Table 1. Influence of nitrogen form, rate, and time of application on grain yield on a Webster clay loam, Southwest Experiment Station, Lamberton, MN 1989.

Nitrogen Treatment			1989					29-year
Rate	Form	Time	Rep. 1	Rep. 2	Rep. 3	Rep. 4	Avg.	Avg.
#N/Ac			Bu/Ac @ 15.5 % moisture					
--	Check	----	73.4	79.2	73.2	95.1	80.2	66.0
40	Ammonium Nitrate	Fall	102.5	101.9	110.4	107.8	105.7	84.0
40	Urea	Fall	79.0	103.2	108.0	122.2	103.1	87.0
40	Ammonium Nitrate	Fall Surface	87.3	99.3	97.3	105.1	97.3	82.0
40	Urea	Fall Surface	106.1	82.4	116.6	113.5	104.7	87.0
80	Ammonium Nitrate	Fall	119.5	117.7	98.2	136.2	117.9	104.0
80	Urea	Fall	105.5	121.9	111.7	146.8	121.5	103.0
160	Ammonium Nitrate	Fall	124.0	122.8	111.5	126.2	121.1	111.0
160	Urea	Fall	138.8	116.6	128.0	123.1	126.6	112.0
40	Ammonium Nitrate	Spring	83.5	92.9	115.8	95.2	96.9	95.0
40	Urea	Spring	81.8	103.2	90.7	114.0	97.4	93.0
80	Ammonium Nitrate	Spring	93.2	91.8	135.0	147.0	116.8	107.0
80	Urea	Spring	124.0	113.5	138.7	157.3	133.4	108.0
40	Ammonium Nitrate	Side Dress	108.4	106.7	123.3	124.2	115.7	97.0
40	Urea	Side Dress	105.9	97.9	122.3	123.9	112.5	97.0
80	Ammonium Nitrate	Side Dress	138.4	111.4	142.4	134.9	131.8	104.0
80	Urea	Side Dress	105.0	100.6	134.9	142.7	120.8	112.0
160	Ammonium Nitrate	Side Dress	119.7	139.6	126.3	127.8	128.4	116.0
	Average						111.5	98.1
	LSD (α=0.05)						16.8	

Table 2. One-way analysis of variance.

Source	DF	Sum of Squares	Mean Square	P value
Block	3	4708.0	1569.0	$7.37 * 10^{-6}$
Treatment	18	18360.0	1020.0	$5.26 * 10^{-9}$
Error	54	7501.0	138.9	

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

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 study 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 1989, tillage had no significant effect on yield. Erosion level had a significant effect on yield (alpha = 0.01) with the higher yields occurring on the less eroded treatments. Corn yields usually decrease with increasing erosion levels 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", and results from 1987 and 1988 were presented in the 1989 "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 in the past was applied based on the soil test of each erosion treatment. In 1989, 157-20-7 pounds of N-P_2O_5-K_2O was broadcast over the entire study. Additional management information is given in Table 1.

Grain yields are given in Table 2. Analysis of variance, using a spilt plot design (tillage = whole plots, erosion class = split plots) is furnished in Table 3.

Summary of results: In 1989, there was no significant difference between moldboard plow and ridge tillage (see Table 6 and 7). The severe erosion class had significantly lower yields than the moderate and slight erosion class (see Table 2 & 3). Least significant differences (LSD's) are provided in the appropriate summary table if analysis of variance is significant.

The entire study was moldboard plowed in the fall of 1989 because of the visual and measured potassium deficiency symptoms that occurred in the ridge tillage treatment, and the study will be continued next year to further examine these nutrient deficiency problems (Table 4).

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

Table 1. Management Information.

Item	Type	Rate	Date
Secondary Tillage[1]	disk	twice	4/24/89
Insecticide	Counter	1.0 #/Ac	4/24/89
Seed	Pioneer 3732	26,000 p/Ac	" "
Herbicides	Lasso	3.0 #/Ac	4/24/89
	Bladex	2.0 #/Ac	" "

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

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

[2] 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 2. Mean yields (bu/ac) of tillage, erosion class and interactions.

Tillage	Erosion Class			Overall
	Slight	Moderate	Severe	Mean
Plow	128.8	128.1	116.3	124.4
Ridge	128.2	127.4	116.3	123.9
Overall Mean	128.5	127.7	116.3	124.2

$LSD_{0.05}$ = 7.6 for comparing erosion classes (averaged over both tillage treatments).

Table 3. Analysis of Variance.

Source	DF	SS	MS	P-value
Block	3	474.4	158.1	0.254
Tillage	1	1.354	1.354	0.897
Whole Plot Error	3	204.7	68.23	
Erosion	2	748.0	374.0	$6.84*10^{-3}$ **
Interaction	2	0.63	0.315	0.994
Sub-Plot Error	12	577.6	48.13	

** significant at alpha = 0.01

Table 4. Earleaf samples at 50 % silking.

Erosion Class	Tillage	Average (%) K	P	N
Slight	Plow	1.67	0.29	3.1
	Ridge	1.33	0.31	3.4
Moderate	Plow	1.83	0.28	3.1
	Ridge	1.09	0.30	3.1
Severe	Plow	1.21	0.28	3.0
	Ridge	0.82	0.29	3.1

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

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%), three tillages (ridge tillage, moldboard plow, and chisel), and tillage/planting directions (up and down the slope, or contour to the slope) in a corn - soybean rotation. In 1989, tillage was the only significant treatment on soybean yields ($\alpha = 0.05$). In the past, slope position and/or planting direction also had significant effect on crop yields ($\alpha = 0.05$).

(The 1989 University of Minnesota "Blue Book" contains information for the years 1986, 1987 and 1988.)

Materials: This study began in the spring 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/planting directions (up and down the slope, or contour to the slope) in a corn and soybean rotation. The slope positions are not taken into account for the 4 and 1 percent slopes. Also the tillage/planting directions are not taken into account for the 1 percent slopes. Yields are measured every year. Soil movement is being monitored by grass catch strips and infrared transit survey.

Additional management information is provided in Table 1.

Results: Main effects are presented in tables followed by the interaction effects. Analysis of variance for each slope treatment is provided (Table 2-7). The 8 and 4% slope had a significant tillage effect with greatest yields occurring on moldboard plow treatments (see Table 2B & 3, and 4B & 5, respectively). Last year ridge tillage was the highest yielding tillage treatment for the first time in four years. All other treatments were not significantly different. Analysis of variance was not performed on the different slope percentages (8, 4 & 1%) however, the overall average yield decreased with increasing slope (see Table 2A, 4A & 6A).

Table 1. Management Information.

Item	Type	Rate	Date
Secondary Tillage[1]	Disk/Digger	1 pass each	4/20
Seed	Corsoy 79	150,000 seeds/ac	5/17
Herbicides	Lasso	3.0 lbs/ac	5/19
	Amiben	2.5 #/Ac	5/19

1/ No secondary tillage on ridge tillage plots.

Table 2 (A-H). Soybean Yields on the 8 Percent Slope.

2A. Overall Average.

	Avg	s[1]
Overall	38.7	3.5

n (sample no.) = 54

1/ s = sample standard deviation.

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

[2] 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.

2B. Tillage (Ranked by ascending averages).

Tillage	Avg	s
Ridge	36.1	3.8
Chisel	38.8	3.0
Moldboard	41.0	2.5

n = 27 $LSD_{0.05}$ = 4.2

2C. Row Direction.

Row Direction	Avg	s
Up & Down	38.6	3.5
Contour	38.7	3.9

n = 27

2D. Slope Position.

Slope Position	Avg	s
Top	38.9	4.2
Mid	38.6	3.7
Bottom	38.5	3.3

n = 18

2E. Tillage - Row Direction Interaction.

Tillage	Row Dir.	Avg	s
Chisel	Up & Down	38.8	2.6
Chisel	Contour	38.9	3.3
Moldboard	Up & Down	40.7	2.4
Moldboard	Contour	41.4	2.7
Ridge	Up & Down	36.4	4.0
Ridge	Contour	35.9	3.9

n = 9

2F. Tillage - Slope Position Interaction.

Tillage	Slope Pos.	Avg	s
Chisel	Top	38.9	3.7
Chisel	Mid	38.8	3.2
Chisel	Bottom	38.9	2.1
Moldboard	Top	41.9	2.8
Moldboard	Mid	41.2	2.6
Moldboard	Bottom	40.0	2.1
Ridge	Top	35.8	3.9
Ridge	Mid	35.9	3.6
Ridge	Bottom	36.7	4.5

n = 6

2G. Row Direction - Slope Position Interaction.

Row Dir.	Slope Pos.	Avg	s
Up & Down	Top	37.5	4.3
Up & Down	Mid	39.6	3.4
Up & Down	Bottom	38.8	2.4
Contour	Top	40.2	3.7
Contour	Mid	37.6	3.9
Contour	Bottom	38.2	4.1

n = 9

2H. Tillage - Row Direction - Slope Position Interaction.

Till[1]	Row Dir.	Slope Pos.	Avg	s
CH	Up & Down	Top	38.6	3.9
CH	Up & Down	Mid	38.8	2.6
CH	Up & Down	Bottom	39.0	2.3
CH	Contour	Top	39.1	4.3
CH	Contour	Mid	38.8	4.4
CH	Contour	Bottom	38.8	2.4
MP	Up & Down	Top	40.3	2.3
MP	Up & Down	Mid	42.3	2.6
MP	Up & Down	Bottom	39.5	2.1
MP	Contour	Top	43.6	2.5
MP	Contour	Mid	40.0	2.4
MP	Contour	Bottom	40.5	2.5
RT	Up & Down	Top	33.5	4.2
RT	Up & Down	Mid	37.7	4.0
RT	Up & Down	Bottom	37.9	3.3
RT	Contour	Top	38.0	2.3
RT	Contour	Mid	34.2	2.8
RT	Contour	Bottom	35.5	6.0

n = 3

1/ Tillage Codes: CH = Chisel Plow, MP = Moldboard Plow, RT = Ridge Tillage

Table 3. Analysis of Variance for the 8 Percent Slope.

Randomized block with split - split plot restriction

Number of: Cases = 54 Blocks = 3
Row Directions = 2 Tillage Levels = 3 Slope Positions = 3

Source	DF	SS	MS	P-value
Block	2	27.56	13.78	0.181
Row Dir.	1	0.0938	0.09375	0.877
Whole Plot Error	2	6.081	3.041	
Tillage	2	216.7	108.4	0.0162 *
Row*Tillage	2	2.929	1.464	0.908
Sub-Plot Error	8	120.3	15.04	
Position	2	1.176	0.5878	0.944
Row*Position	2	52.79	26.39	0.0959
Tillage*Position	4	13.79	3.447	0.849
Row*Till*Pos	4	27.77	6.942	0.612
Sub-Sub Plot Err	24	244.6	10.19	

* significant at alpha = 0.05

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

4A. Overall Average.

	Avg	s
Overall	43.9	2.7

n = 12

4B. Tillage. (ranked by ascending averages).

Tillage	Avg	s
Chisel	41.3	3.6
Ridge	43.9	2.8
Moldboard	46.3	1.8

n = 4 $LSD_{0.05}$ = 2.5

4C. Row Direction.

Row Dir.	Avg	s
Up & Down	41.9	3.4
Contour	45.9	1.9

n = 6

4D. Tillage - Row Direction Interaction.

Till	Row Dir.	Avg	s
CH	Up & Down	38.6	3.0
CH	Contour	44.1	0.7
MP	Up & Down	45.4	0.4
MP	Contour	47.5	2.2
RT	Up & Down	41.7	1.8
RT	Contour	46.1	1.0

n = 2

Table 5. Analysis of Variance for the 4 Percent Slope.

Randomized block with split plot restriction
Number of: Cases = 12 Blocks = 2
Tillage Levels = 3 Row Directions = 2

Source	DF	SS	MS	P-value
Block	1	5.4	5.4	0.440
Row Dir.	1	47.8	47.8	0.172
Whole Plot Error	1	3.685	3.685	
Tillage	2	51.77	25.88	0.0253 *
Row*Tillage	2	5.945	2.973	0.386
Sub-Plot Error	4	9.758	2.44	

* significant at alpha = 0.05

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

6A. Overall Average

	Avg	s
Overall	46.5	2.0

n = 6

6B. Tillage.

Tillage	Avg	s
Chisel	45.4	1.9
Moldboard	48.0	3.0
Ridge	45.8	1.9

n = 2

Table 7. Analysis of Variance for the 1 Percent Slope.

Randomized block

Number of: Cases = 6 Blocks = 2
Tillage Levels = 3

Source	DF	SS	MS	P-value
Block	1	0.2017	0.2017	0.890
Tillage	2	8.163	4.082	0.667
Whole Plot Error	2	16.33	8.167	

THE RETENTION OF NITROGEN FERTILIZER APPLIED DURING THE WINTER
SOUTHWEST EXPERIMENT STATION
LAMBERTON, MN[1]

D.J. Fuchs and W.W. Nelson[2]

Abstract: Fertilizer nitrogen loss occurs primarily by four methods: 1) leaching, 2) volatilization, 3) denitrification, 4) and runoff. This study was conducted to determine if winter application of nitrogen reduced corn yields in comparison to spring application. In this study, nitrogen (120 lbs./ac. as urea) was applied during mid-December, mid-February, and before planting in the spring. A check treatment of 0 lbs./ac. of nitrogen was also included. Three years of research indicate only a slight yield advantage to spring application in comparison to winter applications, but a significant difference between 0 and 120 lbs. nitrogen.

Environmental concerns about possible contamination of surface water and groundwater by nitrates and other agricultural chemicals has generated public interest. A study was needed to determine the possible reduction of corn yields from nitrogen fertilizer applied in the winter in comparison to spring application as the result of runoff and/or gaseous losses.

EXPERIMENTAL PROCEDURE:

This study was initiated in the winter of 1986/87 in a corn - soybean rotation, looking specifically at the corn portion of the rotation. Nitrogen (120 lbs./ac.) was applied as urea (46-0-0) mid-December, mid-February or in the spring before planting. A control treatment with no nitrogen was also included in the completely randomized block design.

Table 1. lists the management information and actual dates of nitrogen applications for 1989. Management did not vary much for the other years.

Corn grain samples from the plots were collected in the fall and yields were calculated.

RESULTS AND DISCUSSION:

The corn yields are summarized in Table 2. The yields from 1988 were drastically reduced from the drought in comparison to 1987 and 1989. The check exhibited the lowest 3-year average. The analysis of variance shows that there was a significant difference between nitrogen application dates. The major difference occurred between no nitrogen and nitrogen being applied (Table 3 and 2). There was a minor difference between the three application timings with the greatest yields occurring when nitrogen was applied in the spring (101.1 bu/ac) and reduced slightly when applied in mid-February and slightly more reduced when applied in mid-December (98.5 and 93.0, respectively, see Table 2). This seems to prove that there in some nitrogen being volatilized and/or being moved off the field plots by spring runoff. There was also a significant interaction between timing of nitrogen applied and year. This was probably caused by the drought of 1988 (Table 2 & 3).

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[1] Funding provided by Agricultural Experiment Station

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

Table 1. Corn Management Information.

Item		Info.
Soil Test:	P = 42, K = 277, ph = 5.6 (water) ----(lbs/ac)---	
Mid-December N application:		13 December, 1988
Mid-February N application:		28 February, 1989
Spring N application:		25 April, 1989
1988 Fall Primary Tillage:		Soil Saver
Secondary Tillage	Type:	Disk/Digger
	Date:	25 April
Seed	Hybrid/Variety:	P 3732
	Rate:	26,000 ppa
	Date:	2 May
Herbicide	Brand:	Lasso-Bladex
	Rate:	3.0 & 2.0 #/ac
	Date:	4 May
Row Cultivation	Date 1:	23 May
	Date 2:	9 June

Table 2. Corn yields (bu/ac) for specific treatments, years and overall averages.

Year	Check	Mid-December	Mid-February	Spring	Average
1987	130.9	125.6	131.5	132.1	130.0
1988	29.7	42.6	48.6	46.8	41.9
1989	68.8	110.9	115.4	124.4	104.9
Average	76.5	93.0	98.5	101.1	92.3

Table 3. Analysis of Variance.

Variable	DF	SS	MS	p-value
Year	2	65920	32960.0	0
Yr * Replication	9	2028	225.4	0.195
Nitrogen Timing	3	4407	1469.0	0.00015
Yr * N Timing	6	3892	648.7	0.0034
Error	27	4032	149.3	---

SOIL SPECIFIC MANAGEMENT[1]

Pierre Robert, Scott Smith, Wayne Thompson,
Wally Nelson, Dennis Fuchs, and Dean Fairchild[2]

ABSTRACT: The study compared soil specific and conventional management in a 70 ac. field located about one mile west of the Southwest Experiment Station. Soils were grouped in 3 soil potential classes. The conventional treatment received a uniform amount of fertilizer and herbicide. The Soil Specific treatment had variable rates of fertilizer and herbicide as a function of soil classes. The conventional treatment had a yield of 133 bu/ac and the Soil Specific treatment had a yield of 145 bu/ac. The net return of the Soil Specific treatment was $20 higher than the net return of the conventional treatment. Continuous yield measurement was simulated with a plot combine. Results are showing the benefits of this practice. Correlation between soil potential classes and measured yields are shown. The experiment design to study the movement of pesticides on three different soils located on a toposequence under conventional and soil specific management did not yield significant results. Since rainfalls were below average and the soil moisture was extremely low, no water was collected in the samplers.

BACKGROUND AND JUSTIFICATION:

Soil spatial variability within fields has been identified by soil survey maps, soil testing, and yield differences throughout Minnesota. However, present day practices apply only one rate of fertilizer and herbicide to fields with varying soil conditions. This may increase field management costs and contribute to surface and groundwater pollution. The main objectives of the project are to study benefits of Farming by Soil practices on farm profitability and leaching and runoff of pesticides.

EXPERIMENTAL PROCEDURES:

The main study was conducted in a 70 ac. field located about 1 mile west of the Southwest Experiment Station, Lamberton. Soils were grouped in 3 soil potential conditions:

1) High: Glencoe, Canisteo, and Delft/Webster;
2) Medium: Normania, Ves (1 to 4% slopes), and Seaforth;
3) Low: Ves (3 to 6% slopes), Ves/Storden, and Ves/Esterville.

Soil samples were taken in the Fall of 1988 at depths of 0-6", 0-24", and 24-48". Samples were analyzed for N, P, K, and Zn. Samples were taken in the Spring of 1989 at a depth of 0-24" and analyzed for nitrate.

The field management procedures are described in Table 1.

Table 1. Field management information.

Series: HILDRETH 66. Acres

CROP	SECONDARY TILLAGE	PREPLANT INC. HERBICIDE
Type.....CORN	Type.....DIGGER	Name.....ERADICANE X
Exp. Name....Farm by Soil	Date.....05 11 1989	Rate.....4
Var/Hybrid...PIONEER 3732	Type2.....DIGGER	Name2....5/11/89
DoP.....05 12 1989	Date2.....05 11 1989	Rate2....
Population...26100	Type3.....	
Seedbed.....MOIST	Date3.....	
Structure....GRANULAR	CultDate1..05 30 1989	
Crop Year....1989	CultDate2..	
	CultDate3..	
PRIMARY TILLAGE	**INSECTICIDE**	**FERTILIZER**
Type.....PLOW	Type.....COUNTER	Analysis...46-0-0
Residue.....RETURNED	Rate.....1	Rate.....AS PLAN
		Date.....05 11 1989
		Analysis2..
		Rate2.....
		Date2.....

Notes: Stalks Chopped 10/26/89, Plowed 10/27/89, Harvested 10/6/89.

[1] Funding provided by a USDA-CSRS grant.

[2] Assistant Professor, Junior Scientist, Student Junior Scientist, Dept. of Soil Science, Univ. of Minn; Superintendent, Junior Scientist, S.W. Exp. Sta., Univ. of Minn.; and agronomist, Soilteq, Inc., respectively.

Yield goals were adjusted for low soil moisture levels. Yield goals are given in Table 2.

Table 2. Yield goals (bu/A)

Soil condition	
High	150
Medium	135
Low	80
Conventional	130

Fertilizer rates were adjusted from soil test levels and yield potential on each soil condition. Phosphorus and potassium rates are based on soil samples taken in the Fall of 1988. Nitrogen rates were adjusted based on the nitrate levels from samples taken in the Spring of 1989. Eighty percent of the nitrate were used for the 0-24" depth. Levels in the 24-48" zone were generally below 30 lbs/A and not considered in determining nitrogen recommendations. Soil test results used for fertilizer recommendations are listed in Table 3. Fertilizers were broadcast on 5/11/89 using the Soilection equipment from the Co-op County Farmers Elevator in Renville, MN. The impregnation pump was calibrated with Eradicane Extra the day of application. Products used were Urea (46-0-0), Diammonium Phosphate (18-46-0), and Potash (0-0-60) (Table 4).

Table 3. Average soil test levels (lbs/A)

Soil condition	NO^3-N	P	K	Zn
High	67.2	27.5	285	>1.0 ppm
Medium	96	21.7	265	>1.0 ppm
Low	45	17.0	233	>1.0 ppm

Table 4. Fertilizer and herbicide application rates

Treatment	N	P_2O_5	K_2O	Eradicane Extra
1. Conventional	130	40	30	5.3
2. Control	0	0	0	5.3
3. High	140	40	30	5.3
Medium	75	55	30	5.3
Low	50	35	30	5.3
4. High	140	40	30	7.0
Medium	75	55	30	5.3
Low	50	35	30	4.0

Yields were taken using the plot combine late September on marked plots, 2 rows and 30 ft. long. Continuous yield measurements were taken for each treatment strip on rows 6 and 7 every 40 ft. Grain moisture was determined for every tenth harvest sample.

Table 5 gives the 1989 field treatments and Table 6 application costs. Each treatment strip was 60 ft. wide.

Table 5. Field treatment descriptions

Trt. 1. Conventional broadcast fertilizer and herbicide applications. Uniform rates were applied over the entire treatment area.

Trt. 2. Control. No fertilizer was applied to the treatment area. Herbicide was applied at a uniform rate over the entire treatment area.

Trt. 3. Variable fertilizer rates were applied according to the varying soil conditions in the treatment area. Three levels were employed: High, Medium, and Low. A uniform application of herbicide was applied over the entire treatment area.

Trt. 4. Variable fertilizer and herbicide rates were applied according to the varying soil conditions and pH in the treatment area. Three levels were applied: High, Medium and Low.

Table 6. Application costs

Treatment	N	P_2O_5	K_2O	Eradicane Extra	Input Total per Acre
1. Conventional	$27.30	$ 8.80	$3.60	$32.33	$63.03
2. Control	$ 0.00	$ 0.00	$0.00	$32.33	$32.33
3. High	$29.40	$ 8.80	$3.60	$32.33	$74.13
Medium	$15.75	$12.10	$3.60	$32.33	$63.78
Low	$10.50	$ 7.70	$3.60	$32.33	$21.80
4. High	$29.40	$ 8.80	$3.60	$42.70	$84.50
Medium	$15.75	$12.10	$3.60	$32.33	$63.78
Low	$10.50	$ 7.70	$3.60	$24.40	$46.20
Unit prices:	$.21/Lb.	$.22/Lb.	$.12/Lb.	$6.10/pt.	

RESULTS AND DISCUSSION:

Table 7. Grain yields and relative net return by treatment and soil condition.

Treatment	Level	Soil	Surface Available Water Capacity	Yield (bu/A)	Relative Net Return ($/Acre)
1	High	114	5.20	132±25	244±59
1	High	86	3.60	135±17	249±41
1	High	884	4.79	138±08	256±19
1	High	654	3.00	113±24	198±56
1	Medium	446	3.66	135±18	250±43
1	Medium	421B	2.10	143±16	268±38
1	Medium	423	3.15	147±05	278±11
1	Low	421B2	2.10	145±14	274±32
1	Low	954C2	1.85	97±25	159±60
1	Low	999B2	1.96	95±31	156±73
2	High	114	5.20	99±31	194±72
2	High	86	3.60	81±16	155±38
2	High	884	4.79	77±26	145±61
2	High	654	3.00	68±14	122±32
2	Medium	446	3.66	87±20	169±46
2	Medium	421B	2.10	75±23	138±54
2	Medium	423	3.15	82±04	158±09
2	Low	421B2	2.10	61±04	108±10
2	Low	954C2	1.85	42±25	63±50
2	Low	999B2	1.96	71±25	132±58
3	High	114	5.20	145±20	262±46
3	High	86	3.60	142±13	255±30
3	High	884	4.79	135±09	237±20
3	High	654	3.00	122±16	207±38
3	Medium	446	3.66	142±13	264±30
3	Medium	421B	2.10	132±20	241±47
3	Medium	423	3.15	146±10	273±23
3	Low	954C2	1.85	118±16	217±37
3	Low	999B2	1.96	124±24	231±56
4	High	114	5.20	147±17	256±39
4	High	86	3.60	149±15	259±35
4	High	884	4.79	131±23	217±53
4	High	654	3.00	145±04	251±10
4	Medium	446	3.66	147±17	276±41
4	Medium	421B	2.10	139±19	257±44
4	Medium	423	3.15	143±13	267±30
4	Low	421B2	2.10	152±08	306±19
4	Low	999B2	1.96	124±44	239±103

Table 8. Economic analysis results

Treatment	Gross Return[a]	Relative Net Return[b]	Expenses[c]
1	313±51	246±51	68±0
2	191±58	155±58	36±1
3	326±39	251±39	75±3
4	342±42	266±42	76±6

[a] dollar value @ 2.35 per bushel of corn.
[b] gross return minus expenses different between treatments.
[c] see Table 9 for breakdown.

Table 9. Dollar breakdown of production costs[a]

Treatment	Total Expenses[b]	Relative Input Costs[c]	Custom Service Charges[d]	Drying Costs[e]
1	68±0	63±0	4.50	0.01±0.15
2	37±1	32±0	3.50	0.52±0.82
3	75±3	69±3	5.50	0.00±0.00
4	76±6	70±7	5.50	0.08±0.27

[a] dollars per acre.
[b] sum of input costs, custom service charge and drying costs. Identical management costs are not included.
[c] based on pounds of nutrient and volume of herbicide applied: N @ $.21/lb., P2O5 @ $.22/lb., K2O @ $.12/lb., Eradicane Extra @ $6.10/pint. see Table 4 for rates applied per treatment. Weighted values were generated using ratios of linear plot measurements.
[d] application costs:
Trt 1 = Air-Flow with herbicide impregnation,
Trt 2 = Broadcast herbicide application,
Trt 3 & 4 = Soilection with herbicide impregnation.
[e] approximated using $.04/unit % over 15.5%/bushel.

Table 10. Treatment summary

	Treatments			
	1	2	3	4
Yield[a] (bu/A)	133±22	81±25	139±17	145±18
Input Cost[b] ($)	68±0	36±1	75±3	76±7
Relative Net Return[c] ($)	246±51	155±58	251±39[d]	266±42[d]

[a] based on 15.5% moisture content.
[b] include fertilizer and herbicide costs, custom application costs and estimated grain drying costs.
[c] corn value of $2.35/bu less input costs.
[d] weighted by soil condition acreage.

Grain yields and relative net returns are given in table 7 by treatments, soil conditions (high, medium, low) and soil types. They represent means of the three replications. Grain yields and relative net returns are summarized in Table 10.

The farming by soil treatments (treatment 4) shows a $20/acre benefit over the conventional treatment (treatment 1) (Table 10).

The large standard deviations are due to combinations of the following: 1) large range of response in soil complexes (421B2, 954C2, and 999B2); 2) high response to fertilizer applications on 421B2 soils; and 3) inherent variability of soil conditions within each soil type.

Table 11. Analysis of Covariance
Dependent variables: relative net return

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	23723.07	3942.85	36.25	0.0006
Error	5	545.32	109.06		
Corrected Total	11	24268.39			

R-Square	C.V.	Root MSE	Relative Net Return Mean
0.977530	4.56	10.44	229.10

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Replication	2	966.24	483.12	4.43	0.0782
Treatment	3	22441.25	7480.42	68.59	0.0002
Expenses	1	315.58	315.58	2.89	0.1497

LSMeans

	1	2	3	4
1	.	0.01	0.15	0.05
2	0.01	.	0.02	0.02
3	0.15	0.02	.	0.09
4	0.05	0.02	0.09	.

Covariate analysis of the strip means using expenses as covariate showed an 85% probability of receiving a greater net return using variable rate applications versus the conventional uniform rates. Error resulting from the soil variability between treatment strips was adjusted for by using expenses as a covariate, thus clarifying the differences between treatments (LSmeans) (Table 11).

The yield variability is represented by four 3D plots corresponding to each treatment (Figure 1). Each plot was generated using data from the three replications and represents the experimental field (2560 ft. x 1200 ft.). The greatest variability occurs with the check (no fertilizer and no herbicide) and the smallest with the farming by soil treatment.

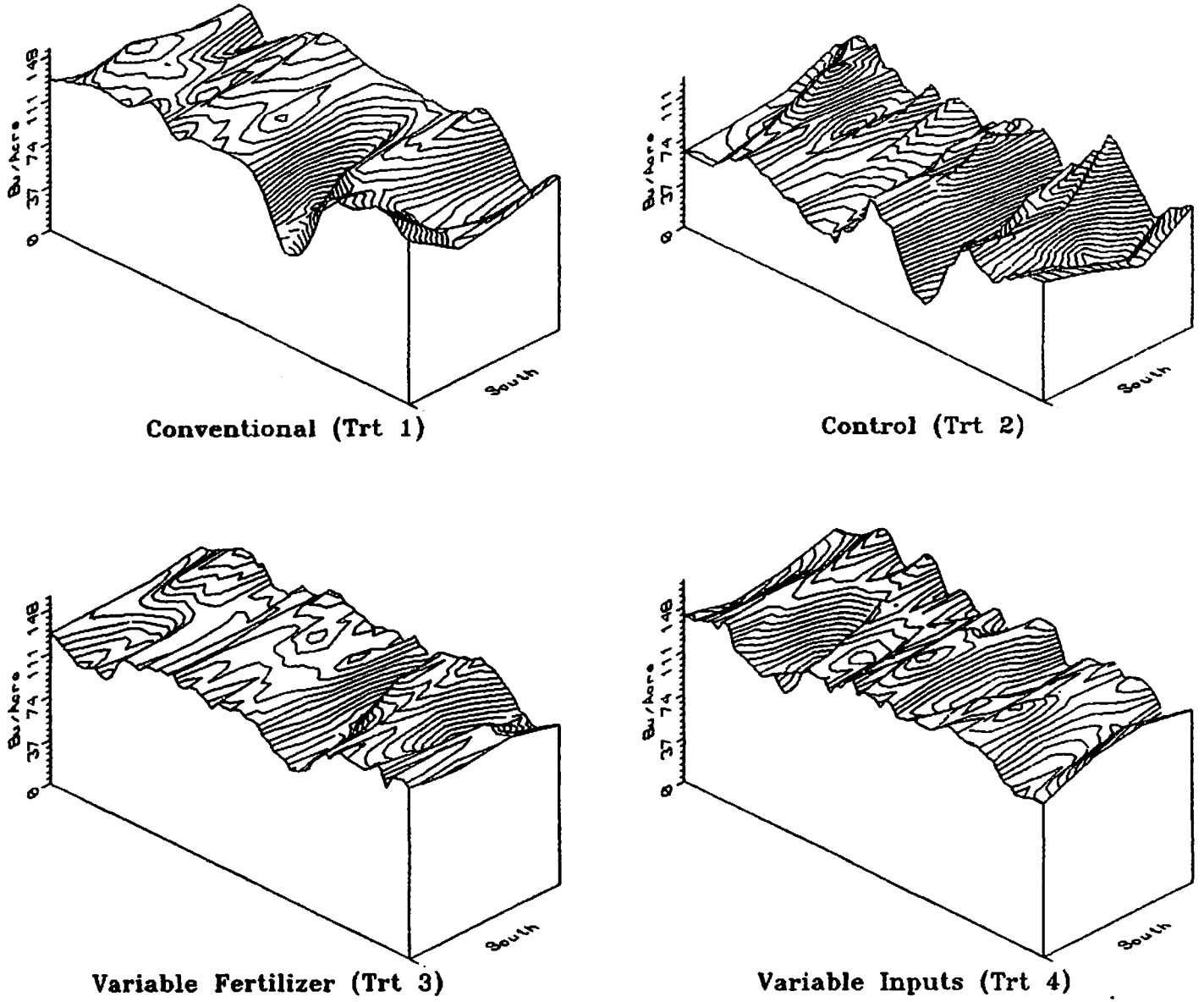

Figure 1. Yield variability.

The effect of tillage and corn hybrid on available potassium, moisture stress, and yields at Lamberton, Minnesota, 1988 and 1989[1]

J.F. Moncrief, W.W. Nelson, D.J. Fuchs, A. Eynard, and J.B. Swan[2]

Tillage and corn hybrid both affected ear leaf concentrations of potassium on a calcareous clay loam soil in southwestern Minnesota in 1988 and 1989. In neither year however were ear leaf concentrations and grain yields correlated. Grain yields were better correlated with extracted soil water at the end of the season.

Tillage has often been observed by researchers to reduce potassium availability to corn on soils with indigenously low levels (eastern Minnesota, eastern Iowa, and Wisconsin) of potassium when full width deep primary tillage is eliminated (Swan, Moncrief, and Schreiber, 1983). Recently this reduction in availability has been observed on soils that have natively high levels of potassium in western Minnesota. Three years of data at the Southwest Experiment Station, Lamberton, Minnesota has shown about a 10 bushels per acre decline in corn yield when using a ridge till system compared to moldboard plowing (Swan, Lindstrom, and Nelson; 1988). This decline has been correlated to reduced levels of tissue potassium (ear leaf at 50% silk emergence) even though soil test levels have been 250 to 300 pounds per acre. Others have also observed that the reduced potassium availability has been associated with specific corn hybrids. In dry years the apparent tillage effect on potassium availability seems to be more severe.

In an effort to evaluate tillage and corn hybrid effects on potassium availability, tillage plots were monitored at the Southwest Experiment Station at Lamberton, Minnesota in 1988.

Methods and Materials

The tillage history at this site has been maintained for three years (first established in the fall of 1985). Corn was grown in rotation with soybeans. Tillage ranges from fall plowing with a moldboard, chisel, or paraplow or elimination of primary tillage (ridge till or no till systems). The paraplow is a unique type of subsoiler that leaves the surface relatively undisturbed but lifts the soil more than a conventional subsoiling operation. The tillage is reduced following soybeans in two treatments since less crop residue is being managed. The moldboard/chisel plow system is moldboard plowed following corn and chisel plowed following soybeans. The chisel/no till system is chisel plowed following corn and no tilled following soybeans. Only the ridge till plots were cultivated on July 7. Nitrogen was applied within two days after planting as anhydrous ammonia.

The soil at this site is a Ves clay loam (Udic Haplustoll) on replications 5, 6, and 7 and Normania clay loam (Aquic Haplustoll) on rep 8. Soil samples (5 cores per composite sample) were taken to a depth of 2 feet in 6 inch increments July 5 -11. Samples were taken on July 5, 6, 7, and 11 for replications 5, 6, 8, and 7 respectively. These samples were analyzed for ammonium acetate extractable potassium and gravimetric water was determined. Potassium has not been applied since 1982 when this field received an application of 100 lbs/acre of 0-0-60 broadcast. Ear leaf samples (20 per composite sample) were taken when the silk in a given treatment was at 50% emergence and analyzed for potassium.

Leaf water potential measurements were made on July 5 and 21 with a pressure chamber technique. Water loss by the leaves between the time of excision and reading was minimized by enclosing the sample in a cooled sheath and the time was kept below 3 minutes. Two leaves per plot were sampled near the daily maximum for evaporative demand under clear conditions.

Results and Discussion

Soil and Plant Tissue Potassium

The soil test potassium (K) is in the medium range (table 1). Although there was not a statistically significant tillage or depth effect on soil test K there was a interaction between the two variables. The trend is for the surface soil test to increase as the tillage is reduced. Fertilizer has not been applied to these plots. This has been shown at other locations in Minnesota. This is due to the phytocycling of K primarily by the corn.

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[1]This project is supported by the Minnesota Agricultural Experiment Station.

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Ear leaf concentrations of K at silk emergence are shown in tables 2-4. Chisel plowing (fall of 1987) alternated with moldboard plowing (fall of 1986) resulted in the highest concentration of K (Md/Ch treatment). The no till treatment in 1988 that was chisel plowed (ch/nt) in the fall of 1986 had similar concentrations of ear leaf K. Paraplowing, ridge till, and continuous no till treatments had similar concentrations which were lower than the chisel plowing treatment. The alternative tillage (chisel plowing after corn and no till after soybeans) is more like the continuous plowing treatment than the continuous no till treatment in the no till year. The established critical level for ear leaf potassium concentrations at 50% silk emergence is 1.80%. All but the continuous plowing and chisel/no till treatments are clearly below the critical level for K. The K level in the corn is linearly related to the amount of energy required for tillage (see figure 1). The paraplow system did not follow this relationship. It appears that energy expended below the plow layer is much less efficient at loosening the soil and increasing root proliferation.

There was also a large effect of corn hybrid on ear leaf concentrations of K (table 3). The Supercross 2410 and Pioneer 3732 were the highest and lowest with the other three falling in between. In this study, the Pioneer 3732 and the DeKalb 524 were clearly below the critical level for K. Grain yields were not closely correlated with ear leaf potassium trends due to tillage or hybrid. The ridge till grown corn had low concentrations of K but tended to have the highest yield. Similarly the Pioneer 3737 had intermediate levels of K but was clearly the highest yielding hybrid. Yields were also influenced by water stress.

Soil Water and Plant Water Stress

The plant water stress and soil water in the row to a depth of two feet in July are shown in table 5. Although tillage was not statistically significant the trend was for the no till treatment to result in higher levels of soil water. Since the samples were in the row the ridge till treatment would not be expected to be higher. The plant stress measurement is a better technique to assess tillage differences and does show less plant stress than the plowing treatments.

The first plant stress measurement was made before ridging (ridge till plots were ridged on July 7). Within six days of the first measurement and the three days following ridging .68 inches of rain fell. In the next eleven days (until the second plant stress measurement) .16 inches of rain fell. The plant water stress before cultivation is rather high (corn leaves roll at about -14 to -16 bars of leaf water potential energy). At the second reading levels were somewhat lower. Air temperatures were also lower (12°F).

The distribution of soil water levels with depth were affected by corn hybrid (table 7). The Pioneer 3737 had higher levels of soil water below 6 inches. There also was a significant effect of hybrid and a tillage by hybrid interaction for the plant stress variable Table 8. The Pioneer 3737 had less plant water stress with ridge tillage. The Pioneer 3732 showed the highest and lowest stress under the moldboard/chisel plowing and continuous no till conditions respectively. The DeKalb had the lowest plant stress and was lowest under continuous no till conditions. The Funks 4327 had the highest stress under moldboard/chisel plowing conditions.

In 1989 plots were split with 20 lbs. K_2O per acre applied with the planter. The paraplowing treatment became spring discing. Only four corn hybrids were evaluated.

Tillage and corn hybrid both influenced ear leaf concentrations of potassium and grain yields. Yield differences due to tillage or corn hybrid were not very well correlated with ear leaf potassium. There was a better correlation with extracted soil water (see figure 2). There was a small but significant response to row applied K (table 9, 4 bushels per acre).

Summary

Tillage and corn hybrid had a major influence on tissue levels of K in southwestern Minnesota in 1988 and 1989. As tillage was reduced soil test K increased in the surface 6 inches from phytocycling in 1988. Also as tillage was reduced tissue K levels also were reduced. There is a linear relationship with the energy associated with tillage and tissue K levels. Systems that eliminate primary tillage resulted in lower levels of plant water stress. Although the tillage effect on grain yields was not statistically significant, they appeared to be correlated with tillage effects on moisture stress more than potassium availability. Hybrid effects on potassium availability was not correlated with grain yields. Although both tillage and corn hybrid affected ear leaf concentrations of potassium, in neither year was ear leaf concentrations correlated with grain yield differences.

Table 1. The effect of tillage and depth on soil test potassium in July, 1988 at Lamberton, Minnesota.

Depth (.174)	Tillage(.226) No til	Ridge	Md/Ch	Para	Average
	----------lbs/acre----------				
0-6"	222	218	191	203	208
6-12"	187	200	197	187	193
12-18"	201	214	203	203	205
16-24"	191	209	191	198	197
Average	200	210	195	198	201

1. The p value for the tillage by depth interaction is .022.

Table 2. The effect of tillage on corn ear leaf potassium concentration and yields at Lamberton, MN., 1988.

Tillage No til	Ridge	Md/Ch[1]	Para	Ch/NT[1]	Sign.
----------percent----------					
1.60b	1.65b	2.05a	1.57b	1.74ab	.033
-------bushels per acre-------					
69	79	72	64	67	.330

1. Tillage is alternated for corn and soybeans for these two treatments. The tillage treatment before the slash follows corn and after the slash soybeans. For the corn year tillage treatments were chisel plowing and no till for the Md/Ch and Ch/NT treatments respectively.

Table 3. The effect of corn hybrid on ear leaf potassium concentration and yields at Lamberton, MN., 1988.

Hybrid P3732	DK524	P3737	F4327	SC2410	Sign.
----------percent----------					
1.46c	1.65b	1.72b	1.78b	1.99a	<.000
------bushels per acre-------					
70	70	82	62	67	<.000

Table 4. The effect of tillage and hybrid on the concentration of potassium in corn ear leaf at 50% silk emergence at Lamberton, MN., 1988.[1]

Hybrid	Tillage No til	Ridge	Md/Ch[2]	Para	Ch/NT[2]
	----------percent----------				
P3732	1.12	1.50	1.48	1.72	1.48
DK524	1.66	1.66	1.97	1.20	1.76
3737	1.48	1.84	2.20	1.49	1.61
F4327	1.63	1.70	2.17	1.36	2.01
SC2410	2.10	1.54	2.45	2.07	1.81

1. The p value for the tillage by hybrid interaction is .024
2. Tillage is alternated for corn and soybeans for these two treatments. The tillage treatment before the slash follows corn and after the slash soybeans. For the corn year, tillage treatments were chisel plowing and no till for the Md/Ch and Ch/NT treatments respectively.

Table 5. The effect of tillage on plant moisture stress, soil water, and yield in July, 1988 at Lamberton, MN.

	Hybrid(<.000) Tillage(.020) No til	Ridge	Md/Ch[1]	Para	Average
Date(.066)[2]	----------(-bars)----------				
7/5/88	14.0	14.5	14.9	14.9	14.6
7/21/88	13.4	13.2	14.4	13.5	13.6
Average	13.7	13.9	14.7	14.2	14.1
Soil Water[3]	----------%w/w--------				
(.163)	10.5	9.6	9.7	9.9	
	-----Bushels/acre-----				
Yield(.330)	69	79	72	64	

1. Tillage is alternated for corn and soybeans for this treatment. The tillage treatment before the slash follows corn and after the slash soybeans. For the corn year the tillage treatment was chisel plowing.
2. The tillage by date interaction has a p value of .329, n=32. Ridge till plots were cultivated to form ridges on July 7.
3. Average soil water in a two foot sample taken in the row between July 5 to 11, 1988.

Table 6. The effect of corn hybrid and depth on soil water taken between July 5 and 11, Lamberton, Minnesota.

Depth (.052)	Hybrid(.357) P3737	P3732	DK524	F4327	Average
	----------%w/w----------				
0-6"	9.2	9.2	9.7	8.9	9.3
6-12"	11.6	10.8	11.2	10.6	11.0
12-18"	9.7	9.0	9.2	9.2	9.3
18-24"	10.6	9.9	9.6	9.7	9.9
Average	10.3	9.7	10.0	9.6	

1. The numbers in parenthesis are p values. The p value for the hybrid by depth interaction is .049, n=16.

Table 7. The effect of corn hybrid on plant moisture stress in July, 1988 at Lamberton, MN.[1]

	Hybrid(<.000)				
	P3737	P3732	DK524	F4327	Average
Date(.066)	(-bars)				
7/5/88	15.0	15.1	13.4	14.8	14.6
7/21/88	14.0	13.2	13.3	13.9	13.6
Average	14.5	14.2	13.4	14.4	14.1
Yield(<.000)	82	70	70	62	

1. The hybrid by date interaction has a p value of .001, n=32.

Table 8. The effect of tillage and depth on soil test potassium in July, 1989 at Lamberton, Minnesota.

	Tillage					
Depth	Ntl	Rdge	Md/ch	Ch/Nt	Dsc	Average
(<.001)	lbs/acre					
0-1'	274	263	304	202	260	275a
1-2'	267	246	282	273	239	258b
2-3'	238	219	251	259	232	233c
3-4'	167	176	185	194	178	180d
4-5'	186	190	202	190	193	192d
Avg.	226a	219a	244a	228a	220a	

Table 9. The effect of corn hybrid on ear leaf potassium concentration and yields at Lamberton, MN., 1989.

Hybrid				Row K with Planter (lbs K_2O/acre)	
P3732	DK524	P3737	SC2410	0	20
percent					
1.14a	1.17b	1.56a	1.46a	1.29a	1.37a
bushels per acre					
127c	139a	135ab	129bc	131a	135b

Table 10. The effect of tillage on corn ear leaf potassium concentration and yields at Lamberton, MN., 1988.

Tillage				
No tl	Ridge	Md/Ch[1]	Ch/NT[1]	Disc
percent				
1.23b	1.12b	1.70a	1.27b	1.34b
bushels per acre				
124b	135ab	141a	130ab	134ab

1. Tillage is alternated for corn and soybeans for these two treatments. The tillage treatment before the slash follows corn and after the slash soybeans. For the corn year tillage treatments were chisel plowing and no till for the Md/Ch and Ch/NT treatments respectively.

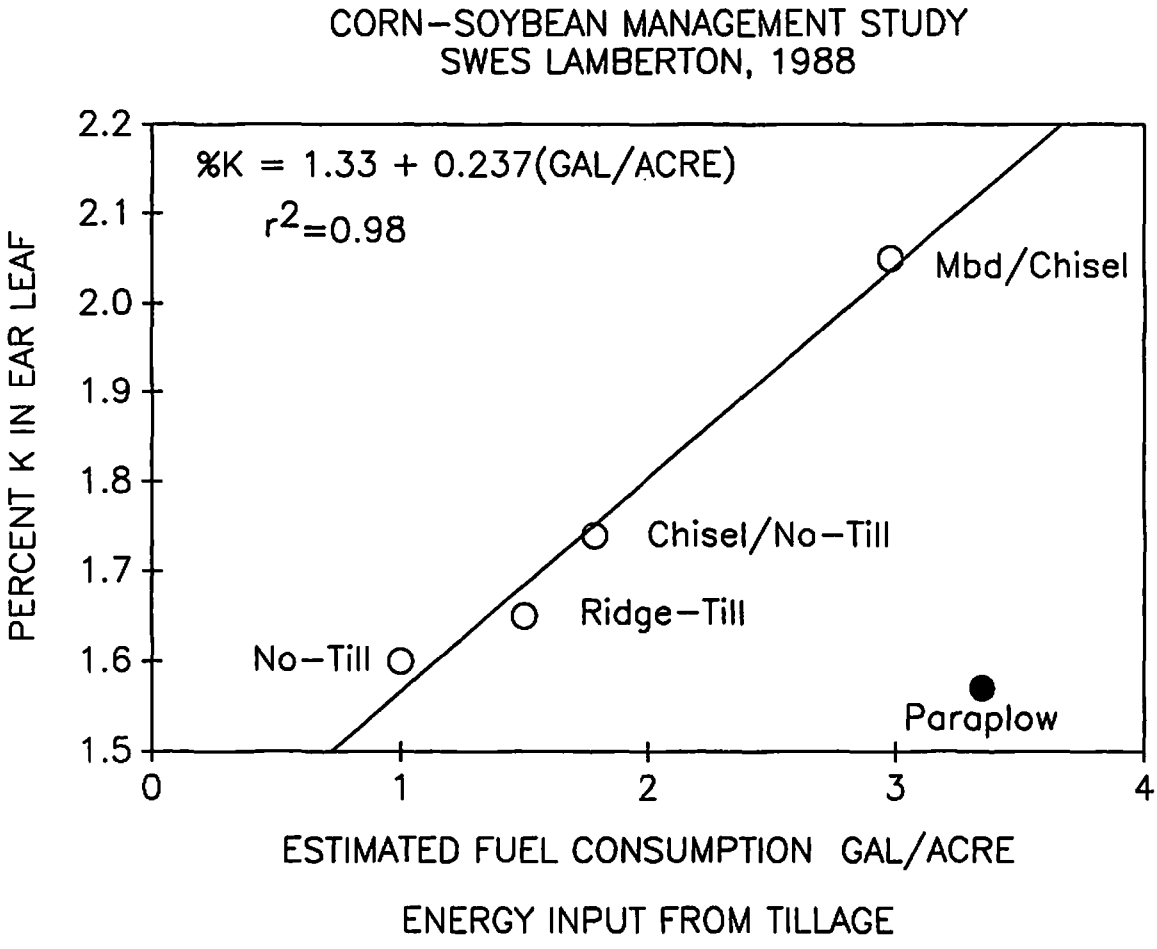
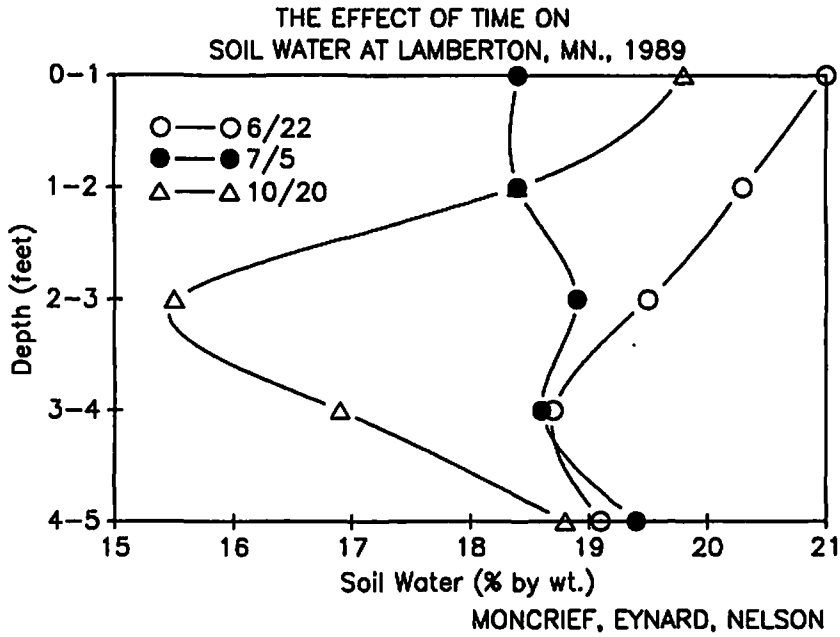


Figure 1. The relationship between energy associated with tillage and ear leaf potassium concentration.



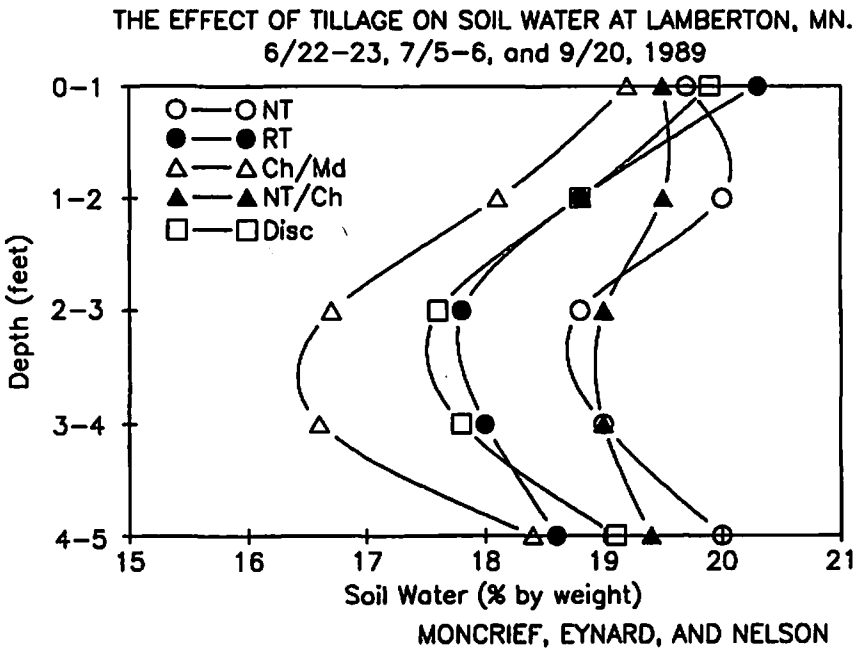


Figure 2. The effect of tillage and time on soil water during the growing season, 1989.

WEST CENTRAL EXPERIMENT STATION
WEATHER SUMMARY - 1989

		Precipitation			Temperature			Soil Temperature		
		100-yr.		Dev.	100-yr.		Dev.	(10 cm depth)		
Month	Period	1989	av.	from av.	1989	av.	from av.	1989	10 yr. av.
January	1-31	0.59	0.68	-0.09	15.7	8.0	+ 7.7	24.6	20.7
February	1-28	0.58	0.67	-0.09	2.8	12.8	-10.0	14.7	23.9
March	1-31	1.37	1.13	+0.24	21.5	26.7	- 5.2	28.9	29.2
April	1-10	0.70	0.57	+0.13	33.7	38.0	- 4.3	36.1	
	11-20	0.14	0.64	-0.50	40.4	44.4	- 4.0	40.7	
	21-30	1.56	1.05	+0.51	52.7	48.3	+ 4.4	51.6	
Total or av.		2.40	2.26	+0.14	42.1	43.6	- 1.5	42.8	41.4
May	1-10	0.78	0.77	+0.01	45.1	52.0	- 6.9	48.1	
	11-20	0.40	0.95	-0.55	63.7	55.8	+ 7.9	64.9	
	21-31	0.75	1.25	-0.50	61.1	60.0	+ 1.1	63.0	
Total or av.		1.93	2.97	-1.04	56.6	56.1	+ 0.5	58.8	57.1
June	1-10	0.03	1.29	-1.26	59.5	63.0	- 3.5	66.6	
	11-20	2.30	1.30	+1.00	64.0	66.3	- 2.3	67.5	
	21-30	2.26	1.37	+0.89	70.3	68.1	+ 2.2	74.9	
Total or av.		4.59	3.96	+0.63	64.5	65.8	- 1.3	69.6	69.3
July	1-10	2.34	1.44	+0.90	75.8	70.1	+ 5.7	83.2	
	11-20	1.64	1.06	+0.58	69.6	71.4	- 1.8	79.8	
	21-31	0.33	1.01	-0.68	73.4	71.4	+ 2.0	81.5	
Total or av.		4.31	3.51	+0.80	73.0	70.9	+ 2.1	81.5	76.7
August	1-10	0.02	1.04	-1.02	70.5	70.4	+ 0.1	80.1	
	11-20	1.88	0.93	+0.95	70.1	69.0	+ 1.1	75.8	
	21-31	1.13	1.04	+0.09	66.7	66.9	- 0.2	71.8	
Total or av.		3.03	3.01	+0.02	69.0	68.7	- 0.3	75.7	73.9
September	1-30	3.75	2.20	+1.50	58.2	59.0	- 0.8	62.1	61.5
October	1-31	1.00	1.74	-0.74	47.0	47.2	- 0.2	50.5	47.8
November	1-30	0.50	0.97	-0.47	25.9	29.7	- 3.8	33.0	33.6
December	1-31	0.39	0.68	-0.29	7.4	15.2	- 7.8	16.7	23.4
April-Aug. Growing Season		16.26	15.71	+0.55	61.1	61.0	+ 0.1	65.8	63.8
January-December Annual		24.44	23.78	+0.66	40.5	42.0	- 1.5	46.8	46.7

FOLIAR UAN CONCENTRATIONS ON HARD RED SPRING WHEAT[1]
MORRIS, 1989

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, when applied at the flag leaf stage of wheat. Results of this study indicate that increasing amounts of leaf burn occured with increasing concentrations of 28% UAN. Yield was not affected by leaf burn at the flag leaf stage of application. This same study conducted in 1988 with application of UAN at the tillering stage of growth resulted in similar results.

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 evaluate the effects of leaf burn, as related to N concentration in the spray, and if/or how much leaf burn is permissible before yield decreases occur.

Experimental Procedure: The experiment was established on a Hamerly clay loam soil (Aeric Calciaquoll). A radomized complete block design with four replications was used. Soil samples collected in the fall of 1988 showed NO_3-N levels of 78 lbs./acre in the 0-24 inch zone and 44 lbs./acre in the 24-48 inch zone. The entire plot received an additional 70 lbs. N/acre as urea on April 24. 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 at 30 psi pressure at the flag leaf stage of wheat to provide 40 lbs. N/acre for treatments 1, 2, 3, and 4, respectively. Marshall wheat was seeded at 100 lbs./acre on April 24. Bronate (.25 lbs./acre a.i.) and Hoelon (.25 lbs./acre a.i.) were broadcast for weed control on May 18 and 24 respectively. A second application of Bronate, at the same rate, was broadcast on May 30. The foliar UAN was applied on the fully emerged flag leaf on June 19 and leaf damage ratings were recorded on June 22. Sevin was applied for grasshopper control on June 28. Plant heights were recorded on July 31 and plots were harvested with a plot combine on August 1. Samples of grain were taken for grain yield, test weight, and moisture.

Results and Discussion: Leaf damage on the 100% UAN treatment was significantly greater than the 50% and 33% UAN treatments, which in turn had greater leaf damage than the 25% UAN treatment. Grain yield, test weight, grain moisture, and plant height were not affected by UAN concentration. These are the same results as achieved in 1988 when the UAN was applied at the 4-5 leaf stage of growth.

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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, when applied at 40 lbs/N acre, on spring wheat applied at tillering (1988) and flag leaf (1989) stage of growth.

Trt. No.	Spray Concentration	Leaf[1] Damage 1988	Leaf[1] Damage 1989	Plant Height 1988	Plant Height 1989	Grain Moisture at harvest 1988	Grain Moisture at harvest 1989	Test weight 1988	Test weight 1989	Grain yield at 13% moisture 1988	Grain yield at 13% moisture 1989
				- inches -		- - % - -		- lbs./bu.		bu./acre	
1	100% UAN	3.75	4.75	16.8	24.8	15.4	14.2	53.7	61.0	17.0	54.7
2	50% UAN 50% H_2O	3.50	3.75	16.3	24.3	15.6	13.9	55.8	60.8	17.8	54.5
3	33% UAN 67% H_2O	2.50	3.25	16.0	25.3	15.6	14.2	55.3	60.9	16.7	55.9
4	25% UAN	2.00	2.00	16.0	25.3	15.4	14.3	56.1	60.8	16.8	55.4
Signif. level (%)		<99	>99	31	91	59	34	90	11	43	81
BLSD (.05)		0.8	0.7	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)		16.3	13.9	6.2	2.2	1.1	3.0	2.3	0.6	7.6	1.7

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

CHLORIDE FERTILIZER ON SPRING WHEAT[1]
Morris, 1987-89

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

ABSTRACT: A three year study to determine the need for chloride fertilizer for spring wheat production in west central Minnesota was completed in 1989. The experiment was established on a Hamerly clay loam (Aeric Calciaquoll) soil with soil tests that indicated possible chloride response. Two rates of chloride fertilizer were band applied at seeding in 1988 and 1989 on Marshall and Guard. In 1987 the study included only Marshall at two chloride rates. No agronomic responses from chloride fertilization occurred in any of the three years. In 1988 and 1989 there were significant differences between varieties, but no interaction between variety and chloride.

There has been interest in increasing yields of hard red spring wheat through chloride fertilization. This study was set up to evaluate the yield response to 2 rates of chloride fertilizer. Studies in South Dakota have indicated that Marshall responds to chloride fertilization and Guard does not.

Experimental Procedure: In 1989 the experiment was established on a Hamerly clay loam soil. Plot size was 8 ft. X 45 ft. and a randomized complete block design with 4 replications was used. Soil samples collected in the fall of 1988 showed NO_3-N levels of 78 lbs./acre in the 0-24 inch zone and 44 lbs./acre in the 24-48 inch zone. The entire plot received an additional 70 lbs. N/acre as urea on April 24. Treatments 1, 2, and 3, were 0, 15, and 30 lbs. chloride/acre, respectively. The experiment was seeded to Marshall and Guard wheat varieties at 100 lbs./acre on April 24. Chloride fertilizer (using KCl, 0-0-60, as the chloride source) was applied through the drill in a band next to the seed at seeding. Bronate (.25 lbs./acre a.i.) was broadcast for weed control on May 18 and a second application at the same rate was made on May 30. Hoelon (.25 lbs./acre a.i.) was broadcast for grass control on May 24. Emergence was uniform on all plots with wheat fully emerged on May 9. Heading dates and plant heights were recorded at maturity. On June 28 the plots were sprayed with Sevin for grasshopper control. Plots were harvested with a plot combine on July 31 and the total grain sample was weighed for grain yield. A grain sample was saved for bushel weight and grain moisture.

Results and Discussion, 1989: There were no significant effects of chloride on plant height, heading date, grain moisture, bushel weight, or grain yield (Table 1) yielded significantly more than Guard, but there was no interaction of variety and chloride on yield. Yields averaged 50 bu./acre with good growing conditions.

Results and Discussion, 1987 - 1989: In 1987, 1988, and 1989 there were no significant effects of chloride fertilization on plant height, grain moisture, heading date, or grain yield (Table 2). In 1987 bushel weight was significantly affected by chloride, but the bushel weight data was quite variable. There were no significant effects on bushel weight in 1988 and 1989. In both 1988 and 1989 there was a significant effect of variety on yield, but no interaction between variety and chloride (Table 3). With soil tests for chloride in the top 2 feet testing at 23 lbs./acre in 1987, 28 lbs./acre in 1988, and 16 lbs./acre in 1989, the possibility of a response to chloride fertilizer was expected. Rates of chloride applied in 1987, 1988, and 1989 are given in table 4. Even with low chloride soil tests and high chloride application rates, there were no effects on yield. This non-response to chloride over the last 3 years indicates the possibility (1) that chloride requirements for wheat are much less than we expected, (2) that chloride fertilization has not been fine tuned enough to be a profitable practice at this time, or (3) that the wheat was able to obtain sufficient chloride from depths below 24 inches.

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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. Effect of chloride treatment on date of heading, plant height, grain moisture, bushel weight, and grain yeild on wheat, 1989.

Treatment No.	Chloride	Date of Heading	Plant Height	Grain Moisture	Test Weight	Yield
	lbs/acre		inches	%	lbs./bu.	bu./acre
1	0	6/22	24.4	13.1	60.7	51.1
2	15	6/22	23.8	12.8	60.6	49.1
3	30	6/22	24.3	13.0	60.7	51.2
Signif. level (%)		0	62	56	45	48
LSD (.05)		NS	NS	NS	NS	NS
CV (%)		NS	2.1	3.2	0.3	7.4

Table 2. Statistical analysis of wheat chloride study for 1987, 1988, and 1989

Year	Plant Height	Grain Moisture	Test Weight	Date of Heading	Grain Yield
1987					
Signif. level (%)	76	43	>99	---	83
LSD (.05)	NS	NS	3.3	---	NS
CV (%)	3.5	13.3	3.6	---	6.0
1988					
Signif. level (%)	78	26	12	0	31
LSD (.05)	NS	NS	NS	NS	NS
CV (%)	5.9	5.2	1.6	NS	8.2
1989					
Signif. level (%)	62	56	45	0	48
LSD (.05)	NS	NS	NS	NS	NS
CV (%)	2.1	3.2	0.3	NS	7.4

Table 3. Effect of variety and chloride on grain yield, 1988 and 1989.

Variety	1988 Grain Yield bu./acre	Variety	1989 Grain Yield bu./acre
Marshall	16.5	Marshall	53.8
Guard	14.2	Guard	47.2
Chloride -lbs./acre -		**Chloride** -lbs./acre -	
0	15.7	0	51.1
17	15.0	15	49.1
35	15.4	30	51.2
Variety **Chloride** lbs./acre		**Variety** **Chloride** lbs./acre	
Guard + 0	15.0	Guard + 0	49.2
Marshall + 0	16.5	Marshall + 0	52.9
Guard + 17	13.6	Guard + 15	46.3
Marshall + 17	16.3	Marshall + 15	52.0
Guard + 33	14.0	Guard + 30	46.0
Marshall + 33	16.8	Marshall + 30	56.4
Signif. level (%)		**Signif. level (%)**	
Chloride	31	Chloride	48
Variety	>99	Variety	>99
Interaction	40	Interaction	76

Table 4. Summary of plant measurements for 1987, 1988, and 1989.

Year	Chloride Treatment	Plant Height	Grain Moisture	Test Weight	Date of Heading	Grain Yield
- - - -	lbs./acre - -	inches - - -	% - - - -	lbs./bu. - - -	- - - - -	bu./acre
1987	0	21.3	16.5	55.8	---	32.9
	20	20.8	18.3	48.8	---	30.0
	40	21.8	17.9	52.2	---	32.3
1988	0	14.9	15.4	57.0	6/13	15.7
	17	15.6	15.4	57.0	6/13	15.0
	35	14.6	15.6	56.9	6/13	15.4
1989	0	24.4	13.1	60.7	6/22	51.1
	15	23.8	12.8	60.6	6/22	49.1
	30	24.3	13.0	60.7	6/22	51.2

WINTER UREA APPLICATION ON HIGH PH SOILS[1]
MORRIS, 1989

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

ABSTRACT: This study was designed to record the effects of winter application of urea nitrogen on high pH soils for corn production. Applying nitrogen during the winter months may help reduce fall and spring workloads allowing for timely spring planting, but losses may occur due to application of the nitrogen on frozen soil and/or snow. Results in 1989 showed no differences between winter application and traditional spring application of nitrogen.

Objective: The nitrogen retention study was designed to record the effects of winter application of nitrogen on high pH soils for corn production. Applying nitrogen fertilizer during non-cropping times may allow for more timely spring planting operations. The retention study had four treatments: 1) a check with no nitrogen application, 2) nitrogen applied on frozen soil, 3) nitrogen applied in mid-winter with at least a 3-inch snow cover, and 4) nitrogen applied in the spring prior to corn planting. This study will determine if nitrogen loss primarily from volatilization is a problem with late fall and mid-winter applications of urea on high pH soils.

Experimental Procedure: The experimental site was established on a McIntosh silt loam (Aeric Calciaquoll) in 1988 and was cropped to wheat. Soil tests in the fall of 1988 were as follows: pH=7.9, $NaHCO_3$ P=27 lbs./acre, K=357 lbs./acre, NO_3-N (0-24 inches) = 113 lbs./acre, and NO_3-N (24-48 inches) = 84 lbs./acre. The area was moldboard plowed October 28, 1988 and the plots were flagged out October 31. The frozen soil treatment (Trt. 2) was applied on November 17, 1988 on frozen soil with cover depth of 4 to 6 inches. The spring treatment (Trt. 4) was applied April 25, 1989. Urea (46-0-0) was applied to provide 100 lbs. N/acre. The experimental area was field cultivated first on April 25 (immediately after Trt. 4 was applied) and again on May 3. The plot area was seeded to Pioneer 3906 corn at 30,000 seeds/acre on May 3. Lasso @ 3.0 lbs./acre a.i. + Bladex @ 2.2 lbs./acre a.i. were broadcast preemergence after corn planting on May 3. The experiment was sprayed postemergence on June 6 and again on June 15 with Atrazine (0.75 lbs./acre a.i.) and 1 qt./acre of crop oil concentrate. The experiment was cultivated on June 16, stand count taken on June 23, and tasseling and silking notes taken in July. The plots were harvested on October 3 with a plot combine and grain yield, moisture, and test weight were recorded. The harvest area was four 65-foot rows.

Results and Discussion: Plant measurements are given in Table 1. No differences were found between treatments for tassel date, silk date, grain yield, grain moisture, or grain test weight. This was probably due to the high residual soil NO_3-N levels indicated by the lack of nitrogen response when the check treatment is compared to the other treatments. The experiment will be conducted again in 1990.

Table 1. Winter Urea Application Study, Morris 1989 - Plant Measurements

Trt. No.	Treatment Description	Tassel Date from 7/1	Silk Date from 7/1	6/23 Plant Popn.	Grain Yield	Grain Moisture	Grain Test Weight
				1000's/A	bu./A	%	lbs./bu.
1	Check	22.3	24.5	28.6	158.5	22.2	54.0
2	Frozen Ground	22.0	24.3	29.0	157.3	22.2	55.1
3	Snow Cover	22.3	24.8	29.5	155.8	22.3	55.1
4	Spring	22.8	24.8	29.9	154.4	22.5	54.3
Signif. Levels:							
Treatment (%)		43	14	24	10	9	69
BLSD	(.05)	NS	NS	NS	NS	NS	NS
CV	(%)	3.4	3.9	6.0	5.3	3.0	1.8

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

CONTINUOUS CORN SILAGE[1]
MORRIS, 1989

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 24 years show no yield differences due to the removal of silage versus grain. A significant difference in yield exists between the long-term high and low fertilizer rates.

Objective: This is the 24th year of a continuing study initiated in 1965 on a McIntosh silt loam soil. The study was initiated to determine the effects of removal of continuous corn silage and fertilizer rate on soil properties and yield. Half the plots receive a fertilizer rate of 74+48+48 ($N+P_2O_5+K_2O$) lbs/acre and the other half a rate of 148+96+96.

Experimental Procedure: The experiment is set up as a latin square with 4 treatments: (1) silage, low fertility (2) silage, high fertility (3) grain, low fertility (4) grain, high fertility. The fertilizer was applied Oct. 18, 1988. The experimental area was moldboard plowed on Oct. 20, 1988 and field cultivated on April 25 and again on May 3, 1989. Dekalb 461 was planted at 30,000 seeds/acre on May 3. Counter 15G was applied in the row at seeding at 10 lbs/acre (1.5 lbs./acre a.i.). Lasso @ 3 lbs./acre a.i. + Bladex @ 2.2 lbs./acre a.i. were applied preemergence broadcast om May 3. Silage yields were taken from 3 10-foot rows on September 20 and grain yields were taken from 2 45-foot rows on October 3. 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 2 measured areas.

Results and Discussion: Silage yields are given in Table 1. There were no significant differences in silage yields in 1989. The 24-year average shows no effect of silage versus grain but does show significant differences between high and low fertility treatments. Grain yields and an average of the two unfertilized checks adjacent to the experimental area are given in Table 2. The 24-year average and 1989 yields show no significant differences in grain yield between the high and low fertility treatments.

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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 continuous silage or grain on silage yields.

Treatment	1989 Yield	1966-89 Yield
	----- dry matter, tons/acre -----	
Silage, low fertility	7.26	5.51
Silage, high fertility	7.89	6.02
Grain, low fertility	8.02	5.57
Grain, high fertility	7.56	5.87
Signif. levels (%)		
Treatment	91	>99
Year	--	>99
Treatment x year	--	99
LSD, treatment (.05)	NS	0.22

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

Treatment	1988 Yield	1966-89 Yield
	----- bu./acre @ 15.5% M. ------	
Grain, low fertility	131.0	86.5
Grain, high fertility	120.9	91.1
Signif. levels (%)		
Treatment	93	>99
Year	--	>99
Treatment x year	--	>99
LSD, treatment (.05)	NS	5.9
	----- bu./acre @ 15.5% M. ------	
Grain, check	48.2	46.8
	----- dry matter, tons/acre -----	
Silage, check	4.54	3.56

EFFECT OF TILLAGE AND SUBSOILING ON SOIL WATER RECHARGE AND CORN YIELDS[1]
Morris, 1989

S.D. Evans, M.J. Lindstrom, J.F. Moncrief, W.B. Voorhees, and G. A. Nelson[2]

Abstract: Many producers are using subsoilers to alleviate expected compaction due to traffic from tillage, planting, and harvesting equipment. In the fall of 1989 a study was initiated at the West Central Experiment to study the effects of a one-time subsoiling and its interaction with various primary tillage systems on subsequent soil water recharge and corn growth and yield. In the spring of 1989 it was found that the subsoiled areas had a lower bulk density and a lower volumetric moisture content that non-subsoiled areas. By the fall of 1989 the moisture differences disappeared, but the bulk density differences remained. Traffic from planting, cultivating, and harvesting equipment repacked the soil to its original density. There were no effects of tillage or subsoiling on corn grain yields.

Objectives: A 3 year study was initiated at the West Central Experiment Station in the fall of 1988 to study the effects of a one-time subsoiling on subsequent soil bulk density, soil moisture, corn growth, and corn yield in 4 primary tillage systems: fall moldboard plow, fall chisel plow, spring disk, and no-till. The experiment was established on a Hamerly clay loam (Aeric Calciaquoll) and Aastad clay loam (Pachic Udic Haploboroll) complex and will be cropped to continuous corn.

Tillage, Planting, and Harvest Procedures: The experimental plot area was established the fall of 1988. The entire plot area was fertilized with 150 lbs. P_2O_5/acre + 10 lbs. Zn/acre on October 13,1988. Four main plot treatments were then established in the experimental plot area with each treatment split into subsoiled and non-subsoiled subtreatments. A split plot design with 4 replications was used with plots 30 feet wide by 100 feet long. The 1988 crop was corn harvested as silage. The plot areas will be seeded with a 6-row planter to continuous corn for the 3 year duration of the study. The treatments are moldboard, subsoiled (MSS); moldboard, no subsoiling (MNS); chisel, subsoiled (CSS); chisel, no subsoiling (CNS); no-till, subsoiled (NSS); no-till, no subsoiling (NNS); spring disk, subsoiled (DSS); and spring disk, no subsoiling (DNS). One-half of each main plot was subsoiled on October 14, 1988. A 5-tooth subsoiler with a 30-inch tooth spacing operating approximately 16 inches deep was used on the MSS, CSS, and NSS treatments. A paraplow operating approximately 13 inches deep was used on the DSS treatment. The MSS, CSS, NSS, and DSS plots were not tilled with any other implement in the fall of 1988. The non-subsoiled treatments were treated as follows: (1) The MNS treatment was plowed using an onland hitch with 6 18-inch bottoms and CNS treatment was chiseled with a mounted 10-foot chisel plow, (2) The MSS and CSS treatments were not moldboard plowed or chisel plowed before or after the subsoiling operation in the fall of 1988, and (3) The DNS and NNS treatments were not tilled in the fall of 1988.

Crop residue measurements were taken on April 19, 1989. On May 11 the MSS, MNS, CSS, CNS, DSS, and DNS plots were all disked for seedbed preparation. All wheel traffic from tractors during the tillage operations were confined to the position to be used by the tractor pulling the corn planter. The NSS and NNS treatments were not tilled. The plots were seeded to corn, Pioneer 3772 @ 30,000 seeds/acre, on May 12 with a 6-row planter. Counter 15G @ 10 lbs./acre (1.5 lbs./acre a.i.) was applied at seeding. No starter fertilizer was used. Lasso + Bladex (3 + 2.2 lbs./acre a.i. respectively) was broadcast preemergence on May 15. Crop residue measurements after planting were taken on May 17. Anhydrous ammonia was applied at 120 lbs. N/acre on May 22 with a 6-row mounted applicator. Two 10-foot rows in each plot were staked out on May 22 and heights of corn plants were measured on June 15, June 28, July 10, and July 27 to record any plant growth differences. Plots were cultivated on June 16 and sprayed with Atrazine @ 2 lbs./acre a.i. + Tandem @ .75 lbs./acre a.i. for control of escaped weeds on July 7. Tasseling and silking notes were recorded between July 21 and 27. A final stand count was taken in the harvest areas on August 25. Each plot had 2 2-row harvest areas at least 60 feet in length. Plots were harvested for grain with a JD 3300 combine on October 3-4, 1989, again restricting traffic to areas

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[1]Funds provided by West Cent. Expt. Sta., Univ. of Minnesota. Measurements taken by USDA-ARS, Morris, MN, and Soils Dept. Univ. of Minnesota.

[2]S.D. Evans and G.A. Nelson are Professor and Junior Scientist respectively with the West Cent. Expt. Sta., Univ. of Minnesota. M.J. Lindstrom and W.B. Voorhees are Soil Scientists with the Agricultural Research Service, USDA, Morris, MN, and J.F. Moncrief is Associate Professor, Soil Science Dept., Univ. of Minnesota.

previously tracked either by tractor or planter wheels. A grain sample was retained for further analysis. Corn stalks were chopped on MSS, MNS, CSS, and CNS treatments. The MSS and MNS treatments were plowed using an onland hitch with 6 18-inch bottoms and CSS and CNS treatments were chiseled with a 15-foot pull type chisel plow on October 23, 1989. Post-tillage crop residue measurements were taken on November 1.

Soil Sampling Procedures: Three cores were taken from each plot in the fall of 1988, prior to any subsoiling or other tillage, for bulk density and soil moisture determination. Two cores were taken to a depth of 60 inches in increments of 0-6, 6-12, 12-18, 18-24, 24-30, 30-36, 36-48, and 48-60 inches on October 11 and 12, 1988. One additional core was taken in the same manner only to a depth of 24 inches. The soil samples were weighed, dried at 105°C, and weighed back for bulk density and soil moisture determination. Penetrometer readings were taken on October 12.

On May 15, 1989, after spring tillage and corn planting, two 2-foot soil cores were taken in tractor wheel traffic areas and two 2-foot soil cores were taken in non-wheel tracked areas of each plot. No attempt was made to keep track of the subsoiler slots, so some sampling may have coincided with the slots and some sampling would have occurred in areas between subsoiler slots. Spring soil moisture and bulk density were then determined from these samples. Penetrometer readings were also taken on May 15. After grain harvest in the fall of 1989, but before any fall tillage, two 5-foot soil cores (0-6, 6-12, 12-18, 18-24, 24-36, 36-48, 48-60 inch increments) were again taken in tractor wheel tracked and non-wheel tracked areas of each plot. Bulk density was determined on the 0 to 24-inch samples and soil moisture was determined on the 0 to 60-inch samples. Sampling took place on October 10 and 11 and penetrometer readings were taken on October 11.

Measurements and Discussion: Growing conditions were very good in 1989 with very timely rainfall. As a result of this, corn growth was excellent and grain yields were very high. Summaries of residue and plant measurements are given in Table 1. Fall subsoiling significantly reduced residue cover both before spring tillage and after planting and there were significant differences in residue measurements between tillage systems, but there was no tillage by subsoiling interaction in the post-plant measurements. There was a significant tillage by subsoiling interaction on the residue measurements made prior to spring tillage (Tables 1 and 2). This was due to a decrease in residue cover from subsoiling on all tillage treatments except moldboard. With moldboard plow the MSS treatment received only a subsoiling and was not moldboard plowed in the fall of 1988. The MNS treatment was moldboard plowed and this left a residue cover of only 9.5%. Harvest population was significantly influenced by tillage. The no-till treatments averaged more plants/acre than the moldboard and chisel plots, but yielded the same. Therefore, no-till had fewer ears or smaller ears. Grain yield, % moisture, and bushel weight, were not influenced by tillage, subsoiling, or their interaction. The height of corn plants measured at 2 week intervals (data not shown) beginning 33 days after planting was not influenced by any of the tillage and subsoiling treatments.

There was a significant wheeltrack by subsoiling interaction on bulk density both in the spring and fall of 1989 (Table 3). Bulk density was decreased by subsoiling , but tractor traffic increased the bulk density to the point that there were no differences between subsoiled and non-subsoiled areas (Table 4). The subsoiling by depth interaction was significant in the fall of 1989 (Table 6). Subsoiling decreased bulk densities in the top 12 inches of soil while below that depth bulk density differences were not observed. There was a significant wheeltrack by soil depth interaction on bulk density in both the spring and fall of 1989. Below the 12-inch depth the presence of wheel tracks did not affect bulk density while above the 12-inch depth bulk density was significantly increased by wheel traffic (Tables 5 and 7). The tillage by wheel traffic interaction in the fall of 1989 (Table 8) shows that the moldboard and chisel treatments had lower bulk densities than the spring disk and no-till treatments in the absence of wheel traffic. Once the treatments were subjected to wheel traffic the differences were not apparent.

Statistical analysis (Table 9) shows that three of the 2-way interactions significantly affected volumetric moisture content in the spring of 1989. The wheel traffic by depth interaction (Table 10) shows that moisture content was greater in the wheel track than in non-wheel track zones at the 0-12 inch depth, while at the 12-24 inch depth there was little difference in moisture content. The subsoiling by depth interaction (Table 11) shows a similar pattern with differences above the 12-inch depth and no differences below the 12-inch depth. The wheel traffic by subsoiler interaction (Table 12) shows a greater difference between NWT and WT where the soil was subsoiled than there it was not subsoiled. In the wheel track areas subsoiled and non-subsoiled areas were nearly equal in moisture content.

In the fall of 1989 the main effect of subsoiling (Table 13) shows slightly greater volumetric moisture in the non-subsoiled areas. The wheel traffic by depth interaction (Table 14) shows equal or greater moisture content under wheel traffic as compared to non-wheel traffic areas, but the greatest differences occur at the 0-6 and 6-12 inch depths. The tillage by wheel traffic interaction in the fall of 1989

(Table 15) shows a lower water content on the moldboard, non-wheel tracked treatment as compared to the chisel, spring disk, and not-till treatments in the non-wheel track areas. Once the treatments were tracked the differences were not apparent.

In conclusion, results from the first year of a three year study, show subsoiling had no effect on grain yield and most other agronomic characteristics in 4 different primary tillage systems. Bulk density was significantly affected by subsoiling, but wheel traffic from tillage and planting tractors repacked to essentially the initial bulk density. Volumetric soil moisture content was significantly affected by subsoiling, wheel traffic, and interactions of these with each other with soil depth. In general, moisture was greater in the wheel tracked and non-subsoiled areas in the top 12 inches of the soil. Below 12 inches there was very little difference in volumetric moisture content. The moisture content was lower in the non-wheel tracked, moldboard treatments than in all other treatments in the fall of 1989.

Growing season precipitation was very timely in this plot site in 1989 and thus differences in soil water and soil physical properties did not translate into yield differences. Under wetter or drier soil conditions, different results may be expected.

Table 1. Summary of plant measurements due to tillage and subsoiling, 1989.

Treatment	4/19	5/17	Tassel Date from 7/1	Silk Date from 7/1	Harvest Plant Popl'n. x 10^{-3}	Grain Hvst. Mst.	Grain Yield 15.5%M.	Grain Test Wt.
	- % cover -				pl/ac	%	bu/ac	lbs/bu
Moldboard	19.0	7.5	22.6	23.6	26.2	20.9	160.2	56.5
Chisel	31.2	11.5	22.9	24.1	26.8	20.9	158.8	56.6
Spr. Disk	49.5	17.0	23.0	24.1	27.0	21.0	157.0	56.3
No-Till	35.8	21.8	23.3	24.8	28.5	21.1	153.7	56.3
Main plots:								
Signif. Level (%)	>99	>99	21	71	96	34	54	23
LSD(.05)	5.6	7.0	NS	NS	1.7	NS	NS	NS
C.V.(%)	21.8	34.4	2.1	2.4	4.1	1.5	4.0	1.0
Subsoiled	29.1	11.8	23.1	24.3	26.7	21.0	157.5	56.3
Not Subsl.	38.6	17.1	22.8	24.1	27.5	21.0	157.3	56.5
Sub-plots:								
Signif. Level (%)	>99	>99	83	62	93	13	6	56
Interaction:								
Signif. Level (%)	>99	87	89	60	48	49	54	39

Table 2. Effect of tillage treatments on residue cover in 1989.

Trt.	4/19/89	5/17/89
	- - - - % cover	- - - -
MNS	9.5	7.5
MSS	28.5	7.5
CNS	38.5	14.5
CSS	24.0	8.5
DNS	57.5	18.5
DSS	41.5	15.5
NNS	49.0	28.0
NSS	22.5	15.5

Table 3. Statistical analysis of bulk densities in subsoiler study.

Variable	10/11-12/88	5/15/89	10/10-11/89
	- - - - - - -	Pr>F	- - - - - - - -
Tillage (T)	.1217	.1157	.1025
- - - - - - - Using Rep * T as an error term - - - - - - - -			
Subsoiling (SS)	.4717	.0079	.0051
T * SS	.5412	.7136	.2761
- - - - - - - Using Rep * T * SS as an error term - - - - -			
Wheel Traffic (WT)	- -	.0001	.0001
T * WT	- -	.1013	.0397
SS * WT	- -	.0014	.0005
T * SS * WT	- -	.9367	.1258
- - - - - - - Using Rep * T * SS * WT as an error term - - -			
Depth (D)	.0001	.0001	.0001
T * D	.0001	.5022	.5668
SS * D	.8673	.1135	.0001
WT * D	- -	.0449	.0001
T * SS * D	.1962	.5574	.8035
T * WT * D	- -	.9569	.1687
SS * WT * D	- -	.6424	.0001
T * SS * WT * D	- -	.6933	.2765
C.V. (%)	4.0	10.2	5.5

Table 4. Effect of subsoiling and wheel traffic on bulk density, 1989.

	4/19/89			5/17/89		
Trt.	NSS	SS	Mean	NSS	SS	Mean
	- - g/cm³ - -			- - g/cm³ - -		
NWT	1.30	1.18	1.24	1.26	1.17	1.28
WT	1.39	1.38	1.39	1.38	1.38	1.38
Mean	1.35	1.28		1.32	1.28	

Table 5. Effect of wheel traffic and depth on bulk density, 5/17/89.

	Depth (inches)		
Trt.	0-12	12-24	Mean
	- - g/cm³ - -		
NWT	1.10	1.38	1.24
WT	1.30	1.47	1.39
Mean	1.20	1.43	

Table 6. Effect of subsoiling and depth on bulk density, 10/10-11/89.

Trt.	Depth (inches) 0-6	6-12	12-18	18-24	Mean
	g/cm³				
SS	.91	1.30	1.40	1.50	1.28
NSS	.98	1.40	1.44	1.47	1.32
Mean	.95	1.35	1.42	1.48	

Table 7. Effect of traffic and depth on bulk density, 10/10-11/89.

Trt.	Depth (inches) 0-6	6-12	12-18	18-24	Mean
	g/cm³				
NWT	.72	1.28	1.40	1.47	1.21
WT	1.19	1.42	1.44	1.50	1.38
Mean	.95	1.35	1.42	1.48	

Table 8. Effect of tillage and wheel traffic on bulk density, 10/10-11/89.

Trt.	Moldboard	Chisel	Spring Disk	No-Till	Mean
	g/cm³				
NWT	1.18	1.18	1.26	1.23	1.21
WT	1.40	1.36	1.41	1.37	1.38
Mean	1.29	1.27	1.33	1.30	

Table 9. Statistical analysis of volumetric moisture content in subsoiler study.

Variable	10/11-12/88	5/15/89	10/10-11/89
	- - - - - - -	Pr>F	- - - - - - - - -
Tillage (T)	.7556	.1497	.8443
- - - - - - - Using Rep * T as an error term - - - - - - - - -			
Subsoiling (SS)	.2330	.0132	.0122
T * SS	.1557	.9983	.5366
- - - - - - - Using Rep * T * SS as an error term - - - - -			
Wheel Traffic (WT)	- -	.0001	.0001
T * WT	- -	.0169	.1335
SS * WT	- -	.0008	.3603
T * SS * WT	- -	.7793	.2570
- - - - - - - Using Rep * T * SS * WT as an error term - - -			
Depth (D)	.0001	.2640	.0001
T * D	.8254	.7138	.5195
SS * D	.7566	.0443	.3798
WT * D	- -	.0008	.0001
T * SS * D	.8376	.4612	.9405
T * WT * D	- -	.9720	.9992
SS * WT * D	- -	.1965	.3359
T * SS * WT * D	- -	.3684	.9999
C.V. (%)	9.1	8.6	15.5

Table 10. Effect of wheel traffic and depth on volumetric water content, 5/15/89.

Trt.	Depth (inches) 0-12	12-24	Mean
	- - - - - - -	%	- - - - - - - - - -
NWT	30.8	32.0	31.4
WT	35.8	33.4	33.4
Mean	33.3	32.7	

Table 11. Effect of subsoiling and depth on volumetric water content, 5/15/89.

Trt.	Depth (inches) 0-12	12-24	Mean
	- - - - - - -	%	- - - - - - - - - -
SS	31.7	32.2	31.9
NSS	34.9	33.3	34.1
Mean	33.3	32.7	

Table 12. Effect of subsoiling and wheel traffic on volumetric water content, 5/15/89.

Trt.	NSS	SS	Mean
	%		
NWT	33.0	29.8	31.4
WT	35.1	34.1	34.6
Mean	34.1	31.9	

Table 13. Effect of subsoiling on volumetric water content, 10/10-11/89.

Trt.	Water Content
	- % -
SS	33.5
NSS	35.4

Table 14. Effect of wheel traffic and depth on volumetric water content, 10/10-11/89.

Depth	Wheel Traffic No	Wheel Traffic Yes	Mean
inches	%		
0-6	18.6	30.6	24.7
6-12	35.2	39.1	37.1
12-18	33.4	33.4	33.4
18-24	31.2	32.5	31.9
24-36	34.8	36.4	35.6
36-48	37.6	39.2	38.4
48-60	39.3	40.9	40.2
Mean	32.9	36.0	

Table 15. Effect of tillage and wheel traffic on volumetric water content, 10/10-11/89.

Trt.	Moldboard	Chisel	Spring Disk	No-Till	Mean
	%				
NWT	29.0	31.2	32.5	32.9	31.4
WT	33.7	34.9	35.0	34.8	34.6
Mean	31.3	33.1	33.8	33.9	

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

Morris, 1989

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

ABSTRACT: This study completed its 19th year in 1989 and will continue. Nitrate movement and yield responses from two initial annual applications of manure have been measured. Results over 19 years show 1986 as the first year the fertilized check yielded significantly more than the manure treatments and this occurred again in 1989. In 1987 the fertilized check yielded more than the manure treatments, but yields were not significantly greater. In 1988 all yields were low due to the drouth and averaged 50 bu./acre. Soil samples taken to a depth of 4 feet in the fall of 1989 showed that the fertilized treatment had more NO_3-N in the root zone than any of the manure treatments. Mineralization of organic N from the manure treatments has evidently slowed to a point were less N is being mineralized from the manure treatments than is being supplied by the mineralization and annual fertilizer applications on the fertilized treatment.

This is the 19th 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-136,000 gal/acre, and Liquid Hog Manure-136,000 gal/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).

Experimental Procedure: The fertilized plots received 120+50+50 ($N+P_2O_5+K_2O$) lbs./acre on October 18,1988 and the entire was moldboard plowed the same day. The study was planted to Pioneer 3906 corn at 30,000 seeds/acre on May 3. Counter 15G was applied at 10 lbs./acre (1.5 lbs./acre a.i.) in the row at seeding. Lasso and Bladex (3.0 lbs./acre a.i. + 2.2 lbs./acre a.i. respectively) tank mix were applied broadcast preemergence on May 3. Plots were sprayed with Basagran (0.75 lbs./acre a.i.) on June 15. Plots were cultivated twice, June 16 and June 21. Corn heights and plant samples were taken on June 21. Tasseling and silking dates were recorded and ear leaf samples were also taken at the mid-silk date. Two 10-foot rows were harvested for silage yields on September 20. Grain yields were calculated from two 110-foot rows harvested with a plot combine on October 3. Three soil cores were taken from each plot in the fall of 1989 to a depth of 4 feet in 1-foot increments. These cores were combined, subsampled, and submitted for nitrogen analysis.

Results and Discussion: Early plant height, early plant dry weight, grain yields, and silage yields are given in table 1. Early plant height was significantly higher for the solid and liquid beef manure treatments over the fertilizer treatment and grain yield and ear weight (as a % of silage) were significantly higher for the fertilized treatment over all other treatments. The fertilized treatment has now outyielded the manure treatments the last 4 years (significantly in 1986 and 1989) with 1986 being the first year since the study was initiated for this to happen. In 1986 and 1989 the effect of the 1970-71 manure applications on yield has decreased to the extent that the fertilized treatment is yielding significantly better than the manure treatments. However, the liquid and solid beef manure treatments are still yielding more than the check treatment. The results of the nitrate and ammonium analyses are given in table 2. There were no significant differences between the manure and fertilized treatments. Nitrate-N levels generally increased with depth while ammonium-N levels decreased with depth.

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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 Centr. 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. Summary of plant measurements - 1989.

Treatment	Early plant height	Early plant (10) dry weight	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
	inches	grams	- -% - -	bu/acre	- - % -	lb./acre	--%--
Check	18.7	31.7	22.5	76.0	44.5	8971	50.2
Fertilized	23.7	66.0	21.4	164.1	41.1	15973	63.9
Solid Beef Manure	26.1	80.3	21.0	118.9	46.4	13031	50.2
Liquid Beef Manure	27.2	83.3	20.8	120.0	49.2	13869	45.5
Liquid Hog Manure	24.0	58.0	20.9	95.9	49.6	12783	47.6
Signif. level (%)	>99	>99	86	>99	86	82	99
LSD (.05)	2.1	17.6	NS	21.1	NS	NS	9.2
CV (%)	4.8	15.0	3.7	10.2	8.6	23.7	9.2

Table 2. Nitrate and ammonium nitrogen levels of a Tara Soil 19 years (Fall 1989) after application of high rates of manure.

Depth Incr.	Treatment CK	Fert.	Solid Beef Manure	Liquid Beef Manure	Liquid Hog Manure	Mean	Treatment CK	Fert.	Solid Beef Manure	Liquid Beef Manure	Liquid Hog Manure	Mean
ft.	- - - - - - ppm NO_3-N - - - - - -						- - - - ppm NH_4-N - - - - - -					
0-1	2.3	8.1	4.3	4.5	2.9	4.4	4.4	5.8	1.8	4.9	5.3	4.4
1-2	0.4	16.8	1.0	1.0	0.5	3.9	3.0	3.5	1.9	4.1	2.9	3.1
2-3	1.5	26.6	0.9	7.9	0.4	7.5	2.6	2.1	1.8	2.6	2.1	2.2
3-4	5.5	12.9	6.3	11.0	6.0	8.3	3.1	2.2	2.5	2.5	2.3	2.5
Mean	2.4	16.1	3.1	6.1	2.5		3.3	3.4	2.0	3.5	3.2	

Signif. Level (%):

Replication	- 43	Replication	- 55	
Treatment	- 87	Treatment	- 69	
Depth	- 88	Depth	- >99	BLSD (.05) 0.5
Trt. x Depth	- 87	Trt x Depth	- >99	

The effect of tillage and corn hybrid on nitrogen response by continuous corn: a six year summary[1]

J.F. Moncrief, S.D. Evans, A.E. Olness, and G. Nelson[2]

This is a six year summary of a study to evaluate tillage, nitrogen, and corn hybrid effects on grain response in a continuous corn sequence. The soil is silt loam in texture and has poor internal drainage. Tillage effects were variable from year to year but over the study period the moldboard, chisel, and ridge till systems resulted in similar yields. Yields were reduced under no till conditions. Nitrogen response was quite variable from year to year. Tillage and corn hybrid also affected nitrogen response. A Pioneer 3906 hybrid consistantly resulted in a higher yield than a DeKalb XL8 although differences were affected by year. The DeKalb XL8 hybrid was affected by tillage more than the Pioneer 3906.

There has been data in the upper midwest that show tillage and corn hybrid affecting the nitrogen response by corn when grown following corn. In an effort to evaluate this, plots were established at Morris, MN. on a Pachic Udic Haploboroll (Tara silt loam). This soil has poor internal drainage and developed in glacial till. This study was conducted from 1984 to 1989.

Methods and Materials

Tillage treatments include: fall moldboard and chisel plowing followed by one field cultivation in the spring, ridge till (two cultivations), and no till systems. Treatments were established in the fall of 1983. Plots were planted with a Hiniker Series One Econo Till planter. In ridge till plots the row area was cleared with planter mounted discs. This was followed with a 2" fluted coulter. Clearing discs were raised for the other tillage systems.

Anhydrous ammonia was applied in the fall before tillage between corn rows from 0 to 160 pounds per acre in 40 pound per acre increments. The only exception to tillage and nitrogen application was in 1985. The fall of 1984 was too wet to accomplish tillage or anhydrous application therefore these operations were done in the spring.

Two single cross corn hybrids were evaluated (Pioneer 3906 and DeKalb XL8, 95 and 85 day relative maturity). Hybrid plots were alternated each year so each hybrid always followed the other. The experimental design is a split-split plot with tillage main plots, nitrogen subplots, and hybrid sub subplots. Sub subplots were four rows wide (30" rows) and 40 feet long. There are four replications.

Weed control was accomplished with a preemergence application of Lasso and Bladex.

Residue measurement were made with a line transect method. Measurements were made within a week following planting. Soil cover was characterized in and between the row (four inches centered over the row and the remainder respectively). Two adjacent rows were measured in each sub subplot. The line traversed the area to be measured diagonally.

Results and discussion

Analysis of Variance

There were significant year, tillage, nitrogen, and hybrid main effects on soil cover by corn residue. In addition there were significant year by tillage and year by nitrogen interactions.

The results of analysis of variance for grain yield is shown in table 1. There were also significant main effects of year, tillage, hybrid, and nitrogen. In addition first order interactions were all significant except the hybrid by nitrogen interaction. The only second order interactions that were statistically significant were the year by tillage by nitrogen and year by hybrid by nitrogen interactions. The third order interaction was not significant.

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[1] This research was supported by the Minnesota Agricultural Experiment Station, and the Agricultural Research Service.

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Table 1. Analysis of variance for grain yields 1984-1989 Morris, MN.

Source of Variance	P>F
Rep	.4171
tillage	.0610
rep x year Error 1	
nitrogen	.0001
tillage x nitrogen	.0515
rep x nitrogen (tillage) Error2	
hybrid	.0001
hybrid x tillage	.0100
hybrid x nitrogen	.7724
hybrid x tillage x nitrogen	.4362
rep x hybrid(tillage x nitrogen) Error 3	
year	.0001
year x tillage	.0020
year x nitrogen	.0001
year x tillage x nitrogen	.0075
hybrid x year	.0001
hybrid x tillage x year	.2558
hybrid x nitrogen x year	.0686
hybrid x tillage x nitrogen x year	.9445
rep x hybrid x (tillage x nitrogen) Error 4	

Soil Cover by Corn Residue

Soil cover by crop residue is shown in figures 1a-c and 2a-d. Soil cover ranged from about 10% with moldboard plowing to about 80% with the no till system (figure 1a). All conservation tillage options resulted in adequate cover by crop residue for erosion control. The fluted coulter reduced the soil cover in the row by about 20% with no other tillage (fig 1a-no till). Soil cover in the row was reduced about 10% and 2% cover with the chisel and moldboard plowing systems respectively. The clearing discs reduced cover 40% with the ridge till system. Soil cover between the row is about 20% lower than the no till system due to the cultivation operation which eliminates residue from two years before and soil covering during the planting operation.

Soil cover did not vary much from year to year (figure 1b). In 1985 clearing discs were not raised for the no till system resulting in lower average values. Soil cover was higher in 1988 due to high yields the previous year. The Pioneer 3906 hybrid resulted in slightly higher soil cover value also most likely due to higher yields (figure 1c).

Tillage effects for individual years are shown in figure 2a-d. The cover reduction in the row was greatest for all systems in 1985.

Table 2. The effect of tillage on soil cover by corn residue.

	Position Relative to Corn Row	
	In row	Between
Tillage	----percent----	
Chisel	32.1	40.9
Moldboard	7.6	9.7
No Till	60.1	77.3
Ridge Till	22.0	60.6

1. In and between the row are defined as four inches centered over the row and the remainder respectively.

Grain Yields

Tillage

Tillage effects on grain yields are shown in figure 3a-c. Tillage effects were quite variable from year to year. In 1985 there was an early frost and the no till system resulted in a decrease in yield. In 1984 the fall was wet and didn't allow plowing. In 1985 spring moldboard plowing, ridge tillage, and no till systems resulted in the lower grain yields than spring chisel plowing. The following year moldboard plowing was again a lower yielding system. In 1987 this system was clearly superior. In the drought year of 1988 moldboard plowing and no tillage had highest yields. In 1989 moldboard plowing and ridge till systems had

yields higher than those of the chisel and no till systems. Average yields over the six years of the study resulted in similar yields for the moldboard and chisel plowing and ridge tillage systems. Yields were lower when corn was grown with a no till system due to increased nitrogen requirement, stand loss, delayed phenology, and the alleopathy associated with in seed furrow corn residue.

Hybrid

Interactions of corn hybrid and tillage or year are shown in figure 3b-c. In all years the Pioneer 3906 resulted in higher yields than the DeKalb XL8. Year effects on hybrid differences appeared to be related to yield level. Differences were greater as the yield level increases (see 1985 and 1988 vs 1987 and 1989).

Tillage effects on hybrid performance were variable. Hybrid differences were the smallest under moldboard plowing (number in parentheses are yield differences). Chisel and no till systems were intermediate. Greatest differences between hybrid was found with the ridge till system. This may have been due to greater sensitivity to root pruning by this hybrid.

Nitrogen Response

Nitrogen responses are shown in figure 4a and 4b. Corn responses to levels of applied nitrogen ranged from none in 1988 to the entire range in 1984 and 1986. Nitrogen response does not appear to be related to yield level. The two highest yielding years (1987 and 1989) required less than 80 pounds per acre for optimum yields. The two years in which corn required in excess of twice this level of applied nitrogen were intermediate in yield level (1984 and 1986). The corn grown in 1989 did not require more than 80 pounds per acre of applied nitrogen due to high residual soil levels from the drought year of 1988 (data not shown). This was not the case for the 1986 year.

Tillage had an effect on nitrogen response. The chisel and moldboard plowing systems resulted in congruent nitrogen response curves. Tillage systems that eliminate full width deep tillage (ridge till and no till systems) require higher levels of applied nitrogen. This appears to be about 20 and 40 pounds per acre additional nitrogen for the ridge till and no till systems. Other Minnesota data has shown that the nitrogen response by corn following soybeans is not affected by tillage.

Tillage affects on nitrogen response was also different in different years (figures 5a-f). Nitrogen responses were similar in 1985. No till and ridge till grown corn required more applied nitrogen in 1987, 1988, and 1989.

Hybrid effects on nitrogen response also interacted with year (figures 6a-f). In 1986 and 1989 hybrid differences in the response to applied nitrogen are greater at the higher levels of applied nitrogen. The DeKalb XL8 appears to be limited by some other factor in these two years. In 1984 the DeKalb XL8 appeared to approach the yield of the Pioneer 3906 at the higher nitrogen rates. Although hybrid effects on nitrogen response varied from year to year there was no hybrid effect on nitrogen response when averaged over years.

Summary

1. Although tillage effects were variable from year to year, yields were similar between the chisel, moldboard, and ridge till systems.

2. The effect of corn hybrid on grain yield was also affected by year. Differences were greater at higher yield levels.

3. Hybrid yield differences were lowest with the moldboard system and greatest with the ridge till system.

4. Nitrogen response was quite variable from year to year and did not correlate well with yield level.

5. No till and ridge till corn appeared to require higher levels of applied nitrogen. Tillage effects on nitrogen response was similar in three years of the six year study different in others.

6. Hybrid effected the nitrogen response from year to year but when hybrid were averaged over all years they did not show different nitrogen responses.

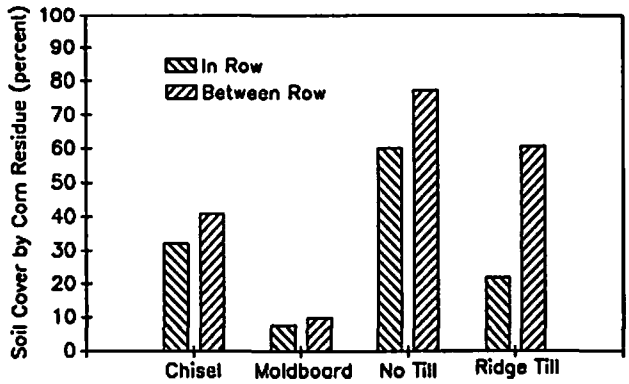

FIGURE 1a. THE EFFECT OF TILLAGE ON SOIL COVER BY CORN RESIDUE, MORRIS, MN. 1985–1989

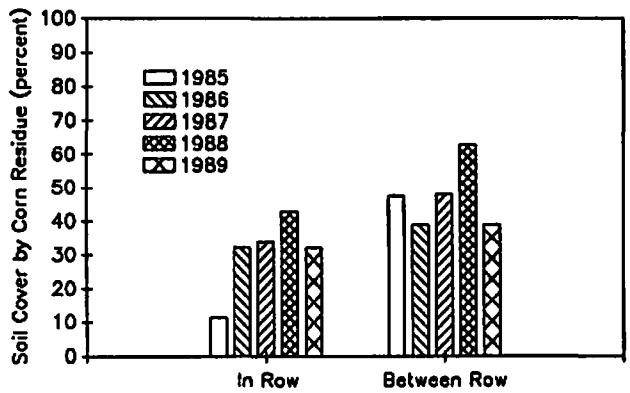

FIGURE 1b. THE EFFECT OF YEAR ON SOIL COVER BY CORN RESIDUE, MORRIS, MN.

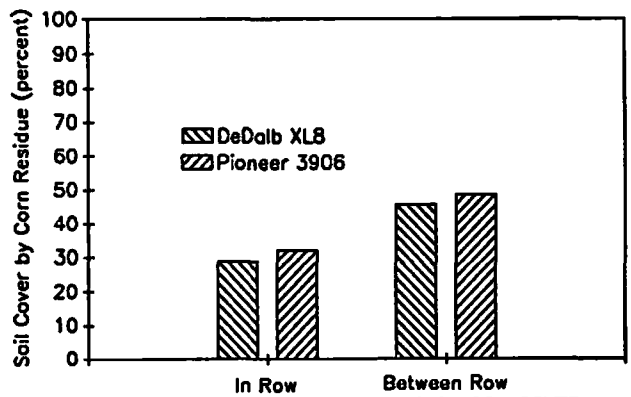

FIGURE 1c. THE EFFECT OF HYBRID ON SOIL COVER BY CORN RESIDUE, MORRIS, MN. 1985–1989

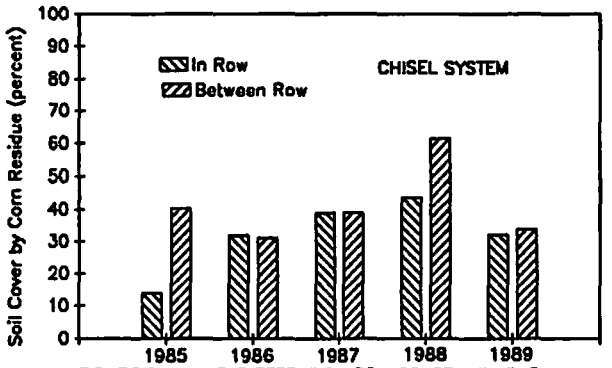

FIGURE 2a. YEAR EFFECT ON SOIL COVER WITH THE CHISEL PLOWING SYSTEM.

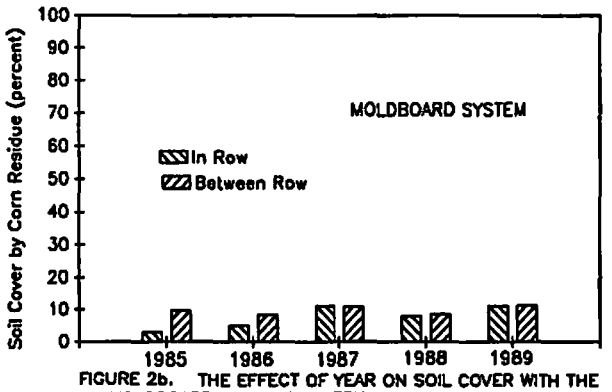

FIGURE 2b. THE EFFECT OF YEAR ON SOIL COVER WITH THE MOLDBOARD PLOWING SYSTEM

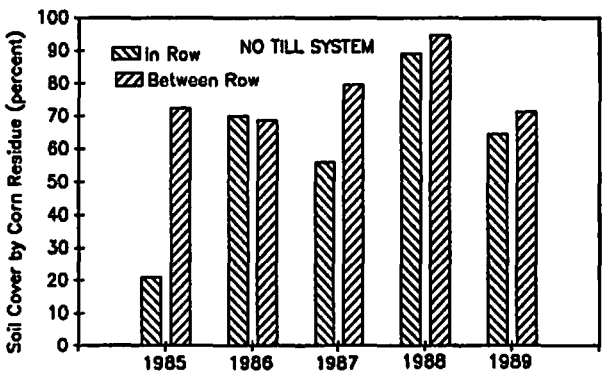

FIGURE 2c. THE EFFECT OF YEAR ON SOIL COVER WITH THE NO TILL SYSTEM

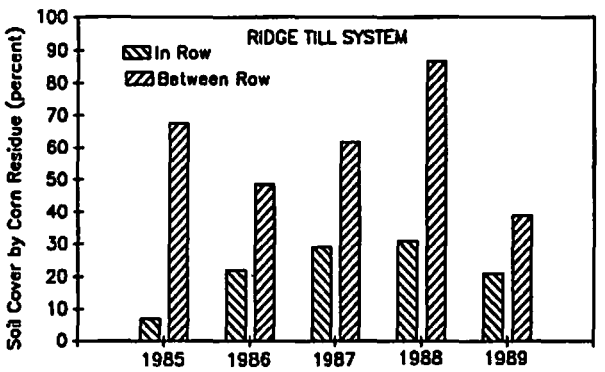

FIGURE 2d. THE EFFECT OF YEAR ON SOIL COVER WITH THE RIDGE TILL SYSTEM

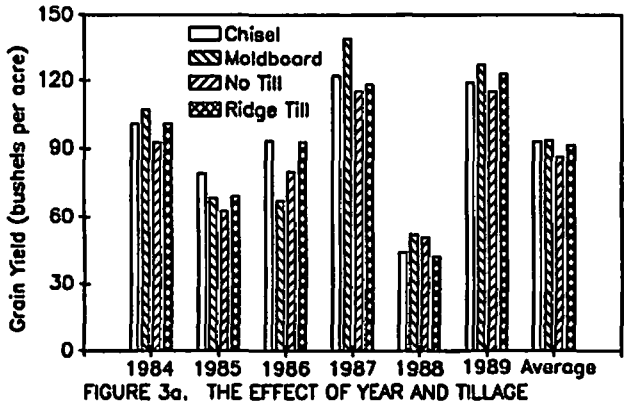

FIGURE 3a. THE EFFECT OF YEAR AND TILLAGE ON GRAIN YIELDS, MORRIS, MN., 1984–1989

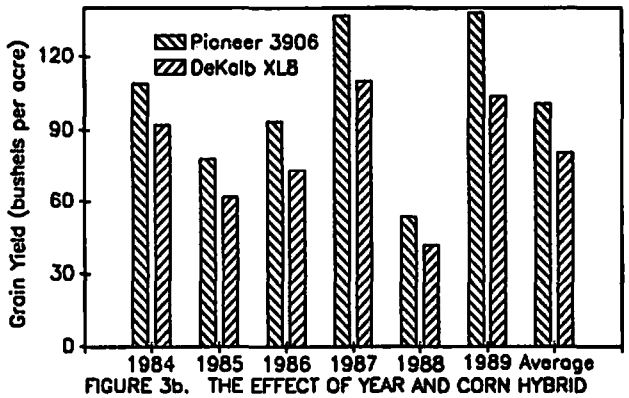

FIGURE 3b. THE EFFECT OF YEAR AND CORN HYBRID ON GRAIN YIELDS, MORRIS, MN., 1984–1989

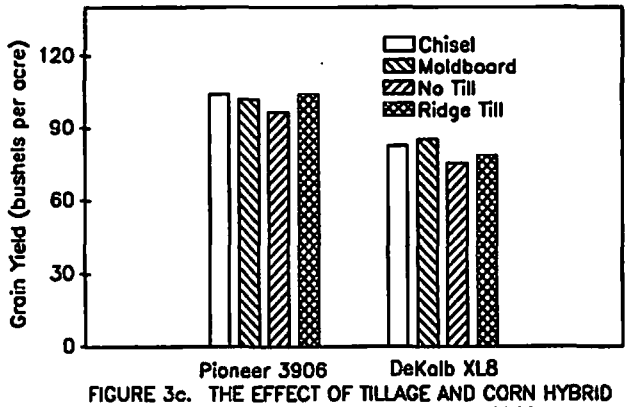

FIGURE 3c. THE EFFECT OF TILLAGE AND CORN HYBRID ON GRAIN YIELDS, MORRIS, MN., 1984–1989

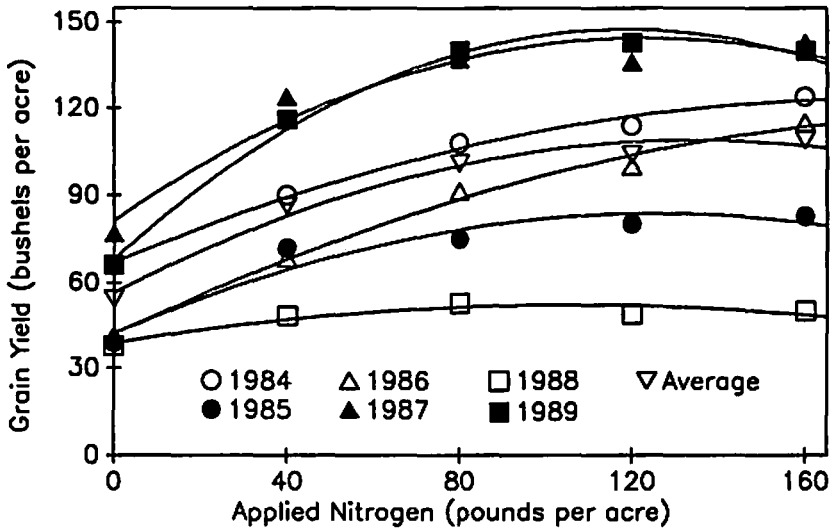

FIGURE 4a. THE EFFECT OF YEAR ON NITROGEN RESPONSE BY CONTINUOUS CORN, MORRIS, MN., 1984–1989

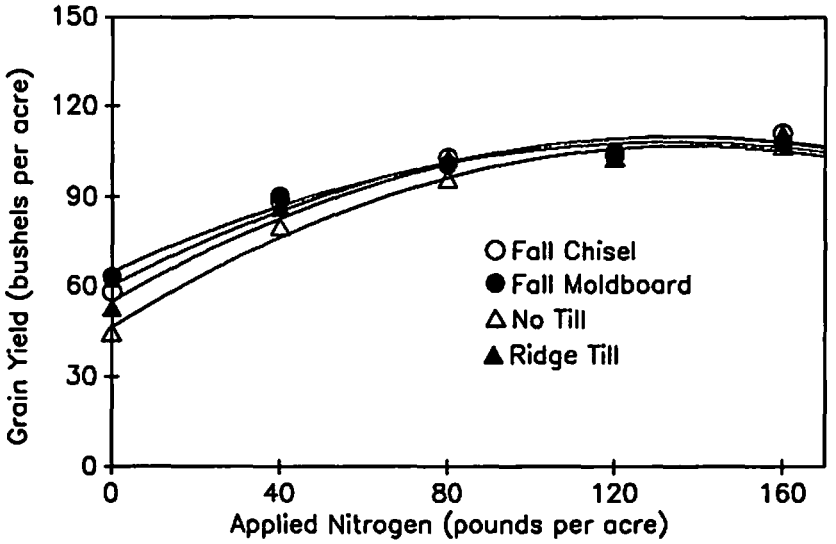

FIGURE 4b. THE EFFECT OF TILLAGE ON NITROGEN RESPONSE BY CONTINUOUS CORN, MORRIS, MN., 1984–1989

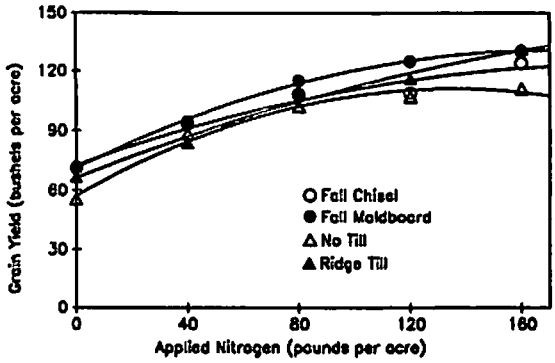

FIGURE 5a. THE EFFECT OF TILLAGE ON THE NITROGEN RESPONSE BY CONTINUOUS CORN, MORRIS, MN., 1984

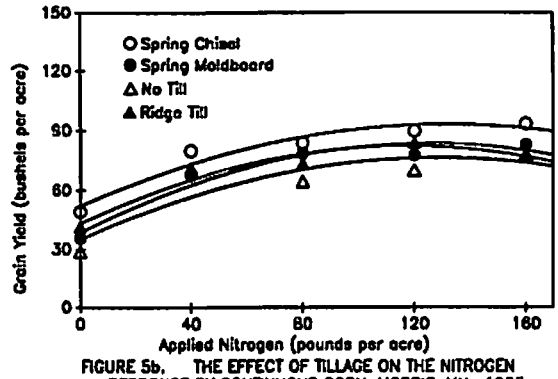

FIGURE 5b. THE EFFECT OF TILLAGE ON THE NITROGEN RESPONSE BY CONTINUOUS CORN, MORRIS, MN., 1985

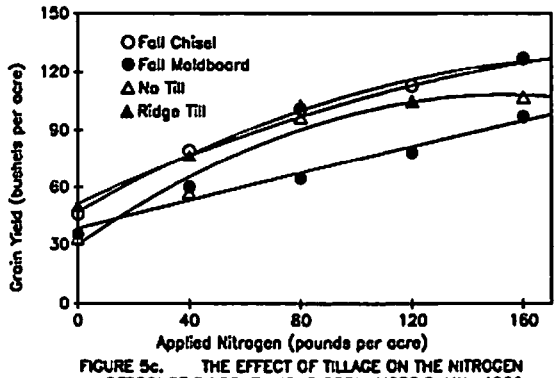

FIGURE 5c. THE EFFECT OF TILLAGE ON THE NITROGEN RESPONSE BY CONTINUOUS CORN, MORRIS, MN., 1986

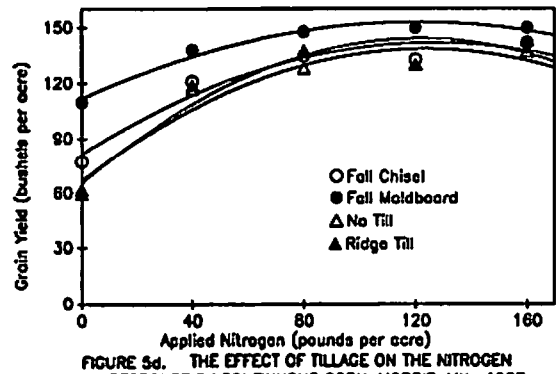

FIGURE 5d. THE EFFECT OF TILLAGE ON THE NITROGEN RESPONSE BY CONTINUOUS CORN, MORRIS, MN., 1987

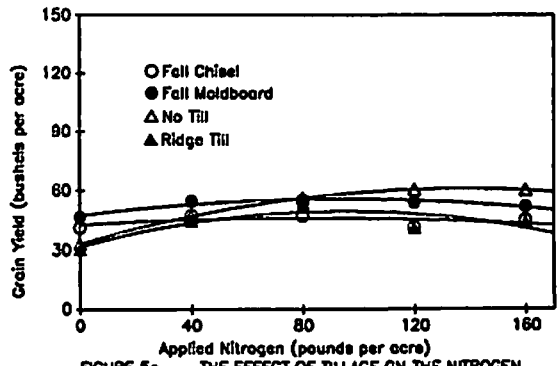

FIGURE 5e. THE EFFECT OF TILLAGE ON THE NITROGEN RESPONSE BY CONTINUOUS CORN, MORRIS, MN., 1988

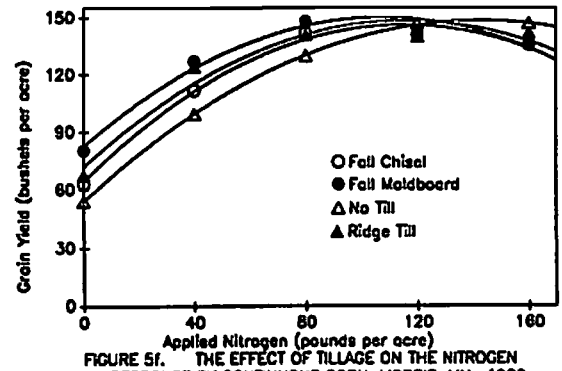

FIGURE 5f. THE EFFECT OF TILLAGE ON THE NITROGEN RESPONSE BY CONTINUOUS CORN, MORRIS, MN., 1989

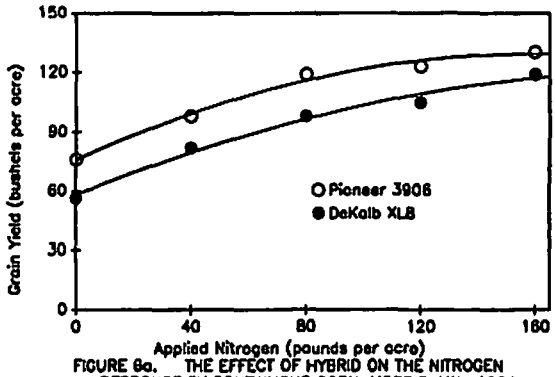

FIGURE 6a. THE EFFECT OF HYBRID ON THE NITROGEN RESPONSE BY CONTINUOUS CORN, MORRIS, MN., 1984

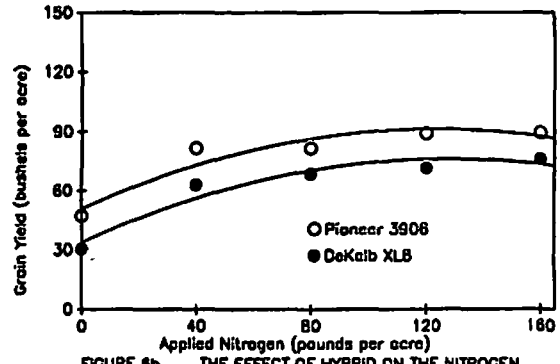

FIGURE 6b. THE EFFECT OF HYBRID ON THE NITROGEN RESPONSE BY CONTINUOUS CORN, MORRIS, MN., 1985

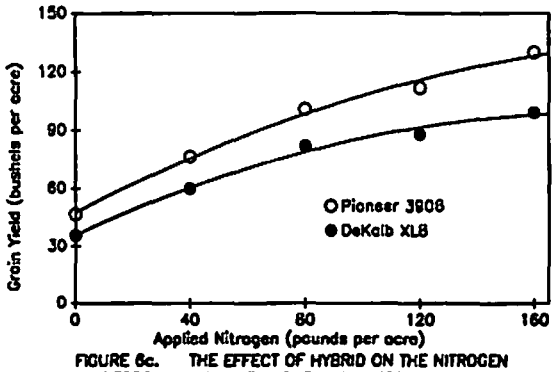

FIGURE 6c. THE EFFECT OF HYBRID ON THE NITROGEN RESPONSE BY CONTINUOUS CORN, MORRIS, MN., 1986

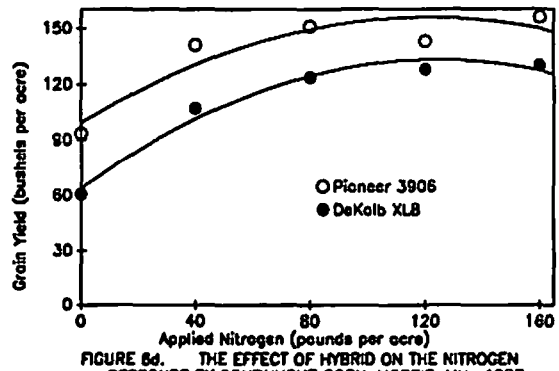

FIGURE 6d. THE EFFECT OF HYBRID ON THE NITROGEN RESPONSE BY CONTINUOUS CORN, MORRIS, MN., 1987

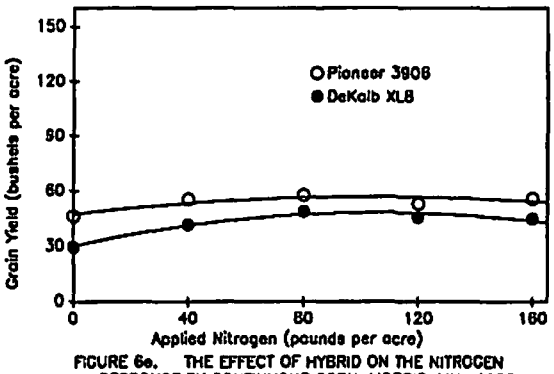

FIGURE 6e. THE EFFECT OF HYBRID ON THE NITROGEN RESPONSE BY CONTINUOUS CORN, MORRIS, MN., 1988

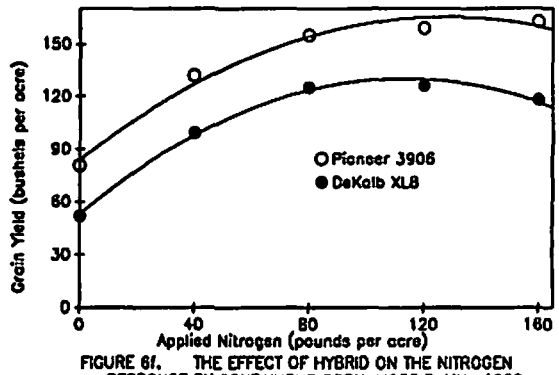

FIGURE 6f. THE EFFECT OF HYBRID ON THE NITROGEN RESPONSE BY CONTINUOUS CORN, MORRIS, MN., 1989

NITROGEN MANAGEMENT FOR CORN PRODUCTION ON IRRIGATED SANDY SOILS

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

ABSTRACT: Detailed research projects conducted for the past 15-20 years have identified and refined the nitrogen management practices needed for irrigated corn production on sandy soils. This research/demonstration project was designed to demonstrate that these practices could be used to grow high-yielding corn. Applied N was used very efficiently. Split applications and the use of a nitrification inhibitor had no positive effect on yield. There were no leaching rains and this would be expected. The amount of NO_3-N measured to a depth of 3 feet was small and not affected by treatment use.

Introduction:

Research studies, which have focused on nitrogen (N) management for corn production on irrigated sandy soils, have shown that split applications of fertilizer N are important. Nitrification inhibitors have proven to be beneficial for this soil if they were added to fertilizer N sources that were applied either before planting or as an early sidedress treatment. There is also some indication that split applications may allow for the use of reduced rates of fertilizer N.

Objective:

This research/demonstration project was conducted to measure the effect of N rate, method of application, and nitrification inhibitor usage on corn yield, and the amount of No_3-N remaining in the root zone at the end of the growing season.

Experimental Procedure:

This study was conducted at the Irrigation Center at Staples. The soil is classified as a Sverdrup sandy loam. Treatments were designed to provide for 2 levels of each of 3 variables and were arranged in a randomized complete block design with 4 replications. The N rates were 160 and 200 lb. per acre. The 2 methods of application consisted of a single application at early sidedress and a split application with equal amounts of fertilizer N applied as both an early and a late sidedress treatment. The fertilizer N was applied either with or without a nitrification inhibitor.

Corn (Pioneer 3790) was planted on May 10. All treatments received a starter fertilizer (20-7-20-7) in a band to the side of and below the seed. Bladex (3 pint/acre) and Dual (2 pint/acre) were applied preemergence for weed control. The early sidedress treatment was made at the 4 - 6 leaf stage. The second application of N for the split treatments was made at the 8 - 10 leaf stage of development. The "checkbook" method was used for irrigation scheduling and a total of 10.35 inches of irrigation water was applied.

Grain yields were measured in mid-October. Soil samples were also taken from depths of 0-12, 12-24, and 24-36 inches at this time. These samples were dried and analyzed for NO_3-N.

Results and Discussion:

In 1989, grain yield was not significantly affected by the N rate, method of application, or the use of the nitrification inhibitor (Table 1). The high yields measured indicated a very efficient use of the fertilizer N that was applied. There were no excessive rains in 1989. Therefore, a response to the use of split applications of N and a nitrification inhibitor would not be expected.

The effect of treatment on the amount of NO_3-N measured to a depth of 3 feet at the end of the growing season is provided in Table 2. As was the case with yield, the N rate, method of application, and nitrification inhibitor use had no significant effect on the amount of NO_3-N in the soil. This was true for all depths sampled.

The amount of NO_3-N found varied from 35 to 52 lb./acre. These are relatively low values for NO_3-N and confirm the use of good management practices for corn production. The results of this study show that high yields of irrigated corn can be achieved on sandy soil if good N management practices are combined with good management of irrigation water. If fertilizer N is used efficiently, only small amounts of NO_3-N will remain in the root zone at the end of the growing season.

[1/] County Extension Agents, Wadena and East Ottertail Counties, and Extension Soil Scientist, respectively.

Table 1. The effect of N management on the yield of corn.

Treatment*	Inhibitor Used	Yield
		bu./acre
200 lb. N/acre early post-emergence	No	191 a*
200 lb. N/acre early post-emergence	Yes	188 a
160 lb. N/acre early post-emergence	No	189 a
160 lb. N/acre early post-emergence	Yes	192 a
200 lb. N/acre post emergence split application	No	186 a
200 lb. N/acre post emergence split application	Yes	194 a
160 lb. N/acre post-emergence split application	No	188 a
160 lb. N/acre post-emergence split application	Yes	193 a

* Treatment averages followed by the same letter are not significantly different from each other at the .05 confidence level.

Table 2. The effect of N management on the NO_3-N in the root zone at the end of the growing season.

Treatment	Inhibitor Use	Depth (in.) 0-12	12-24	24-36	Total
200 lb. N/acre early post-emergence	No	21 a*	9 a	5 a	35 a
200 lb. N/acre early post-emergence	Yes	26 a	13 a	5 a	44 a
160 lb. N/acre early post-emergence	No	29 a	12 a	4 a	45 a
160 lb. N/acre early post-emergence	Yes	23 a	11 a	4 a	38 a
200 lb. N/acre post-emergence split application	No	29 a	12 a	7 a	48 a
200 lb. N/acre post-emergence split application	Yes	29 a	10 a	5 a	44 a
160 lb. N/acre post-emergence split application	No	28 a	16 a	8 a	52 a
160 lb. N/acre post-emergence split application	Yes	26 a	12 a	4 a	42 a

* Treatment averages in each column followed by the same letter are not significantly different at the .05 confidence level.

LUPIN BEAN FERTILITY STUDY

H. Meredith, Mel Weins, Greg Cremers, and Andy Scobbie[5/]

ABSTRACT: A fertility study initiated in 1984 to determine the nutrient requirements of lupin beans (Lupinis albus) was continued in 1989. Population density and weed control were excellent in 1989. Insects as grasshoppers, blister beetles, and dung beetles feeding on flowers were noted. The first observed incidence of stem and seed pod disease likely inflicted significant damage to the lupin crop. Pleiochaeta and Ascochyta were two organisms identified. Ascochyta organisms were responsible for the observed stem cankers and pod spots and the resultant loss in seed quality.

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

		Yield, bu/A									
No.	Treatment	1984	1985	1986		1987		1988		1989	
1	Check	39.1[1/]	71.4[2/]	40.6[2/]	32.0[4/]	57.2[2/]	61.8[4/]	47.6[2/]	61.9[4/]	37.3[2/]	31.9[4/]
2	Sulfur (S)	43.2	71.2	44.0	31.7	54.2	62.8	58.7	67.2	40.1	33.0
3	S + K	40.5	63.8	40.6	43.3	49.9	61.9	50.9	61.1	31.9	27.3
4	S + K + P	39.4	68.8	39.2	40.2	56.6	61.8	42.3	57.2	40.6	33.9
5	S + K + P + Zn	39.4	64.1	41.8	37.4	47.2	56.3	42.8	58.0	35.6	27.7
6	S + K + P + Zn + B	41.5	64.9	33.8	32.8	54.8	60.8	52.0	52.3	35.9	29.5

1/ 30-inch rows
2/ 6-inch drill rows
3/ Old fertility site
4/ New fertility site
5/ Regional Director, Tennessee Valley Authority, Research Plot Supervisor, Staples Irrigation Center, Assistant Scientist, Jr. Scientist, University of Minnesota, respectively.

Percent Nitrogen in Lupin Beans, Staples Station

Treatment	1985	1986		1987		1988		1989	
	1/	1/	2/	1/	2/	1/	2/	1/	2/
1	5.4	5.6	5.4	5.5	5.0	6.2	5.6	5.6	6.2
2	5.4	5.5	5.5	5.5	5.1	6.4	5.6	5.7	6.2
3	5.6	5.6	5.3	5.3	5.0	6.3	5.4	5.8	6.2
4	5.6	5.5	5.1	5.6	4.8	6.0	5.5	5.8	6.0
5	5.7	5.6	5.4	5.6	4.8	6.1	5.5	5.7	6.1
6	5.6	5.6	5.4	5.5	4.8	6.0	5.4	5.7	6.0

1/ Old fertility site
2/ New fertility site