drainage site. Final population was not significantly different among the N treatments.

Table 1. Influence of time of N application and N-Serve on whole plant N, stover yield, and final population of corn following soybeans.

N application		Whole Plant Silk Stage		Stover		
Time	N-Serve	N	DM	N	Yield	Final Population
		%	g/plt	%	TDM/A	ppA x 10^3
Primary trts						
Fall (Oct.)	No	1.44	102	.69	1.74	29.1
Fall (Oct.)	Yes	1.48	102	.67	1.65	29.2
Spr. (April)	No	1.47	96	.72	1.63	29.7
Split[1/]	No	1.41	96	.67	1.52	28.8
Additional trts						
Check	-	1.20	92	.53	1.74	29.2
Spr. (April)	Yes	1.54	103	.71	2.07	29.7
Split[1/]	Yes	1.43	97	.68	1.93	30.0
Statistical Analysis						
Latin square (Primary Trts)						
Signif. Level (%):		50	58	18	58	23
CV (%) :		4.8	7.6	11.	10.	4.1
Completely randomized (7 trts)						
Signif. Level (%):		99	83	94	99	31
BLSD (.05) :		.07	-	-	.30	-
CV (%) :		3.8	6.7	12.	11.	3.5

[1/] 40% preplant + 60% sidedress.

Grain yields in general were low but were also lower for all primary N treatments located in the Latin square design compared to the additional N treatments along the border (Table 2). Significant differences in yield were not found among the four primary N treatments due to the high CV (15%). Although grain moisture tended to be higher in the additional N treatments, differences were not significant due to the high variability. Grain N concentration was improved significantly over the 0-lb N control by all N treatments. In the primary study, grain N was significantly higher for the fall treatment without N-Serve than the split treatment. Grain N removal (product of grain yield times N concentration), silage DM yield, and total N uptake in the silage were not different among the four primary N treatments but were lower for these four treatments than for the border plots when N was applied.

Total N removal in the grain ranged from 66.9 to 92.6 lb/A for the six N treatments (Table 2). Based on these removal amounts, N efficiency (N removed by a treatment - N removed in the check + 135 lb N/A) ranged from 1 to 16% for the four primary treatments up to a maximum of 39% with the spring preplant application with N-Serve. Nitrogen efficiency based on the total plant uptake ranged from 6 to 16% for the four primary treatments up to a high of 43% with the spring preplant application with N-Serve. These efficiency values are very low and reflect the stress conditions during the 1988 growing season.

Total N uptake by the plants prior to silking (Fodder N yield at silking) divided by total N uptake at PM shows that from 79 to 102% of the N was accumulated by the plants prior to silking (Table 3). The lowest amounts of pre-silk N accumulation were found on the additional border plots. In general, split application of N reduced pre-silk N uptake slightly. NEW N in the grain (assumed to be taken up by the plant after silking and translocated to the grain) ranged from -3 to 23%. Under these conditions fall applications of N with or without N-Serve and spring application without N-Serve resulted in almost no post-silk N uptake into the grain. However, post silk N uptake into the grain ranged from 11 to 23% with the split applications.

Table 2. Corn grain and silage production as influenced by time of N application and N-Serve.

N application		Grain					Total N
Time	N-Serve	Yield	H_2O	N	N removal	Silage	uptake
		bu/A	%	%	lb/A	TDM/A	lb/A
Primary trts							
Fall (Oct.)	No	90.9	15.4	1.66	71.4	4.42	95.4
Fall (Oct.)	Yes	101.4	15.8	1.60	76.8	4.65	98.8
Spr. (April)	No	87.6	15.6	1.62	66.9	4.26	90.2
Split[1/]	No	99.6	15.7	1.55	73.2	4.53	93.8
Additional trts							
Check	-	102.4	17.7	1.37	66.4	4.76	85.2
Spr. (April)	Yes	121.4	17.2	1.62	92.6	5.74	122.1
Split[1/]	Yes	123.4	18.5	1.52	89.0	5.57	115.5
Statistical Analysis							
Latin square (Primary trts)							
Signif. Level (%):		84	1	99	59	72	23
BLSD (.05) :		-	-	0.03	-	-	-
CV (%) :		8.9	12.	1.2	11.	5.8	12.
Completely randomized (7 trts)							
Signif. Level (%):		97	66	99	97	99	98
BLSD (.05) :		26.2	-	0.07	20.0	0.63	24.7
CV (%) :		15.	13.	3.2	16.	8.8	15.

1/ 40% preplant + 60% sidedress.

Table 3. Influence of time of N application and N-Serve on time of N uptake.

N application		Fodder N Yield at[1/]		Grain N Yield at PM			
Time	N-Serve	Silk	PM	Total	OLD[2/]	NEW[3/]	NEW[3/]
		lb N/A					%
Primary trts							
Fall (Oct)	No	94.8	24.1	71.3	70.7	.6	1
Fall (Oct)	Yes	97.9	21.9	76.8	76.0	.8	1
Spr (April)	No	92.3	23.3	67.0	69.0	-2.0	-3
Split[4/]	No	85.6	20.6	73.2	65.0	8.2	11
Additional trts							
Check	-	71.3	18.7	66.5	52.6	13.9	19
Spr (April)	Yes	103.5	29.4	92.6	74.0	18.6	17
Split[4/]	Yes	91.7	26.4	89.0	65.3	23.7	23
Statistical Analysis							
Latin square (Primary trts)							
Signif. Level (%):		46	36	59	56	76	77
CV (%) :		13.	18.	11.	13.	318.	332.
Completely randomized (7 trts)							
Signif. Level (%):		99	98	97	99	94	93
BLSD (.05) :		11.8	6.3	20.0	10.2	-	-
CV (%) :		8.9	16.	16.	10.	137.	135.

1/ Silk = silk stage, PM = physiological maturity.
2/ OLD N = N in stover at silk - N in stover at PM; the difference is assumed to be translocated to the grain.
3/ NEW N = Total N in grain - Old N; the difference is assumed to be absorbed from the soil and/or translocated from the roots after silking.
4/ 40% preplant + 60% sidedress.

Water

April through July conditions were extremely hot and dry and resulted in rapid early season growth with subsequent stunting due to low soil water levels. Because precipitation for April through May totaled only 4.42" (69% of the normal 6.40"), tile lines flowed only sporadically from April 28 thru May 20. Drainage ranged from 0.38 to 1.10 acre inches in the plots planted to corn (Table 4).

Table 4. Influence of N application time and N-Serve on NO_3-N concentration and N loss to tile lines in 1988.

N Application		Tile Flow 1/	NO_3-N	
Time	N-Serve		Concentration	Loss
		acre-inches	mg/L	lb N/A
Fall	No	0.62	18.0	2.54
Fall	Yes	1.10	16.1	4.01
Preplant	No	0.87	22.3	4.40
Split	No	0.38	15.5	1.33
None (Fallow) 2/	-	0.62	19.4	2.71

1/ Tile flow occurred August 28 to May 20.
2/ Average of 4 replications.

Flow-weighted NO_3-N concentrations averaged from 15.5 to 22.3 mg/L. Perhaps these high values were partially due to the soybeans in 1987 and the high rate of N (260 lb N/A) applied for the 1986 corn crop. Nitrate-N losses via the drainage water ranged from 1.3 to 4.4 lb/A in 1988 and were highly dependent on volume of drainage water.

Soil

Nitrate-N remaining in the 0-8' soil profile in mid-April was very high in the fallow plots (207 lb/A) compared to those where either soybeans or corn were grown in 1987 (Table 5). Soybeans that had not received fall-applied N averaged 109 lb/A with 76 lb/A remaining in the top 5'. Little residual NO_3-N remained in the 0-8' profile when corn was the previous crop, especially when no N was applied (49 lb/A). Differences among the fall, preplant and split applications were small. Distribution of NO_3 within the profile was consistently high to 6' with the fallow system, high in the surface 1-foot and uniformly medium to high to 7' with soybeans, and generally high in the surface 1-foot, medium to high in the 1 to 2' zone, and low below 2' for corn.

Table 5. Nitrate-N in the soil profile in April, 1988 as influenced by previous crop and N treatment for corn in 1987.

Profile depth	1987 Crop					
			Corn			
	Fallow	Soybean	0 lb N	Fall	Preplant	Split
feet	lb/A 1/					
0-1	36.4	23.0	20.4	22.0	27.8	23.8
1-2	34.2	13.4	4.8	13.0	16.3	12.2
2-3	35.6	10.5	1.4	5.6	13.4	7.0
3-4	34.3	10.7	1.8	4.7	7.1	6.0
4-5	23.4	18.1	3.6	4.4	5.6	5.1
5-6	19.3	14.7	5.0	4.8	5.0	5.1
6-7	12.0	10.0	6.1	4.9	4.8	5.1
7-8	11.7	8.4	5.6	5.4	4.6	5.1
Total in						
0-5' profile	163.9	75.7	32.0	49.7	70.2	54.1
0-8' profile	206.9	108.8	48.7	64.8	84.6	69.4

1/ Average of 4 replications

Residual NO_3-N remaining in the 0-8' profile after the 1988 crop was considerably higher in the fallow plots (447 lb/A) and the soybean area planted to corn without N (224 lb N/A) than in April (Table 6). This was due to high mineralization activity during the 1988 growing season. Residual NO_3 remaining in the fertilized corn plots was also quite high and reflects the low crop demand. Differences among the N treatments were not substantial; however, consistently higher levels were found with the N-Serve treatments.

Table 6. Residual NO_3-N remaining in the 0-8' soil profile after harvest as influenced by time of N application and N-Serve.

Profile depth	Fallow	Check	Application Time: N-Serve Fall	N-Serve Preplant	N-Serve Split	No N-Serve Fall	No N-Serve Preplant	No N-Serve Split
ft.	lbs NO_3-N/A[1/]							
0-1	85.3	45.1	75.8	67.9	138.7	56.9	69.4	93.9
1-2	84.7	26.0	59.1	60.7	95.0	57.1	93.3	108.9
2-3	63.9	20.0	40.9	34.5	29.3	42.7	37.9	40.9
3-4	57.9	24.0	28.1	24.6	23.1	36.4	31.7	29.2
4-5	56.4	24.3	37.7	25.6	27.4	38.1	33.4	28.4
5-6	43.0	29.4	33.9	25.7	25.2	30.9	30.0	30.3
6-7	29.5	28.7	26.5	23.0	25.6	33.9	27.4	26.7
7-8	26.6	26.7	24.2	19.7	20.6	32.6	28.4	24.9
Total in								
0-5' profile	348	139	242	301	314	231	266	213
0-8' profile	447	224	326	282	385	329	352	383

1/ Avg. of 4 replications

CONCLUSIONS

The hot and dry conditions resulted in low and highly variable corn yields, poor N efficiency, and low drainage volume and accompanying NO_3-N losses. Nitrate N concentrations in the tile water averaged about 18 mg/L. Mineralization of soil organic matter is thought to have caused substantial increases in soil NO_3-N in the 0-8' profile between April and October even when corn received no N fertilizer. As of mid-October high levels of residual NO_3 remained in the upper two feet of the profile in all corn plots except the 0-lb N rate.

NITROGEN LOSS TO TILE LINES AS AFFECTED BY TILLAGE[1/]

Waseca, 1988

G. W. Randall and B. W. Anderson[2/]

ABSTRACT: No tillage (NT) is thought to increase infiltration and, therefore, should increase the amount of water percolating through the soil compared to conventional tillage. This long-term study is being conducted to determine if greater amounts of NO_3-N and pesticides are being lost to tile drainage water with NT compared to moldboard plow (MP) tillage. Rainfall during 1988 was 5.4" below normal and tile flow was limited. Although NO_3-N losses were similar for the two tillage systems, NO_3-N concentrations were markedly higher with MP tillage -- the first time in seven years. Corn yields and N uptake were consistently higher with MP but due to high variability these differences were often not significant at the P = 90% level. Substantially higher amounts of NO_3 remained in the 8-foot soil profile in October with the MP system compared to NT.

Nitrogen losses to tile lines have been documented in a number of research studies including some conducted at Lamberton and Waseca, Minnesota. These studies primarily showed that N losses were a function of the N application rate and amount of precipitation. To some degree the time of application and crop grown have been shown to influence NO_3-N loss to tile lines. The purpose of this long-term study is to determine if tillage has an effect on N utilization, accumulation of NO_3-N in the soil profile, and the subsequent loss of NO_3-N to tile lines.

EXPERIMENTAL PROCEDURES

A study was initiated in 1975 on a Webster clay loam at Waseca to monitor the movement of N into a tile line installed in each of 12 plots measuring 45' by 50'. Each plot is enclosed with plastic sheeting to a 6' depth. Annual N rates of 0, 100, 200, and 300 lb N/A were applied from 1975-1979. No N was applied for the 1980 and 1981 crops. Residual N from N applied over the 5-year period (75-79) was utilized by the 1980 and 1981 corn crops. Soil samples to 10' and tile water samples taken in late 1981 showed little remaining evidence of the previous treatments.

In the fall of 1981, eight plots with the most uniform tile flow rates over the 1975-81 period were selected. Two tillage treatments (fall moldboard plow and no tillage) were replicated four times and randomized over the previous plot histories. Corn was grown on these plots in 1982 through 1987. The stalks were chopped in October, 1987 and moldboard plots plowed.

On April 18, 180 lb N/A as ammonium nitrate was broadcast applied to the surface of all plots. The moldboard treatment was then field cultivated. Corn (Pioneer 3732) was planted on May 6 at a population of 27700 plants/A with a John Deere Max-Emerge planter equipped with ripple coulters. Starter fertilizer was not used because of the high soil tests. Counter was applied at 1 lb (ai)/A to control rootworms. Weeds were controlled with a preemergence application of Lasso (3½ lb/A) and atrazine (3 lb/A) applied May 13. Weed and insect control were excellent. Percent surface residue was measured on April 8 and averaged 6 and 97% for the MP and NT systems, respectively.

The leaf opposite and below the ear was taken from 10 randomly selected plants per plot at silking (MP = July 14 and NT = July 21) and was analyzed for N. Silage and grain yields were taken at physiological maturity by hand harvesting 40' and 80' of row, respectively, from each plot.

Tile lines flowed from only April 27 to May 26. When tile lines were flowing, flow rates were measured daily and samples taken on a daily basis for the first week and then on a M-W-F basis thereafter for NO_3 analysis. All analyses were done by the Research Analytical Lab.

Soil NO_3-N in the 0-8' profile was determined from two cores/plot taken in 1-foot increments on October 14, 1988.

1/ Funding provided by the North Central Regional Research Committee (NC-98) and the Southern Experiment Station.

2/ Professor and Asst. Scientist, Southern Experiment Station, Univ. of Minnesota.

RESULTS

Although yields and N removal tended to be consistently higher with the moldboard plow (MP) system compared to the no tillage (NT) system, differences between the two tillage systems were not significant at the P = 90% level (Table 1). Total N uptake in the silage was significantly increased 93% level) by the MP tillage system. This was due to the high variability caused by the moisture and heat stress conditions during June, July and early August. Leaf N was increased significantly by the MP tillage system, but grain N concentration was not affected by tillage.

Table 1. Influence of tillage system on corn production and N utilization at Waseca in 1988.

Tillage system	Final population	Leaf N	Silage Yield	Silage N uptake	Grain Yield	Grain N	Grain N removal
	x10	%	T DM/A	lb N/A	bu/A	%	lb N/A
Moldboard Plow	24.8	2.58	3.79	102.1	100.6	1.67	78.9
No Tillage	24.4	2.28	3.26	87.5	83.3	1.64	64.7
Signif. Level (%):1/	33	98	79	93	75	45	86
CV (%) :	5.8	4.3	13.	7.8	19.	4.2	14.

1/ Probability level of significance.

Precipitation during the growing season was 6.0" below normal. Thus, tile flow was confined from late-April into late-May. Tile flow was slightly higher for the NT system; however, NO_3-N concentrations were markedly higher with the MP system. Nitrate losses to the drainage water were similar for the two systems. Soil moisture samples taken July 21 showed 1.76 and 3.26" of available water in the 5-foot profile for the MP and NT systems, respectively. This is probably the reason corn fared better on the NT plots than on the MP plots in late July and August.

Table 2. Influence of tillage system on tile flow, NO_3-N concentration and NO_3-N loss in 1988.

Tillage system	Tile flow	Nitrate-N Concentration1/	Nitrate-N Loss
	acre inches	mg/L	lb N/A
Moldboard Plow	1.80	14.8	5.68
No Tillage	2.52	9.4	5.27

1/ Flow-weighted

Residual NO_3-N in the soil profile at the end of the 1988 growing season showed about 112 lb/A more N remaining with the MP system (Table 3). The largest differences between the two tillage systems occurred in the top 2' where substantially more NO_3 accumulated with MP. These results are similar to 1987.

Table 3. Influence of tillage systems on residual NO_3-N in the soil profile in Oct., 1988.

Profile depth	Tillage System: Mb. Plow	Tillage System: No Tillage
feet	NO_3-N (lb/A)	
0-1	97.2	54.0
1-2	64.1	24.2
2-3	30.6	27.6
3-4	31.1	22.5
4-5	31.6	24.4
5-6	32.8	28.9
6-7	32.5	28.9
7-8	28.7	26.3
Total (lb NO_3-N/A 0-8')	348.6	236.8

SEVEN-YEAR SUMMARY

The cumulative totals for the 7-year period (1982-1988) are shown in Table 4. Corn yields over this period have averaged 9 bu/A better with moldboard plow tillage. Approximately 11% more N has been removed in the grain with moldboard plow tillage. This has been due to both higher yields and slightly higher grain N concentrations with the moldboard tillage system some years. Even so, very little difference in applied N removed in the grain exists between the two treatments (49% vs 44% for MP vs NT, respectively). Even though total water flow and NO_3-N lost through the tile lines was about 8% higher with no tillage, this small difference is considered to be insignificant when considering tile flow variability among the eight plots over this 7-year period.

Table 4. Cumulative effects of the two tillage systems over the 7-year period.

Parameter	Tillage System	
	Mb. plow	No tillage
Fert. N applied (lb/A)	1260	1260
Corn grain removed (bu/A)	932	869
N removed in grain (lb/A)	623	559
N removed in grain as a percent of applied N (%)	49	44
Tile flow (acre inches)	60.4	65.2
Nitrate-N lost in tile (lb/A)	146.4	157.8
N lost via tile lines as a percent of applied N (%)	12	13

RESIDUAL SOIL NITRATE FOLLOWING ALFALFA AS INFLUENCED BY TILLAGE AND CORN HYBRID[1/]

C. G. Zadak, G. W. Randall, and M. P. Russelle[2/]

ABSTRACT: Experiments were initiated at three locations in 1988 to determine the influence of tillage, N rate, and corn hybrid on the residual NO_3-N remaining after harvest in a first year corn after alfalfa cropping system. Soil NO_3 in the 0-5' profile was low prior to tillage and planting in the spring. Thirty to 50% of the profile NO_3 was found in the top foot. The applied N resulted in higher residual NO_3 in the fall at all three locations with the majority accumulated in the top foot. Corn hybrid affected residual NO_3 in one location while tillage significantly affected fall NO_3 levels at another location. Substantially more NO_3-N remained with moldboard plow tillage compared to no tillage especially when 62 lb N/A was applied. These data indicate that soil NO_3-N levels following alfalfa change dramatically between the spring and fall and that N rate, tillage and hybrid can affect NO_3 levels.

Recent evidence has shown that residual soil nitrate (NO_3) in the upper part of the root zone may be helpful in more accurately predicting fertilizer N needs of corn. The purpose of this study was to determine: (1) the amount of NO_3-N in the 0 to 5' profile in the spring following alfalfa, (2) the amount of residual NO_3-N remaining after 1st year corn following alfalfa was harvested, and (3) the effect of tillage, corn hybrid, and fertilizer N rate in this alfalfa-corn sequence on residual NO_3-N.

EXPERIMENTAL PROCEDURES

Studies were initiated into growing alfalfa stands at the Rosemount Agricultural Experiment Station, Southern Experiment Station at Waseca, and on the Gary Luehmann farm in Winona Co. in April, 1988. The primary soil type at each location was Port Byron sil, Nicollet cl, and Seaton sil, respectively. A randomized, complete-block experiment in a split-plot arrangement with four replications was used. Main plots consisted of two primary tillage variables (moldboard plow vs no tillage) while subplots consisted of six genetically dissimilar 105-day RM corn hybrids.

Random soil cores were taken in 1-foot increments to a depth of 7', 6' and 5' at the Rosemount, Winona, and Waseca locations in mid-April prior to spring tillage. Specific treatments were sampled in mid-October after corn harvest by taking two cores per plot and compositing the cores according to the depth increments. The soil was forced-air, oven-dried at 120°F, crushed to pass a 2 mm sieve, and analyzed for NO_3-N concentration.

RESULTS AND DISCUSSION

Spring sampling

Samples taken prior to tillage of the alfalfa showed low levels of NO_3-N in the 0-5' profile at each site (Table 1). Lowest values were obtained at Winona and Waseca. From 30 to 50% of the NO_3 in the 5-foot profile was found in the top foot.

Fall sampling

Rosemount

Fall soil NO_3-N data for Rosemount are given in Tables 2 and 4. In contrast to the spring data, this site showed the lowest amount of total NO_3-N in the profile of the three sites -- as much as 100-150 lbs N/A less. These differences might be due to differences in the 1987 alfalfa stand. There were no differences in total residual NO_3-N at Rosemount due to tillage when averaged over hybrid and N rate, but differences due to N rate and hybrid were present. The magnitude of the difference between the 0 and 62 lb N/A rates was nearly equal to the 62 lb N/A application. Most of this N remained in the top foot of soil, however. In fact, very little

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1/ Funding provided by the Minnesota Agric. Exp. Stn. and the So. Exp. Stn. at Waseca.
2/ Graduate research assistant, Dept. of Soil Science; Professor, So. Exp. Stn., Waseca; and Assoc. Professor, Dept. of Soil Science and USDA-ARS-USDFRC.

NO_3-N was detected below 2 feet. Approximately 20 lbs less N/A was present under P3569 than under P3732 (no difference in total N uptake between these hybrids was detected, however).

Winona Co.

Fall results for the Winona Co. site are given in Tables 3 and 4. Again, a significant increase in total profile NO_3-N occurred due to N application, with most of the NO_3-N concentrated in the top foot. There were 80 lbs N/A more in the profile under moldboard tillage than under no-tillage when averaged over N rates and hybrids. This is likely the result of greater mineralization of the alfalfa residues caused by the tillage. The presence of a significant tillage X N rate interaction is a bit puzzling. Perhaps this was due to greater uptake of the fertilizer N under no-tillage (a good response to fertilizer N addition was observed for no-tillage) or greater immobilization of the surface-applied N occurred under no-tillage. No differences in residual NO_3-N between the two hybrids (P3732 and DK547) were detected.

Waseca

Fall total profile NO_3-N values were similar to those at Winona Co. (Tables 5 and 6). Again, addition of N resulted in higher residual NO_3-N levels, with most of the NO_3-N in the top foot. Little to no differences in the residual NO_3-N are apparent under the 30, 62, and 90 lb N/A rates, however. No difference in residual N due to tillage is apparent. Clearly, the low yields that occurred at this site minimized the potential for differences in soil NO_3-N to show up.

Table 1. Soil nitrate-N following alfalfa in April, 1988.

Profile depth	Location		
	Rosemount	Winona Co.	Waseca
feet	lb NO_3-N/A		
0 - 1	32.4	13.2	16.0
1 - 2	13.6	7.1	9.7
2 - 3	6.7	4.3	6.6
3 - 4	4.2	2.9	3.1
4 - 5	2.2	2.0	3.5
Total in profile	59	30	39

Table 2. Residual soil nitrate-N after harvest in October, 1988 at Rosemount as influenced by tillage, hybrid, and N rate.

Profile depth	Moldboard				No-tillage			
	P3732		P3569		P3732		P3569	
lb N/A:	0	62	0	62	0	62	0	62
feet	lb NO_3-N/A							
0 - 1	51.4	103.3	52.4	88.9	38.8	122.5	36.2	53.2
1 - 2	10.5	17.9	6.7	23.1	4.8	15.4	4.4	8.1
2 - 3	3.1	3.3	1.7	4.7	1.7	3.0	1.4	2.3
3 - 4	1.4	2.3	1.2	2.8	1.3	1.9	1.0	1.4
4 - 5	0.8	1.2	0.9	2.2	1.6	1.4	1.0	1.1
Total in 0-5' profile	67	128	63	122	48	144	44	66

Table 3. Residual soil nitrate-N after harvesting in October, 1988 at Winona Co. as influenced by tillage, hybrid, and N rate.

Profile depth	Moldboard				No-tillage			
	P3732		DK547		P3732		DK547	
lb N/A:	0	62	0	62	0	62	0	62
feet	lb NO_3-N/A							
0 - 1	71.4	160.2	75.0	148.4	53.8	83.9	36.7	89.3
1 - 2	51.4	86.8	43.3	56.6	32.9	47.2	24.0	46.9
2 - 3	16.6	18.0	16.2	17.5	15.8	18.2	15.1	16.4
3 - 4	20.4	17.7	13.1	17.2	13.9	16.1	12.8	13.5
4 - 5	18.5	19.1	15.8	19.6	20.0	16.3	15.4	16.0
Total in 0-5' profile	178	302	163	259	136	182	104	182

Table 4. Means for main effects and interactions for total residual soil nitrate-N (0-5') after harvest at Rosemount and Winona Co. in October, 1988.

Treatment		Location: Rosemount	Location: Winona Co.
		lb NO_3-N/A	
Tillage			
Moldboard		95	231
No-tillage		76	151
P >F		0.44	0.05
N Rate (lb/A)			
0		56	139
62		115	231
P >F		0.01	0.01
Hybrid			
P3732		97	200
P3569/DK547		74	177
P >F		0.04	0.15
Tillage X N Rate Interaction			
Moldboard	0	65	164
	62	125	281
No-tillage	0	46	120
	62	105	182
P >F		0.97	0.03
Tillage X Hybrid Interaction			
Moldboard	P3732	98	247
	P3569/DK547	92	215
No-tillage	P3732	96	159
	P3569/DK547	55	143
P >F		0.10	0.65
N Rate X Hybrid Interaction			
0	P3732	58	152
	P3569/DK547	53	126
62	P3732	136	242
	P 3569/DK547	94	221
P >F		0.08	0.90
Tillage X N Rate X Hybrid Interaction			
P >F		0.10	0.34

Table 3. Residual soil nitrate-N after harvesting in October, 1988 at Winona Co. as influenced by tillage, hybrid, and N rate.

Profile depth		Moldboard				No-tillage			
		P3732		DK547		P3732		DK547	
	lb N/A:	0	62	0	62	0	62	0	62
feet		lb NO_3-N/A							
0 - 1		71.4	160.2	75.0	148.4	53.8	83.9	36.7	89.3
1 - 2		51.4	86.8	43.3	56.6	32.9	47.2	24.0	46.9
2 - 3		16.6	18.0	16.2	17.5	15.8	18.2	15.1	16.4
3 - 4		20.4	17.7	13.1	17.2	13.9	16.1	12.8	13.5
4 - 5		18.5	19.1	15.8	19.6	20.0	16.3	15.4	16.0
Total in 0-5' profile		178	302	163	259	136	182	104	182

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Treatment		Location: Rosemount	Location: Winona Co.
		lb NO_3-N/A	
Tillage			
Moldboard		95	231
No-tillage		76	151
P> F		0.44	0.05
N Rate (lb/A)			
0		56	139
62		115	231
P> F		0.01	0.01
Hybrid			
P3732		97	200
P3569/DK547		74	177
P >F		0.04	0.15
Tillage X N Rate Interaction			
Moldboard	0	65	164
	62	125	281
No-tillage	0	46	120
	62	105	182
P> F		0.97	0.03
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Moldboard	P3732	98	247
	P3569/DK547	92	215
No-tillage	P3732	96	159
	P3569/DK547	55	143
P> F		0.10	0.65
N Rate X Hybrid Interaction			
0	P3732	58	152
	P3569/DK547	53	126
62	P3732	136	242
	P 3569/DK547	94	221
P> F		0.08	0.90
Tillage X N Rate X Hybrid Interaction			
P> F		0.10	0.34

Table 5. Residual soil nitrate-N after harvest in October, 1988 at Waseca for P3732 as influenced by tillage and N rate.

Profile depth	lb N/A:	Moldboard 0	Moldboard 30	Moldboard 60	Moldboard 90	No-tillage 0	No-tillage 30	No-tillage 60	No-tillage 90
feet		lb NO_3-N/A							
0 - 1		64.5	90.0	103.2	112.1	66.4	96.4	105.0	116.6
1 - 2		38.1	56.4	57.5	57.4	44.5	51.5	42.6	45.0
2 - 3		20.1	17.5	24.1	20.7	27.1	26.8	23.2	23.7
3 - 4		24.0	21.2	22.4	21.2	22.7	21.6	27.8	24.5
4 - 5		23.5	24.7	24.8	23.2	23.3	26.0	24.2	25.6
Total in 0-5' profile		170	210	232	235	184	222	223	236

Table 6. Means for total residual soil nitrate-N after harvest for tillage and N rate at Waseca.

Treatment	Residual N lb NO_3-N/A
Tillage	
Moldboard	212
No-tillage	216
N Rate (lb/A)	
0	177
30	216
60	227
90	235

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Sincere appreciation is given to the hybrid seed corn companies that furnished the seed for these trials.

IMPACT OF NITROGEN AND TILLAGE MANAGEMENT PRACTICES ON CORN YIELD AND POTENTIAL GROUNDWATER CONTAMINATION IN SOUTHEASTERN MINNESOTA[1/]

Center for Agricultural Impacts on Water Quality
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ABSTRACT: Studies are being conducted on the silt loam soils of southeastern Minnesota to evaluate specific N and tillage practices for their role in providing profitability (BENEFIT) while minimizing NO_3 occurrences in the water below the root zone (RISK). The dry conditions seriously impacted corn yields and NO_3 leaching at two of the three sites. In general, continuous corn yields were optimized at N rates from 100 to 150 lb N/A except when alfalfa and manure were in the system (1983-85). Corn yields were not improved with split or sidedress N applications. Tillage did not appear to effect either corn yield or NO_3-N concentrations in the soil water. Manure applications resulted in slightly higher yields but greatly increased NO_3-N concentrations in the water. When profitability was highest, NO_3-N concentrations at 5' ranged between 10 and 14 mg/L. Fall applications of N doubled the NO_3-N concentration in the soil water at 5'. In an effort to more clearly define BMP's for these soils, additional years will be needed to more closely ascertain benefit vs risk relationships of these various N and tillage practices.

Current agricultural production systems are being linked closely to the occurrence of agricultural chemicals in the groundwater. This concern is especially prevalent in southeastern Minnesota where agriculture is quite intensive and the soils are rather shallow over a fractured limestone and sandstone bedrock geology (karst). The purposes of these studies are to: (1) determine the cause and effect relationship of specific N and tillage management practices on corn production and NO_3 and pesticide accumulation/movement through the soil and (2) identify best management practices that minimize groundwater contamination while maintaining economic profitability.

EXPERIMENTAL PROCEDURES

Three sites were continued for the 1988 studies. The primary site with the most intensive investigation is being conducted in Olmsted Co. on the Lawler Farm. The other sites are in Goodhue Co. on the Foss Farm and in Winona Co. on the Kalmes Farm.

Olmsted County - Lawler Farm

In April of 1986 a 6½ acre site of Port Byron soil was identified on the Richard Lawler and Sons Farm approximately 6 miles east of Rochester. A very comprehensive field history for the last 7 years was provided. Corn was grown in 1986. No herbicides and no nitrogen (N) fertilizer were applied to the corn which was cultivated three times.

Nitrogen Study

A randomized, complete-block with 4 replications was established in the fall of 1986 and was continued in 1988. Ten N treatments including both anhydrous ammonia and manure were established for a total of 40 plots (Table 1). Each plot was 30' wide and 65' long. The fall N treatments were applied on October 30, 1987. Spring N fertilizer treatments were applied on April 21 and again on June 16, 1988. Liquid hog manure was obtained from a neighbor, James Stellplug, on April 15 and applied to the soil surface using his equipment. The manure was incorporated with a disk within 3 hours. The rates of application were 6600 and 9500 gal/A. Six manure samples were taken and sent to Minnesota Valley Testing for analyses. Nitrogen, P_2O_5 and K_2O concentrations averaged 40.3, 27.4 and 8.1 lb/1000 gallons, respectively. All plots except the no-till treatment were disked again on April 25.

Corn (Pioneer 3737) was planted on May 4 at 30,600 plants/A. Lasso (3 lb/A) and atrazine (2½ lb/A) were applied preemergence. Counter was applied in the furrow at a rate of 8 oz/1000' of row to control rootworms. Cultivation was not performed during the season.

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Whole plants were harvested from selected rows at silking, were weighed, dried, ground and analyzed for total N to determine pre-silk N uptake. Stover and grain yields were taken from 20' and 80' of row, respectively, at physiological maturity (Sept. 24). All samples were weighed, dried, ground and analyzed for total N.

Soil samples were obtained from each plot on April 12 and Oct. 24 by taking two 2-inch cores in 1-foot increments to the bedrock and then compositing the cores from each increment. The samples were forced-air, oven-dried at 120°F, ground, and analyzed for inorganic N (NH_4-N and NO_3-N).

Suction lysimeters installed in 1987 at the 5 and 7.5-foot depths in each plot were used to extract soil water from these depths to measure NO_3 concentrations in the soil water. Samples were collected on April 18, May 13, Aug. 12, Oct. 5 and Nov. 14.

Pesticide Study

An area adjacent to the N study was established in the fall of 1986 to accommodate a study to evaluate the movement of Lasso, atrazine, Banvel and Counter through the soil profile as influenced by four tillage systems. The four tillage treatments (moldboard plow, chisel plow, ridge tillage, and no tillage) were initiated in November, 1986. Nitrogen was applied on April 21 at a rate of 180 lb N/A as anhydrous ammonia. All other planting operations were the same as in the N study. The herbicides were applied using specialized plot equipment. Potassium bromide was broadcast-applied to a 15-foot section of each plot. The Br serves as a tracer to which pesticide movement can be compared. The corn was cultivated two times. The ridge plots were ridged in mid-June.

Each plot was intensively soil sampled throughout the season to monitor herbicide movement. Stainless steel suction lysimeters installed at 5' and 7½' depths were used to extract soil water. Grain and stover yields were taken at physiological maturity (PM) from the non-Br treated areas.

Goodhue County - Foss Farm

In May of 1986 an area of 5.1 acres of Port Byron soil was identified on the Selmer Foss and Sons (James Foss) farm in Goodhue County. A good field history was provided for the past 6 years. Corn was grown in 1986 and received a minimal amount of N (75 lb N/A) because it was in continuous corn. Weeds were controlled with 4 lb atrazine/A. Due to wet conditions no primary tillage was performed in the fall of 1986.

A randomized, complete-block design with 4 replications was established at this site in April, 1987 and was continued in 1988. Sixteen N treatments all consisting of anhydrous ammonia applied to chiseled and no-till plots were established. Each of the 64 plots measures 30' wide and 65' long. Chisel plowing was done with a John Deere Mulch Tiller on November 4, 1987. Anhydrous ammonia was applied preplant on April 20. All chisel plots were disked on May 5.

Corn (Pioneer 3790) was planted at 30,200 plants/A on May 6. Lasso (3 lb/A) and Bladex (2½ lb/A) was applied preemergence. Counter was applied at 1 lb a.i./A to control corn rootworms. The chisel plowed plots were cultivated to remove weeds and volunteer corn. Sidedress applications of N as anhydrous ammonia were applied at the 6-leaf stage (June 6) and 8 to 9-leaf stage (June 16).

Plant sampling procedures at silking and at PM were essentially the same as at the Olmsted Co. site. Soil sampling to the 10-foot depth on April 15 and October 31 was accomplished using the same procedures as in Olmsted Co. Suction lysimeters installed in six treatments (24 plots) to a 5' depth in 1987 were sampled on Apr. 15, May 12, Sept. 30 and Nov. 17 to determine the NO_3 and pesticide concentrations in the extracted soil water.

Winona County - Kalmes Farm

A 3.0 acre contour strip of Seaton soil was identified in early April, 1987. This farm is owned by Eugene Kalmes and son, Robert Kalmes. A field history was provided for the last 4 years. Corn was grown in 1986 and received 70 lb N/A and 2 lb atrazine/A. Alfalfa was grown in 1983-85 and received 6 T manure/A in the fall of 1985.

A randomized, complete-block design with 4 replications was established at this site in mid-April, 1987 and was continued in 1988. Twelve N treatments were established for a total of 48 plots. Each plot measures 20' wide by 65' long.

Spring chiseling was conducted on October 28, 1987. The preplant anhydrous ammonia treatments were applied immediately afterward. A field cultivator was used as secondary tillage just prior to planting.

Corn (Pioneer 3790) was planted at 30,200 plants/A on May 2. Lasso (3 lb/A) and Bladex (2½ lb/A) was applied preemergence. Counter (8 oz/1000') was used to control corn rootworms. The chisel plowed plots were cultivated to remove weeds. Sidedress applications of N as anhydrous ammonia were applied at the 6 to 7-leaf stage (June 8) and the 8 to 9-leaf stage (June 17).

Plant and soil sampling procedures were identical to those used in Olmsted Co. Stainless steel and PVC suction lysimeters installed in 1987 at the 5' depth in six treatments (24 plots) were sampled on April 18, May 13, Aug. 17, Oct. 5, and Nov. 18 to determine NO_3 and pesticide concentrations in the extracted soil water.

RESULTS AND DISCUSSION

Olmsted Co.

Corn grain yields in 1988 were increased significantly by both the fertilizer and manure N treatments (Table 1). The addition of 75 lb N/A increased yield by 60 bu/A resulting in very high fertilizer N efficiency. The 150-lb N rate applied preplant (PP) gave the optimum yield among the fertilizer treatments. Yields were about 8 bu/A higher with the two hog manure treatments, but this difference was not significantly (P = 95% level) above the 150-lb N/A PP treatments. Corn yields with the fall and split 150-lb treatments were not significantly different from the 150-lb PP treatment. There was no significant yield difference between the chisel and no tillage systems. Average 2-year yields showed greatest economic return to the 150-lb PP application with no advantage to higher rates, fall application or split treatments.

Table 1. Effect of N treatments on the 1988 corn grain yields and NO_3-N concentrations in the water at 5' in Olmsted Co.

Treatment				Grain Yield		Nitrate-N[3/] Conc.in Water	
No.	Tillage	N Rate	Time/Method	1988	1987-88	5'	7.5'
		lb N/A		---- bu/A -----		--- mg/L ---	
1	Chisel	0	-----	79.9	94.6	1	4
2	Chisel	75	Spr., preplant	139.7	161.0	6	7
3	Chisel	150	Spr., preplant	153.5	176.9	12	9
4	Chisel	225	Spr., preplant	153.4	168.7	18	8
5	Chisel	150	Fall, post tillage	153.9	174.8	24	-
6	Chisel	150 + NI[1/]	Fall, post tillage	156.8	174.0	22	-
7	Chisel	150 split	50% Spr., preplant 50% SD, 8-leaf	152.6	172.8	10	-
8	No tillage	150	Spr., preplant	155.0	176.7	14	-
9	Chisel	175[2/]	Spr., disked in	161.7	184.5	41	10
10	Chisel	230[2/]	Spr., disked in	161.0	185.2	63	5
	Significance Level (%):			99			
	BLSD (.05)	:		15.2			
	CV (%)	:		7.7			

1/ N-Serve
2/ Applied liquid swine manure at rates of 6600 and 9500 gal/A, respectively.
3/ Total N rates were 280 and 360 lb N/A or approximately 175 and 230 lb "available" N/A. Oct. 5, 1988

Nitrate-N concentrations in the soil water extracted from the 5-foot depth were correlated linearly with the spring-N rate (Table 1). Concentrations below 10 mg/L were found only with the 0 and 75-lb N rates, but economical return was also considerably less with the treatments. The split N application resulted in a similar NO_3-N concentration as the spring preplant application. Fall application, regardless of the inclusion of N-Serve, resulted in NO_3-N concentrations almost twice as high as with the spring applications. There appeared to be no difference between tillage systems. Highest NO_3-N concentrations occurred with realistic application rates of liquid hog manure. Nitrate leaching from the treatments had not reached the 7.5-foot depth at the end of the two growing seasons