$140 at CASS91. The other two locations were not affected by N level. The HKNAN variety return the greatest amount of money overall N levels and locations.

Table 5. Means and statistical analyses for recoverable sucrose per ton processed as affected by N level and variety, 1990-1991.

Variety	N Level	NWES 90	CASS 90	SOMN 90	CASS 91	Mean
	lb/A	lb/T				
LKNAN	100	298	305	243	261	271
LAN	100	321	326	242	277	292
HKNAN	100	302	325	236	273	284
LKNAN	300	292	311	231	244	269
LAN	300	274	316	238	242	268
HKNAN	300	291	309	233	239	265
Statistical Analyses						
N Level (N)		++	NS	NS	**	
Variety (V)		NS	**	NS	NS	
N X V		NS	*	NS	NS	
C.V.		6.6	2.4	5.9	7.0	

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

Table 6. Means and statistical analyses for loss to molasses as affected by N level and variety, 1990-1991.

Variety	N Level	NWES 90	CASS 90	SOMN 90	CASS 91	Mean
	lb/A	%				
LKNAN	100	1.51	1.53	1.64	1.95	1.66
LAN	100	1.59	1.48	1.74	2.15	1.74
HKNAN	100	1.84	1.51	1.79	2.15	1.82
LKNAN	300	1.81	1.59	1.77	2.23	1.85
LAN	300	2.04	1.67	1.69	2.30	1.93
HKNAN	300	2.17	1.74	1.92	2.50	2.08
Statistical Analyses						
N Level (N)		**	*	NS	*	
Variety (V)		**	NS	NS	++	
N X V		NS	NS	NS	NS	
C.V.		8.0	6.2	10.2	8.5	

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

Table 7. Means and statistical analyses for dollar return per acre as affected by N level and variety, 1990-1991.

Variety	N Level	NWES 90	CASS 90	SOMN 90	CASS 91	Mean
	lb/A	$/A				
LKNAN	100	446	810	227	620	526
LAN	100	530	864	323	710	607
HKNAN	100	488	931	304	760	621
LKNAN	300	505	944	282	548	570
LAN	300	474	910	363	549	574
HKNAN	300	613	908	358	572	613
Statistical Analyses						
N Level (N)		*	NS	NS	*	
Variety (V)		++	NS	++	NS	
N X V		*	*	NS	NS	
C.V.		12.1	5.4	24.9	17.6	

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

Summary: The data presented above indicates that soil NO_3-N should not be a major consideration in variety selection by the sugar beet producer. The reasons for this lie in the fact that before a variety can be planted in the Minnesota and North Dakota sugar beet growing areas it must meet criteria in the coded variety trials. The differences in quality between approved varieties are smaller than the differences that can occur from soil types and climates.

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Allan Cattanach and the NDSU crew for their help at the Casselton location; Stan Prokosch for providing the Southern Minnesota location; The Northwest Experiment Station crew for planting, thinning and harvesting the study; American Crystal Sugar for the Quality Analyses; and the Sugar Beet Research and Education Board for the financial assistance to run this study.

THIRTY-TWO YEARS OF CONTINUOUS CORN WITH VARIABLE NITROGEN SOURCE, PLACEMENT, AND TIME OF APPLICATION AT THE SOUTHWEST EXPERIMENT STATION[1]

D.J. Fuchs, D.R Huggins and W.W Nelson[2]

ABSTRACT

Optimizing nitrogen management is an important objective of corn production. A field study was started in 1960 to determine if continuous corn yields are affected by nitrogen form, (urea or ammonium nitrate), amount (13 to 173 lbs N/ac), time of application (fall, spring or sidedressed). and placement (surface, moldboard plow incorporation or sidedress). Each year corn is established with conventional tillage (moldboard plow) and planted in 30-inch rows on a Normania loam. The 31-year average of the treatments indicate that corn yields respond the greatest to N rate with a slight advantage to spring application and with little difference between N form. In 1991, the corn yields, averaged across N form and time of application, were 77, 119, 141, and 160 (bu/ac) for the 13, 53 93 and 173 lbs N/ac treatments, respectively.

METHODS AND MATERIALS

The continuous corn study is a nitrogen fertilization experiment involving various rates and application times of ammonium nitrate and urea. The experiment has been conducted since 1960 on a tiled Normania loam. The fertilizer treatments have now been applied annually to the same plot area (1550 ft^2) for 32 years. The experimental design is a randomized incomplete block with four replications. After ear corn removal and stalk cutting, the plots with treatments of fall applied N receive either broadcast N followed by moldboard plowing or moldboard plowing followed by surface applied N. All other treatments are also fall moldboard plowed to a depth of 12 inches. Spring treatments of applied N are broadcast before seedbed preparations in late April or early May. The corn is planted in 30-inch rows, and starter fertilizer is banded at a rate of 13 lbs N/ac, 34 lbs P_2O_5/ac, and 12 lbs K_2O/ac in all treatments. Sidedress treatments of applied N are broadcast in June and incorporated during cultivation. Additional management information is provided in Table 1. A one-way analysis of variance is provided, also the average corn yields for the various treatments are given in Table 2 and 3, respectively. The 31-year yield averages are provided in Table 4 (In 1976, no yields were obtained due to drought, thus only 31 years of data exist).

RESULTS AND DISCUSSION

The one-way analysis of variance of corn yields in 1991 indicates a significant combined treatment effect (Table 2). In 1991, corn yield response to N rate ranged from 77 bu/ac for control plots (13 lbs N/ac) to 159 bu/ac for the 173 lbs N/ac treatments (Table 3). This year, as in the past, there was a trend of increased yield with delayed application time. Corn yields with 40 lbs N/ac, of either N form, applied as a side dress, were not significantly different from the 80 pounds N/ac treatments (Table 3).

The long-term average yields for the 40 and 80 lbs N/ac treatment indicate that urea nitrogen had about a 2 bu/ac yield advantage over ammonium nitrate (Table 4). This year, as in the past, there was little difference in yield between the nitrogen source.

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[1] Funding provided by Agricultural Experiment Station

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

Table 1. 1991 Management Information.

Item	Type	Rate	Date
Secondary Tillage	Disc	1 pass	4/26
	Digger	1 pass	5/8
Seed	Pioneer	27,700 seeds/ac	5/9
Fertilizer	Starter	14-41-15 lbs/ac ($N-P_2O_5-K_2O$)	5/9
Herbicides	Lasso	3.0 lbs/ac (ai)	4/26
	Bladex	2.0 lbs/ac (ai)	
Insecticides	Counter	1.0 lbs/ac (ai)	5/9
	Pounce 3.2E	6.0 oz/ac (ai)	6/27
Cultivation		1 pass	6/18

Table 2. One-way analysis of variance for corn yield.

Source	DF	SS	MS	F	P
Block	3	853.23	284.4	1.13	0.3464
Treatment	17	31782	1869.5	7.42	0.0000
Error	51	12855	252.1		

Table 3. 1991 corn yields (bu/ac).

Application Time	Ammonium Nitrate (lbs/ac)			Urea (lbs/ac)		
	40	80	160	40	80	160
Fall Incorporated	102 b	137 cde	162 f	119 bc	136 cde	159 f
Fall Plowed Surface	115 bc	---	---	117 bc	---	---
Spring Pre-plant	117 bc	147 def	---	119 bc	142 def	---
Side Dress	130 cd	137 cde	157 ef	128 cd	148 def	---
Check: 77 a	Comparable AN Avg: 131			Comparable Urea Avg: 134		

$LSD_{0.05}$ = 22.5 (bu/ac)
Means with the same letter do not differ significantly using Fisher's $LSD_{0.05}$.

Table 4. 31 year long-term average yields (bu/ac).

Application Time	Ammonium Nitrate (lbs/ac)			Urea (lbs/ac)		
	40	80	160	40	80	160
Fall Incorporated	86	106	114	89	105	114
Fall Plowed Surface	84	---	---	89	---	---
Spring Pre-plant	97	109	---	95	110	---
Side Dress	99	106	118	99	114	---
Check: 67	Comparable AN Avg: 100			Comparable Urea Avg: 102		

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

D.J. Fuchs, M. Lindstrom, D.R. Huggins, and W.W. Nelson[2]

ABSTRACT

Field data is needed to evaluate crop growth simulation models. The objective of this study is to determine the effect of tillage and soil erosion class on corn yields. A field study was initiated in 1984 where continuous corn is grown with conventional tillage (fall moldboard plow) or ridge tillage on sites where soil types are slightly, moderately, or severely eroded. In 1991, erosion class had a significant effect on corn yields. Corn on severely eroded soil yielded 18 percent less and on moderately eroded 15 percent less than corn grown on soil that was only slightly eroded across tillage treatments. Over the course of the experiment, the effect of erosion class on corn yield has been consistent with the higher yields occurring on the less eroded treatments. In 1991, corn yields were not effected by tillage treatment. In the past, tillage effects on corn yields have been inconsistent.

MATERIALS AND METHODS

Field plots were established in 1984 with continuous corn and two tillage regimes in areas which had been slightly, moderately, and severely eroded. The soil type for the slight and moderately eroded areas is a Ves loam (fine-loamy, mixed, mesic Typic Haplustolls). The soil type on the severely eroded area is a Storden loam (fine-loamy, mixed (calcareous), mesic Typic Udorthents). The two tillage systems used on each erosion class were fall moldboard plow (MP) and ridge tillage (RT).

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. Ridges were re-established during the 1990 growing season. In 1991, the ridge tillage plots were row cultivated with a conventional cultivator, but because of wet field conditions, they were not ridged with the ridge cultivator. In the fall of 1991, the ridge tillage area was para-plowed. Additional management information is given in Table 1. Analysis of variance, using a spilt plot design (tillage = whole plots, erosion class = split plots) is given in Table 2. If treatments were significantly different (0.05 level), means were separated using the Fisher's $LSD_{(0.05)}$.

RESULTS AND DISCUSSION

The objectives of this study are to asses the effect of erosion on soil characteristics and potential productivity of selected soils with emphasis on evaluation of physically-based simulation models. In 1991, corn yields on severely eroded soil yielded 18 percent less and on moderately eroded 15 percent less than corn grown on soil that was only slightly eroded (Table 2 and 3). Over the past seven years, erosion levels affected corn yields with the greatest yields occurring on the least eroded soil. In 1991, tillage treatment did not significantly affect corn yields (Table 2 and 3). In the past, tillage effects on yields have been inconsistent, however, the seven year average corn yields indicate very little difference between the two tillage treatments (Table 4).

ACKNOWLEDGEMENTS

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

[2] Assistant Scientist - U of MN, Southwest Experiment Station; Soil Scientist - USDA-ARS, Morris, MN 56267; Soil Scientist, and Superintendent - U of MN, Southwest Experiment Station, respectively.

Table 1. 1991 Management Information.

Item	Type	Rate	Date
Primary Tillage (RT)	None	1	Fall 1990
	Para-plow	1	10/16/91
Primary Tillage (MP)	Moldboard Plow	1	Fall 1990
	Moldboard Plow	1	10/12/91
Secondary Tillage[1]	Disc	1 pass	5/9
	Digger	1 pass	5/10
Seed	Pioneer 3615	27,700 seeds/ac	5/10
Fertilizer	Urea	150 lbs N/ac	4/10
	Starter	13-34-12 lbs/ac ($N-P_2O_5-K_2O$)	5/10
Herbicides	Lasso	3.0 lbs/ac (ai)	5/11
	Bladex	2.0 lbs/ac (ai)	5/11
Insecticides	Counter	1.0 lbs/ac (ai)	5/10
Row Cultivation (MP)		once	6/3
row Cultivation (RT)		once	6/12

1/ Secondary tillage was only done on the moldboard plow area.

Table 2. Analysis of Variance.
Variable: Corn yields (bu/ac)
Randomized block with split plot restriction
Number of: Cases = 24 Blocks = 4
Tillage Levels = 2 Erosion Levels = 3

Source	DF	SS	MS	F	P
Block	3	32.01	10.67	0.07	0.97
Erosion class	2	3403.60	1701.80	11.51	** 0.01
Whole plot error	6	887.47	147.91		
Tillage	1	348.08	348.08	2.29	0.16
Tillage*Erosion	2	7.88	3.94	0.03	0.97
Sub-plot error	9	1370.20	152.25		

** significant at alpha = 0.01

Table 3. Mean corn yields (bu/ac) of tillage, erosion class and interactions.

Tillage	Erosion Class[1]			Overall average
	Slight	Moderate	Severe	
Moldboard plow	153.1	147.9	126.9	142.7
Ridge area	146.8	140.5	117.8	135.0
Overall average	150.0	144.2	122.3	138.8

1/ $LSD_{0.05}$ = 14.9 for comparing erosion classes (averaged over both tillage treatments)

Table 4. Average annual corn yields (bu/ac).

Tillage	1985	1986	1987	1988	1989	1990	1991	Average
Moldboard	162.5	164.2	136.6	44.0	124.4	123.5	142.7	128.3
Ridge area	153.4	149.5	129.0	52.1	123.9	135.2	135.0	125.4

TILLAGE MANAGEMENT FOR INCREASING CROP YIELDS AND DECREASING SOIL EROSION AT THE SOUTHWEST EXPERIMENT STATION[1]

D.J. Fuchs, M. Lindstrom, D.R. Huggins, and W.W. Nelson[2]

ABSTRACT

Field research is needed to evaluate soil movement under different crop production practices and the consequent effects on crop yield. This study was conducted to examine the effects of slope percentage (1%, 4%, and 8%), tillage (ridge tillage, moldboard plow, and chisel), tillage/planting direction (up and down the slope, or contour to the slope), and slope position (top, middle, and bottom) on soil movement and yield in a corn and soybean rotation. In 1991, the only significant treatment effect was tillage on the 8 percent slope. On the site with 8 percent slope, soybean yields with moldboard plowing were 26.8 percent and chisel plowing 21.7 percent greater than ridge tillage. The differences in yield were attributed to herbicide injury in the ridge tillage system. No other treatments significantly affected soybean yield.

MATERIALS AND METHODS

This study began in the spring of 1985 to examine the effects of slope percentage (1%, 4%, and 8%), tillage (ridge tillage, moldboard plow, and chisel), tillage/planting direction (up and down the slope, or contour to the slope), and slope position (top, middle, and bottom) on soil movement and yield in a corn and soybean rotation. The field experiments are located at three different sites with one site for each slope percentage. Treatments at the site with 8 percent slope are tillage, plant row direction, and position on the slope (top, middle, and bottom). Treatments at the site with 4 percent slope are tillage, and plant row direction, while the site with 1 percent slope has only a tillage treatment. Yields are measured every year. Base line data on soil movement was collected at the start of the experiment. Soil movement will be assessed at the conclusion of the study by grass catch strips and infrared transit survey. Additional management information is provided in Table 1. Analysis of variance was performed for each slope percentage. If treatments were significantly different (0.05 level), means were separated using Fisher's $LSD_{0.05}$.

RESULTS AND DISCUSSION

In 1991, the only significant treatment effect was tillage on the 8 percent slope (Tables 2, 5, and 7). On the site with 8 percent slope, soybean yields with moldboard plowing were 26.8 percent and chisel plowing 21.7 percent greater than ridge tillage (Table 3). The soybean plants with ridge tillage exhibited symptoms of severe herbicide injury from the pre-emergent application of Sencor and Lasso. Some of the soybeans did not recover from the herbicide injury and this reduced the stand and yield. The herbicide injury symptoms were not observed on the other two tillage treatments. Soybean yield data by row direction, tillage, and slope position are shown in Table 4, however, there were no significant yield differences on the 8 percent slope between row direction, or position (Table 2 and 4).

Soybean yields were not significantly affected by tillage treatment or row direction on the site with 4 percent slope (Table 5) or by tillage treatment on the site with 1 percent slope (Table 7). Yields by tillage and row direction (4 percent slope) are presented in Table 6 and by tillage (1 percent slope) in Table 8. The different slope percentages (8%, 4% & 1%) were not compared with an analysis of variance, however, the overall average soybean yield on the 8, 4, and 1 percent slopes were 36.8 (bu/ac), 40.5 (bu/ac), and 44.2 (bu/ac), respectively. The trend of decreasing yield with increasing slope percentage is consistent with past years.

The three year average soybean yields for each tillage system (averaged over all three slope areas) are similar but show a trend of increased yield in the moldboard plow tillage system (Table 9). The three year average corn yields for each tillage system (averaged over all three slope areas) are similar but indicate a slight yield advantage to the ridge tillage treatment (Table 10).

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

[2] Assistant Scientist - U of MN, Southwest Experiment Station; Soil Scientist - USDA-ARS, Morris, MN 56267; Soil Scientist, and Superintendent - U of MN, Southwest Experiment Station, respectively.

Table 1. 1991 Management Information.

Item	Type	Rate	Date
Secondary Tillage	Disc	1 pass	5/21
Soybean Variety	Hardin	150,000 seeds/ac	5/22
Herbicides	Lasso Sencor	3.0 lbs/ac (ai) 0.375 lbs/ac (ai)	5/22
Row Cultivation		Twice	6/17, 7/1

1/ No secondary tillage on ridge tillage plots.

Table 2. Analysis of Variance for the 8 Percent Slope.
Variable: Soybean grain yield (bu/ac)
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	F	P
Block	2	16.92	8.46	0.60	0.63
Row Direction	1	10.23	10.23	0.72	0.48
Whole Plot Error	2	28.29	14.15		
Tillage	2	1201.70	600.84	26.83	** 0.00
Row*Tillage	2	57.57	28.79	1.29	0.33
Sub-Plot Error	8	179.16	22.40		
Position	2	6.15	3.07	0.34	0.72
Row Position	2	2.09	1.05	0.12	0.89
Tillage*Position	4	55.40	13.85	1.53	0.23
Row*Tillage*Position	4	23.85	5.96	0.66	0.63
Sub-Sub Plot Error	24	217.85	9.08		

** significant at alpha < 0.01

Table 3. Soybean Yields on the 8 Percent Slope by Tillage.

Tillage	Average yield* (bu/ac)	Standard deviation
Moldboard	41.4 a	2.8
Chisel	38.7 a	3.7
Ridge	30.3 b	3.7

* $LSD_{0.05}$ = 3.6
Means in a column with the same letter do not differ significantly using Fischer's LSD (0.05 probability level).

Table 4. Soybean Yields on the 8 Percent Slope by Tillage-Row Direction-Slope Position Interaction.

Row direction	Tillage	Slope Position	Average yield (bu/ac)	Standard deviation
Up & Down	Moldboard	Top	41.1	4.3
		Middle	41.1	4.2
		Bottom	41.5	2.9
	Chisel	Top	39.9	3.4
		Middle	37.8	1.9
		Bottom	37.1	2.7
	Ridge	Top	31.7	1.3
		Middle	31.6	1.0
		Bottom	33.3	1.8
Contour	Moldboard	Top	42.2	2.7
		Middle	41.9	2.0
		Bottom	40.7	3.1
	Chisel	Top	40.9	5.1
		Middle	36.4	4.0
		Bottom	39.9	5.1
	Ridge	Top	25.8	3.1
		Middle	29.2	6.8
		Bottom	30.3	2.3

Table 5. Analysis of Variance for the 4 Percent Slope.
Variable: Soybean grain yield (bu/ac)
Randomized block with split plot restriction
Number of: Cases = 12 Blocks = 2
Tillage Levels = 3 Row Directions = 2

Source	DF	SS	MS	F	P
Block	1	112.24	112.24	0.91	0.51
Row direction	1	0.08	0.08	0.00	0.99
Whole plot error	1	123.52	123.52		
Tillage	2	70.45	35.22	0.82	0.50
Row*Tillage Interaction	2	263.16	131.58	3.06	0.16
Sub-plot error	4	171.86	42.97		

Table 6. Soybean Yields on the 4 Percent Slope by Tillage-Row Direction Interaction.

Tillage	Row direction	Average yield (bu/ac)	Standard deviation
Moldboard	Up & Down	42.2	5.7
	Contour	43.2	3.9
Chisel	Up & Down	36.1	2.6
	Contour	47.3	4.2
Ridge	Up & Down	43.0	18.3
	Contour	31.3	0.9

Table 7. Analysis of Variance for the 1 Percent Slope.
Variable: Soybean grain yield (bu/ac)
Randomized block
Number of: Cases = 6 Blocks = 2
Tillage Levels = 3

Source	DF	SS	MS	F	P
Block	1	10.40	10.40	0.58	0.53
Tillage	2	57.88	28.94	1.61	0.38
Whole plot error	2	36.05	18.03		

Table 8. Soybean Yields on the 1 Percent Slope by Tillage.

Tillage	Average yield (bu/ac)	Standard deviation
Moldboard	48.1	2.5
Chisel	44.0	2.1
Ridge	40.5	6.0

Table 9. Average Soybean Yields (bu/ac) for 1987, 1989 and 1991.

Tillage	1987	1989	1991	Average
Moldboard	44.0	45.1	43.2	44.1
Chisel	45.0	41.8	42.4	43.1
Ridge	45.4	41.9	36.0	41.1

Table 10. Average Corn Yields (bu/ac) for 1986, 1988 and 1990.

Tillage	1986	1988	1990	Average
Moldboard	176.0	23.8	133.1	111.0
Chisel	174.1	31.8	133.9	113.3
Ridge	175.1	41.7	132.3	116.4

MICRO-PLOT PESTICIDE LEACHING AND RUNOFF STUDY UNDER CONVENTIONAL AND SOIL SPECIFIC MANAGEMENT[1]

B.R. Khakural, P.C. Robert and D.J. Fuchs[2]

ABSTRACT: Leaching and runoff loss of alachlor was studied on a soil catena with varied slope and drainage characteristics under conventional and soil specific management. There was no significant difference in alachlor concentration of surface (0-6 in.) soil or runoff water between conventional and soil specific treatments. No alachlor was detected in the soil samples from below 1 foot depth. Detectable amount of alachlor (0.6, 1 ppb) was found in only 2 out of 60 soil water samples collected at 6 different dates in 1990. In 1991, an alachlor concentration of ≥ 1 ppb was detected in 17 to 33% of the earlier samples (collected within 8 days of application) and 17% of the later samples at a depth of 2 feet respectively. At 4 feet depth, a concentration of ≥ 1 ppb was detected in 33% of the earlier samples only. The highest alachlor concentration in runoff water was observed at the first runoff event (47 to 226 ppb) and the concentration decreased with time in later events during both years of study. Average alachlor concentration for the Ves (6-12%) soil was 1.5 and 2 times higher than the Ves (1-4%) and Webster (0-3%) soils respectively. Pesticide loss through surface runoff seems to be more of a problem in these soils than leaching.

Introduction:

Growing concerns about crop management sustainability and surface and ground water pollution by agricultural chemicals have initiated soil specific management system (SSMS). In order to measure the effect of SSMS on leaching and runoff of chemicals, landscape micro-plots were established for long term pesticide leaching and runoff study at the Southwestern Experiment Station, Lamberton, Minnesota in 1989.

Materials and Methods:

A landscape comprised of two soil series with varied drainage characteristics was selected for this study. Two soil series used in this study were a well drained Ves (fine-loamy, mixed, mesic Udic Haplustoll) and a poorly drained Webster (fine-loamy, mixed, mesic Typic Haplaquoll). They represent a catena with the Ves soils on the backslope (1-4%) and sideslope (6-12%) and the Webster soil on the toeslope (0-3%) positions. Selected properties of the three soil types studied are presented in Table 1.

Table 1. Selected physical and chemical properties of Ves and Webster soils.

Depth	CF† (> 2 mm)	Sand	Silt	Clay	OC	pH
in	%					
			Ves (1-4%)			
0-8	4	42	30	28	3.5	5.6
8-16	3	41	29	30	2.5	5.6
16-24	3	39	28	33	1.0	5.9
24-32	2	38	32	30	0.6	6.3
32-40	4	41	32	24	0.5	7.0
40-48	5	38	38	24	0.4	7.4
			Ves (6-12%)			
0-8	2	44	28	28	3.3	5.8
8-16	3	44	28	28	2.3	5.9
16-24	5	41	29	30	1.2	6.4
24-32	5	35	28	37	0.7	6.8
32-40	5	35	31	34	0.6	7.2
40-48	10	27	36	37	0.5	7.5
			Webster (0-3%)			
0-8	0	35	35	30	4.2	6.3
8-16	1	35	35	30	2.9	6.5
16-24	1	34	36	30	1.5	6.7
24-32	3	39	36	25	0.6	6.9
32-40	3	63	20	17	0.3	7.2
40-48	7	77	11	11	0.3	7.2

†Coarse Fragments

[1]Funding for this project was provided by a USDA-CSRS grant

[2]B.R. Khakural and P.C. Robert are Post Doctoral Research Associate and Assistant Professor respectively in the Soil Science Department at the University of Minnesota, St. Paul, MN 55108. D.J. Fuchs is Junior Scientist, Southwest Experiment Station, University of Minnesota.

Six micro-plots (7 feet X 7 feet: 2 on each soil type) were established. Each plot was isolated vertically with polyethylene sheets (0.0059 in.) to a depth of 5 feet. Suction cups were installed in duplicates at 2 and 4 feet depths. Half of the experimental area (including 3 micro-plots and buffer zone) receives a constant rate of nitrogen and alachlor (Lasso) herbicide (Conventional treatment) and remaining half receives soil specific rates (FBS). Stainless steel sampling gutters attached to a vertically installed glass container have been used to receive runoff water and sediments samples. Corn and soybean crops have been rotated each year. TDR wave guides and thermocouple wires were installed at 2, 6, 12, 24 and 48 in. depths in each micro-plot to monitor soil water and temperature in 1991.

Plot Management

1990	1991	
Crop-Soybean Variety: Corsoy 79	Crop- Corn Variety: Pioneer 3615	Planting Date: 5-11-1991
Herbicide used: alachlor	Herbicide used: alachlor	Date of application: 5-21-91
Date application: 5-3-90	Nitrogen source: Anhydrous ammonia	Date of Application: 5-22-91
Herbicide rate: Same as in 1991		

Soil	Fertilizer and herbicide rates (1991):			
	Nitrogen rate		Herbicide rate	
	Conventional	Soil Specific	Conventional	Soil Specific
	lb/A		lb/A	
Ves (1-4%)	100	85	3.0	3.5
Ves (6-12%)	100	60	3.0	2.5
Webster (0-3%)	100	135	3.0	4.0

Sampling and laboratory procedure:

TDR and neutron probe readings were recorded every week. Soil samples (0-4 feet) were collected using a sampler with a plastic liner. One sampling was done before alachlor application and 5 samplings were done afterwards during the growing season. Runoff samples were obtained by placing the stainless steel sampler at the end of a 30 feet crop row (30 feet X 30 in). Soil water suction samples were collected after each significant rainfall. Only surface runoff and soil water samples were collected during the 1990 cropping season. Soil, soil water and runoff water samples were analyzed for alachlor concentration in the laboratory using gas chromatographic procedure.

Results and Discussion:

There was no significant difference in alachlor concentration of surface (0-6 in.) soil or runoff water between conventional and soil specific treatments (Table 2). Soil alachlor concentration at different sampling dates is presented in Table 3. No alachlor was detected in soil samples obtained from deeper than 12 in. depth. Detectable amount of alachlor was observed at 6-12 in. only at the first sampling (16 days after alachlor application) and in treatments with higher herbicide rates (Ves 1-4%-FBS, Ves 6-12%-Conv and Webster-FBS). Average alachlor concentration in the surface (0-6 in) layer was higher in the Webster soil than in the Ves soils (Figure 1). This could be related to the differences in organic carbon content (Table 1). A high alachlor adsorption is expected in the Webster soil with the higher organic carbon content.

Two and five runoff events occurred during 1990 and 1991 cropping seasons respectively. The alachlor concentration in runoff water at different runoff events is presented in Table 4. Timing of runoff events (days after application) and slope gradient determined the alachlor concentration in runoff water. The highest alachlor concentration in runoff water was observed at the first runoff event and the concentration decreased with time in later events. The concentrations were 68 to 265 ppb in 1990 and 47 to 193 ppb in 1991 at the first runoff events which occurred 20 and 7 days after application respectively. The concentration decreased to 0.3 to 2 ppb at the fifth runoff event in 1991 (119 days after application). The Ves soil with 6-12% slope had higher alachlor concentration than the Ves (1-4%) and Webster soils at the first runoff event after alachlor application (Figure 2). At later events, the Ves soil in general had higher concentration than the Webster soil. The average concentration (of 7 events) was 1.5 and 2 times higher in the Ves (6-12%) soil compared to the Ves (1-4%) and Webster soils respectively.

No alachlor was detected in soil water samples collected at 5 different dates (5-21, 6-21, 6-29, 8-30, 9-24) in 1990. Alachlor concentration in soil water suction samples collected at 2 and 4 feet depths are presented in Table 5. The alachlor concentration in soil water samples varied from 0 (ND) to 15 ppb in 1991. An alachlor concentration of ≥ 1 ppb was detected in 17 to 33% of the earlier samples (collected within 8 days of application) and 17% of the later samples at a depth of 2 feet respectively. At 4 feet depth, a concentration of ≥ 1 ppb was detected in 33% of the earlier samples only. No particular trend with soil types or herbicide rates was observed.

Table 2. Analysis of Variance for alachlor concentration in soil and runoff water.

Source	Soil (0-6 in.)	Runoff water
Soil type (S)	*	*
Alachlor rate (Conv vs FBS) (AR)	NS	NS
S X AR	NS	NS
Date/Event (D)	****	****
S X D	*	**
AR X D	NS	NS
S X AR X D	NS	**

*,**,**** Significant at the p = 0.05, 0.01, and 0.0001 levels, respectively.
NS = Not significant at the p = 0.05 level.

Table 3. Alachlor concentration in soil samples.†

Soil	Date:	5-14-91		6-6-91				6-27-91		7-23-91		9-26-91	
	Depth:	0-6 in		0-6 in		6-12 in		0-6 in		0-6 in		0-6 in	
		Conv	FBS	Conv	FBS	Conv	FBS	Conv	FBS	Conv	FBS	Conv	FBS
		ppb											
Ves (1-4%)		9	16	64	79	ND	3	32	10	2	7	7	12
Ves (6-12%)		6	8	80	63	2	ND	6	7	1	3	1	2
Webster (0-3%)		24	13	221	128	ND	2	39	43	9	4	7	4

Table 4. Alachlor concentration in runoff water.†

Soil	Date:	5-23-90		6-18-90		5-28-91		6-11-91		6-21-91		6-28-91		9-17-91	
		Conv	FBS	Conv	FBS	Conv	FBS	Conv	FBS	Conv	FBS	Conv	FBS	Conv	FBS
		ppb													
Ves (1-4%)		103	68	11	13	82	111	37	52	11	4	14	8	2	0.3
Ves (6-12%)		224	226	36	36	110	193	56	29	12	16	20	6	4	0.3
Webster (0-3%)		166	-	28	11	133	47	32	-	8	8	4	4	1	2.0

Table 5. Alachlor concentration in soil water at 2 and 4 feet depths.†

Soil	Date:	7-23-90		5-20-91		5-29-91		6-5-91		6-21-91		7-3-91		7-23-91	
		Conv	FBS	Conv	FBS	Conv	FBS	Conv	FBS	Conv	FBS	Conv	FBS	Conv	FBS
		ppb													
		2 feet													
Ves (1-4%)		-	-	ND	2.0	1.3	0.3	ND	ND	1.0	ND	0.2	-	-	-
Ves (6-12%)		ND	ND	ND	ND	0.2	1.3	ND	ND	ND	ND	ND	0.2	-	-
Webster (0-3%)		0.6	ND	ND	ND	ND	0.5	ND	1.0	ND	ND	-	3.4	ND	0.5
		4 feet													
Ves (1-4%)		ND	ND	15.0	ND	0.1	2.2	ND	ND	ND	ND	ND	ND	0.4	ND
Ves (6-12%)		1.0	ND	0.1	0.1	0.1	1.0	ND	ND	ND	ND	ND	-	-	ND
Webster (0-3%)		-	ND	0.6	6.8	0.5	0.3	ND	ND	ND	ND	ND	ND	ND	-

†ND = Not detected - Unable to get samples

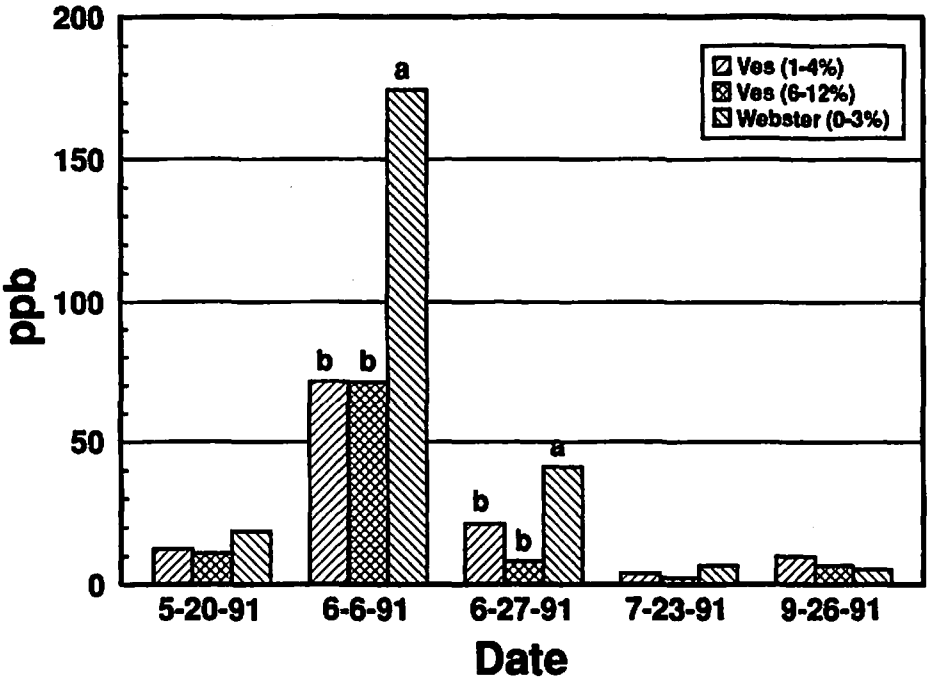

Figure 1. Soil alachlor concentration (0-6 in.)

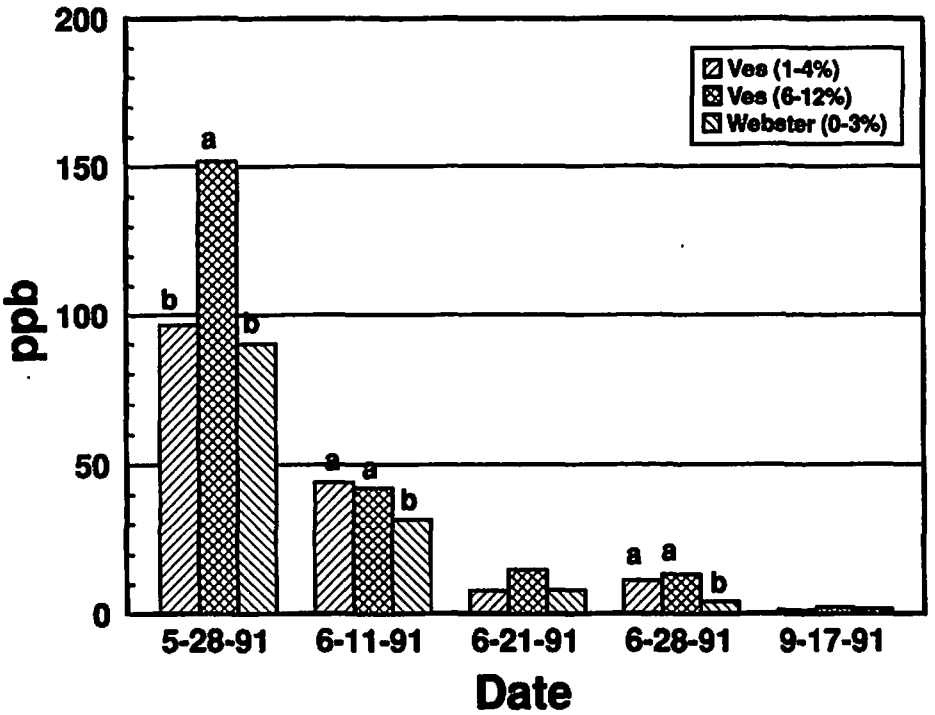

Figure 2. Alachlor concentration in runoff water

Means within a sampling date followed by the same letter are not significantly different at the p = 0.05 level. An absence of letters indicates no statistical difference

WEST CENTRAL EXPERIMENT STATION
WEATHER SUMMARY - 1991

		Precipitation			Temperature			Soil Temperature (10 cm depth)	
Month	Period	1991	100-yr. av.	Dev. from av.	1991	100-yr. av.	Dev. from av.	1991	10 yr. av.
January	1-31	0.36	0.68	-0.32	7.9	8.0	- 0.1	19.1	20.7
February	1-28	0.86	0.67	+0.19	21.9	12.8	+ 9.1	28.9	23.9
March	1-31	1.79	1.13	+0.66	29.9	26.7	+ 3.2	32.8	29.2
April	1-10	0.09	0.57	-0.48	53.3	38.0	+15.3	36.1	
	11-20	1.85	0.64	+1.21	39.4	44.4	- 5.0	40.7	
	21-30	1.78	1.05	+0.73	49.0	48.3	+ 0.7	51.6	
Total or av.		3.72	2.26	+1.46	46.6	43.6	+ 3.0	42.8	41.4
May	1-10	0.94	0.77	+0.17	43.3	52.0	- 8.7	47.0	
	11-20	0.56	0.95	-0.39	66.7	55.8	+10.9	68.7	
	21-31	1.99	1.25	+0.74	70.2	60.0	-10.2	73.4	
Total or av.		3.49	2.97	+0.52	60.4	56.1	+ 4.3	63.2	57.1
June	1-10	2.31	1.29	+1.02	68.4	63.0	+ 5.4	73.2	
	11-20	0.99	1.30	-0.31	71.5	66.3	+ 5.2	77.7	
	21-30	2.28	1.37	+0.91	69.3	68.1	+ 1.2	73.6	
Total or av.		5.58	3.96	+1.62	69.8	65.8	+ 4.0	74.8	69.3
July	1-10	1.70	1.44	+0.26	67.7	70.1	- 2.4	74.1	
	11-20	2.98	1.06	+1.92	74.9	71.4	+ 3.5	80.8	
	21-31	1.60	1.01	+0.59	67.3	71.4	- 4.1	74.2	
Total or av.		6.28	3.51	+2.77	69.9	70.9	- 1.0	76.3	76.7
August	1-10	1.62	1.04	+0.58	66.9	70.4	- 3.5	73.7	
	11-20	0.38	0.93	-0.55	68.6	69.0	- 0.4	79.0	
	21-31	0.76	1.04	-0.28	75.2	66.9	+ 8.3	80.9	
Total or av.		2.76	3.01	-0.25	70.4	68.7	+ 1.7	78.0	73.9
September	1-30	2.88	2.20	+0.68	57.7	59.0	- 1.3	66.2	61.5
October	1-31	0.74	1.74	-1.00	43.2	47.2	- 4.0	52.5	47.8
November	1-30	0.89	0.97	-0.08	22.6	29.7	- 7.1	32.5	33.6
December	1-31	0.35	0.61	-0.07	17.9	15.2	+ 2.7	29.4	23.4
April-Aug. Growing Season		21.83	15.71	+6.12	63.5	61.0	+ 2.5	67.6	63.8
January-December Annual		29.96	23.78	+6.18	43.3	42.0	+ 1.3	50.2	46.7

CONTINUOUS CORN SILAGE[1]

MORRIS, 1991

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. In 1991 there were significant effects of silage removal vs. grain removal only and of fertilizer level. However, 26-year averages 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 26th 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, fall applied. Silage and shelled corn yield samples were collected.

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 1990 corn stalks were chopped and fall fertilizer was spread on October 9, 1990. The experimental area was disked on October 10 and moldboard plowed on October 23, 1990. The study was field cultivated on May 8, 1991 for seedbed preparation. The study was then seeded to Pioneer 3751 corn at 27,512 seeds per acre on May 9, 1991. Lorsban 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 pre-emergence broadcast on May 9. The study was cultivated on June 3 and June 13, and date of tasseling and silking was recorded. Silage yields were chopped from 3-10 foot rows on September 5 and grain yields were calculated from 2-45 foot rows harvested with a plot combine on September 26, 1991. Yields were also taken, as in past years, on an adjacent unfertilized (check) area where only the grain is removed. Prior to fall fertilization and tillage soil samples were collected to an 8-inch depth in each plot and analyzed by the Minnesota Soil Testing Laboratory.

RESULTS AND DISCUSSION

Silage Yields: There were significant differences in silage yields in 1991 (Table 1) at the 10% level. There appears to be no interaction between fertilizer and biomass harvested in 1991. The difference between low fertility and high fertility averaged close to 1.30 tons/acre on both the silage and grain treatments. The grain treatments averaged 1.27 ton/acre more than those on which silage has been removed continuously. The 26-year average shows no effect of silage versus grain but does show significant differences between high and low fertility treatments.

Grain Yields: The 1991 grain yields (Table 2) show a significant difference in grain yield between the high and low fertility treatments of 26.7 bu./acre. The long-term 26-year average also shows a significant grain yield advantage for high fertility over low fertility of 5.0 bu./acre.

Soil Analysis: The results of the soil analyses are given in Table 3. The P soil test differs significantly between low fertility and high fertility, but the small difference between grain and silage was not significant even though both low and high fertility treatments show about 3 ppm less available P where silage has been removed compared to only grain removal. The K soil tests show effects of both fertility treatment and biomass removal. The greatest effect on K soil test was the removal of the complete above ground biomass compared to removing only the grain. These results point out the need to apply extra fertilizer on those fields which are used routinely for corn silage production.

This study will be continued in 1992.

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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	1991 Yield	1966-1991 Yield
	dry matter, tons/acre	
Silage, low fertility	6.42	5.55
Silage, high fertility	7.75	6.05
Grain, low fertility	7.72	5.62
Grain, high fertility	8.99	5.96
Signif. Levels (%)		
Treatment	93	>99
Year	--	>99
Treatment x Year	--	>99
LSD, treatment (.05)	NS	0.17
LSD, treatment (.10)	1.25	0.15

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

Treatment	1991 Yield	1966-1991 Yield
	Bu/ac @ 15.5% M.	
Grain, low fertility	150.9	88.9
Grain, high fertility	177.6	93.9
Signif. Levels (%)		
Treatment	96	>99
Year	--	>99
Treatment x Year	--	>99
LSD, Treatment (.05)	25.3	2.9
Grain, check (Bu/Ac)	99.7	48.7
Silage, check (D.M. Tons/Ac)	4.32	3.54

Table 3. Effect of removal of continuous silage or grain on P and K Soil Tests after 26 years.

Treatment	pH	P	K
		ppm	
Silage, Low fertility	8.2	13.5	119
Silage, High fertility	8.2	33.3	139
Grain, Low fertility	8.1	16.5	158
Grain, High fertility	8.1	36.5	199
Signif. Level (%)	NS	>99	>99
BLSD (.05)	--	9.2	15
CV (%)	--	21.5	5.8

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

Morris, 1991

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

Abstract: Many producers use subsoilers periodically to alleviate expected compaction due to traffic from tillage, planting, and harvesting equipment. In the fall of 1988 a study was initiated at the West Central Experiment Station to study the effects of a one-time subsoiling and its interaction with various primary tillage systems on subsequent soil compaction, soil water recharge, corn growth, and yield. This study was carried out on a site that had been farmed many years by normal 6-row equipment and on which serious compaction problems had not been observed. Results from the third year of a 3-year study, show subsoiling and subsoiling interactions with tillage had no significant effect on grain yield and other agronomic characteristics in 4 different primary tillage systems. Effects of subsoiling on soil bulk density 3 years after treatment were very small. It appeared that tillage and wheel traffic had repacked the soil to the extent that yield benefits did not occur from subsoiling even though small decreases in bulk density were observed in some soil depth increments. Subsoiling effects on the soil volumetric moisture content were not significant in 1991. Wheel traffic areas continued to have higher soil moisture content than non-wheel traffic areas.

OBJECTIVES

A 3-year study was initiated at the West Central Experiment Station to study the effects of (one time) subsoiling on subsequent crop growth, soil compaction, and soil moisture 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 was cropped to continuous corn. This report will discuss the 3rd year (1991) results of the 3-year study.

EXPERIMENTAL PROCEDURES

Tillage, Planting, and Harvest: The experimental plot area was established the fall of 1988. The entire plot area was fertilized with 150 lbs. P_2O_5/acre and 10 lbs.zinc/acre broadcast on October 13, 1988. Four main plot treatments were then established in the experimental plot area with each treatment split into subsoiled and not 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 grain harvested as silage and the 1989 and 1990 crops (1st and 2nd year of the study) were corn harvested with a combine. The plot area was planted with a 6-row planter. 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 16 inches (41 cm) deep, was used on the MSS, CSS, and NSS treatments. A paraplow, operating 13 inches (33 cm) 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 the 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.

In the fall of 1989 and 1990 the plots were treated as follows: (1) The MSS and MNS treatments were plowed using an onland hitch with 6 18-inch bottoms, (2) The CSS and CNS treatments were chiseled with a 15-foot pull type chisel plow, and (3) The NSS, NNS, DSS, and DNS treatments were not tilled.

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

[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.

Crop residue measurements were taken on May 14, 1991. On May 15 the DSS and DNS treatments were disked one time, and the MSS, MNS, CSS, and CNS treatments were field cultivated one time, 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. All subsequent wheel traffic was also confined to corn planter tractor wheel tracks. The NSS and NNS treatments were not tilled. The plots were seeded to Pioneer 3788 corn at @ 27,512 seeds/ac on May 15, 1991 with a 6-row planter. Lorsban 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.) was broadcast pre-emergence on May 15. Accent (0.66 oz./acre + Booster) was sprayed on NNS and NSS plots on June 10 to control escaped grasses. Crop residue measurements after planting were taken on May 22. Anhydrous ammonia was applied at 120 lbs. N/acre on June 13. Plots were cultivated on June 17. Plant population counts were taken on June 26. Tasseling and silking notes were recorded July 18-20. Plots were harvested for grain with a plot combine on September 30, 1991 and harvest weight and grain moisture were recorded. A grain sample was retained and bulk corn was harvested from all plots.

Soil Sampling: There was no soil sampling in the spring of 1991 for moisture and bulk density due to extremely wet soil conditions. After grain harvest in the fall of 1991 two soil cores in 0-6, 6-12, 12-18, and 18-24 inch depth increments were taken in wheel track and non-wheel track areas of each plot for bulk density and soil moisture determination. At the same time one soil core of 24-36 and 36-48 inch increments was taken in the wheel track and non-wheel track areas of each plot for soil moisture determination. The soil samples were weighed, dried at 105°C, and weighed back for bulk density and soil moisture determination. Sampling took place on October 2-3 and penetrometer readings were taken on October 3.

RESULTS AND DISCUSSION

Planting and Growing Conditions: Planting was delayed by wet soil conditions and growth was retarded at some times by wet soils. Growing conditions were excellent in 1991 with 21.83 inches of precipitation from April through August, 6.12 inches above average, with the months April through July with above average precipitation.

Residue Cover and Plant Measurements: Subsoiling (fall 1988) had no effect (Table 1) on 1991 crop residue cover, tasseling date, silking date, grain moisture, or grain yield. Tillage systems did significantly affect residue cover and date of tasseling. There were no significant subsoiling by tillage interactions.

Soil Bulk Density: An overall statistical analysis of soil bulk densities is given in Table 2. The main effects, subsoiling and tillage, had no significant effect on soil bulk density. The 1991 bulk density interaction of subsoiling by wheel traffic by depth (Table 3) showed greater bulk densities in the 0-6 and 6-12 inch soil increments of wheel-tracked areas than in non-wheel track areas. There were no significant differences in bulk density in the 12-18 and 18-24 inch depth increments. There also appeared to be a slight reduction in bulk density remaining due to subsoiling in the 6-12 inch depth increment, non-tracked area. This trend was been observed in fall soil measurements the past 2 years and was within the subsoiling depth of 16 inches for moldboard, chisel and no-till and 13 inches for disk. The same effect appeared only in 1991 in the 18-24 inch depth increment, non-tracked area, but this was below the subsoiling depth.

Soil Volumetric Moisture: A 3-way interaction of subsoiling by wheel traffic by depth (Tables 2 and 4) also occurred in soil volumetric moisture content, showing a larger content in wheel tracked than in non-tracked areas in the 0-6 inch depth increment, a very small difference in the 6-12 inch depth increment, and no differences at deeper depths. The volumetric water content difference between wheel tracked and non-wheel tracked areas was very small in the subsoiled plots, but was considerably larger in non-subsoiled plots (Tables 4 and 5). A tillage by depth interaction (Table 6) showed some variation in volumetric water content by depth, but the effects were small and no clear trends were apparent.

Soil Penetrometer Measurements: Penetrometer readings taken in the fall of 1991 after harvest are shown in Figure 1. Major differences observed were due to wheel traffic with tracked area having much higher penetrometer resistance than non-wheel track areas. In general, resistance increased with soil depth with no large differences between moldboard, chisel, and no-till. It appeared that resistance was highest in 35-50 cm depth increment in wheel tracked areas that had been subsoiled, except in the disk treatment. In the disk treatment this effect was not apparent and may have been due to a shallower subsoiling with the paraplow (33 cm). This effect did not appear in the fall of 1990. The penetrometer data has not been statistically analyzed.

SUMMARY

A one-time subsoiling of a soil that had been farmed with normal 6-row equipment had no effect on plant growth or yield over 3 cropping seasons following the subsoiling operation. Subsoiling had significant effects on soil bulk density and soil volumetric water content, but these effects decreased with time. The effects of normal wheel traffic following the subsoiling operation showed that the soil quickly returned to the same density and moisture condition as that of non-subsoiled areas. There were no large differences between 4 primary tillage systems that followed the subsoiling operation. Therefore, subsoiling areas that do not have serious compaction problems did not result in better yields or a better soil moisture availability.

Table 1. Summary of plant measurements due to tillage and subsoiling, 1991.

Treatment	5/14	5/22	Tassel Date from 7/1	Silk Date from 7/1	Grain Harvest Moisture	Grain Yield 15.5% M.
	- -% cover-				-- % --	-bu/ac-
Moldboard	14.5	14.8	18.0	19.1	19.7	150.3
Chisel	58.5	53.5	18.6	19.6	20.4	143.1
Spr. Disk	80.8	59.0	18.6	19.6	20.4	149.1
No-Till	81.0	80.3	19.0	20.0	19.9	140.9
Main plots:						
Signif. Level (%)	>99	>99	98	94	11	62
LSD (.05)	4.1	7.7	0.6	NS	NS	NS
C.V. (%)	3.2	6.5	1.3	1.6	4.4	5.4
Subsoiled	58.8	52.0	18.6	19.6	20.1	143.9
Not Subsoilded	58.6	51.8	18.6	19.6	20.1	147.8
Sub plots:						
Signif. Level (%)	15	16	--	43	--	81
Interaction:						
Signif. Level (%)	49	38	69	66	61	71

Table 2. Statistical analysis of bulk density and soil volumetric moisture content in subsoiler study, fall 1991.

Variable	Bulk Density	Soil Volumetric Moisture
Tillage (T)	.3362	.3146
using Rep * T as an error term		
Subsoiling (SS)	.4014	.6341
T * SS	.1646	.6819
using Rep * T * SS as an error term		
Wheel Traffic (Wt)	.0001	.0001
T * Wt	.7015	.3626
SS * Wt	.1842	.0090
T * SS * Wt	.4843	.8837
using Rep * T * SS * Wt as an error term		
Depth (D)	.0001	.0001
T * D	.4647	.0376
SS * D	.7817	.7857
Wt * D	.0001	.0001
T * SS * D	.2380	.3998
T * Wt * D	.5772	.2939
SS * Wt * D	.0219	.0441
T * SS * Wt * D	.5733	.5679
C.V. (%)	7.6	9.8

Table 3. Effect of subsoiling and wheel traffic on soil bulk density at several soil depths, fall 1991.

Trt.	0-6 inch increment			Trt.	12-18 inch increment		
	SS	NSS	Mean		SS	NSS	Mean
	- - - g/cm³ - - - -				- - - g/cm³ - - - -		
WT	1.34	1.34	1.34	WT	1.49	1.49	1.49
NWT	.96	.95	.96	NWT	1.49	1.49	1.49
Mean	1.15	1.15		Mean	1.49	1.49	
	6-12 inch increment				18-24 inch increment		
	SS	NSS	Mean		SS	NSS	Mean
	- - - g/cm³ - - - -				- - - g/cm³ - - - -		
WT	1.44	1.47	1.46	WT	1.55	1.56	1.56
NWT	1.37	1.41	1.39	NWT	1.51	1.55	1.53
Mean	1.41	1.44		Mean	1.53	1.56	

NWT = Non-wheel traffic zone
WT = Wheel traffic zone
SS = Subsoiled
NSS = Not subsoiled

Table 4. Effect of subsoiling and wheel traffic on volumetric soil moisture at several soil depths, fall 1991.

Trt.	0-6 inch increment			Trt.	12-18 inch increment		
	SS	NSS	Mean		SS	NSS	Mean
	- - - - % v/v - - - -				- - - - % v/v - - - -		
WT	42.0	41.4	41.7	WT	38.8	38.4	38.6
NWT	29.3	28.7	29.0	NWT	38.8	38.6	38.7
Mean	35.7	35.0		Mean	38.8	38.5	
	6-12 inch increment				18-24 inch increment		
	SS	NSS	Mean		SS	NSS	Mean
WT	45.1	44.6	44.9	WT	37.5	37.4	37.4
NWt	42.6	42.6	42.6	NWT	40.1	37.8	38.9
Mean	43.8	43.6		Mean	38.8	37.7	

Table 5. Effect of subsoiling and wheel traffic on volumetric water content, fall 1991.

	Subsoiling		
Trt.	SS	NSS	Mean
	- - - - - - - - - - % v/v - - - - - - - - - - - -		
NWT	38.7	37.4	38.1
WT	39.7	40.5	40.1
Mean	39.2	39.0	

Table 6. Effect of tillage on volumetric soil moisture at several soil depths, fall 1991.

Depth Increment	Moldboard	Chisel	Spr. Disk	No-Till	Mean
- in. - -	- - - - - - - - - - - - % v/v - - - - - - - - - - - - - - - -				
0-6	32.2	35.6	36.1	37.5	35.3
6-12	42.5	43.6	45.2	43.7	43.7
12-18	37.8	38.6	40.2	37.9	38.6
18-24	36.4	37.1	39.1	40.2	38.2
24-36	36.4	41.5	42.5	39.3	39.9
36-48	37.8	38.9	40.9	37.2	38.7
Mean	37.2	39.2	40.7	39.3	

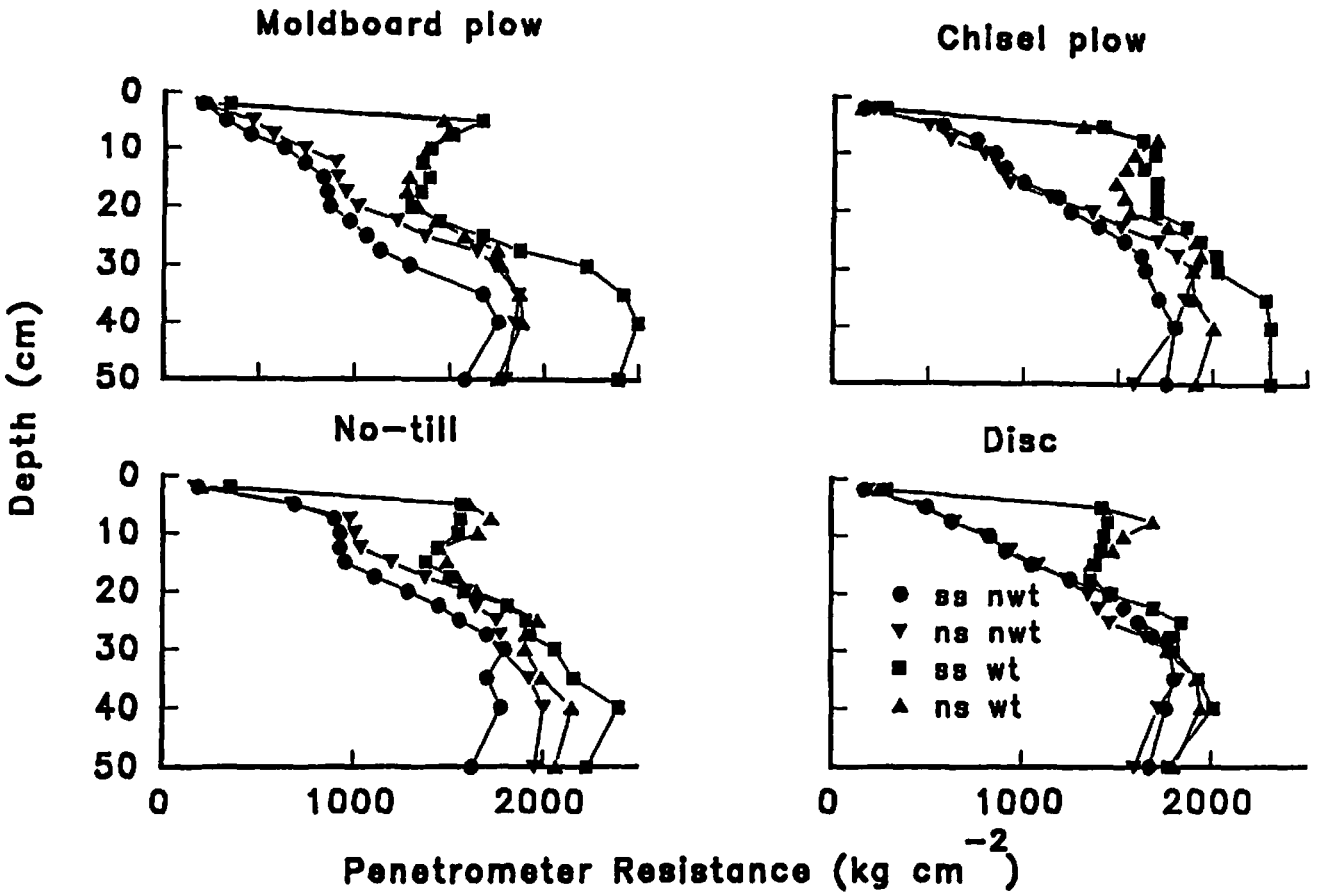

Figure 1. Penetrometer resistance readings for the four tillage systems in the spring and fall for subsoiled (SS), non-subsoiled (NS), wheel track (WT), and non-wheel tracked (NWT) interrows during the 1991 cropping season.

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

Morris, 1991

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

ABSTRACT: This study completed its 21st year in 1991. Nitrate movement and yield responses from two initial annual applications of manure have been measured. Results over 21 years show 1986 as the first year the fertilized check yielded significantly more than the manure treatments. This occurred again in 1989, 1990, and 1991. In 1987 the fertilized check yielded more than the manure treatments, but the difference was not significant. In 1988, a drouth year, all yields averaged about 50 bushels/acre. Soil samples, measuring NO_3-N, were taken to a depth of 4 feet in the fall of 1991. The fertilizer treatment had significantly more NO_3-N in the root zone than the manure treatments. Mineralization of organic N from manure applications has evidently slowed to a point were less N is being mineralized than is being supplied by the fertilized treatment.

This is the 21st year of a 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 9, 1990, and the entire experimental area was moldboard plowed October 15, 1990. The experimental area was worked with a field cultivator 2 times on May 8, 1991 for seedbed preparation. The study was planted to Pioneer 3788 corn on May 9, 1991, at 27,512 seeds/acre. Lorsban 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) were tank mixed and applied broadcast pre-emergence on May 9. Plots were cultivated on June 7. Corn heights were measured and whole plant samples were taken on June 17. Tasseling and silking dates were recorded and ear leaf samples were taken at mid-silk on July 17. Two 10-foot rows were harvested for silage yields on September 5, 1991. Two 110-foot rows were harvested with a plot combine on September 19, 1991 for grain yields. Grain yield and grain moisture were recorded at harvest. On September 22 plots were soil sampled to a depth of 4 feet in 1-foot increments with three subsamples taken per plot. These cores were combined, subsampled, and submitted for nitrogen analysis. On September 24 plots were sampled to a depth of 16 inches in 0-8, 8-12, and 12-16 inch increments for phosphorus analysis. Ten subsamples of each depth increment were composited per plot.

RESULTS AND DISCUSSION

Early Plant Height and Dry Weight: The fertilizer treatment and all manure treatments had significantly taller and heavier plants than the check treatment (Table 1), with the exception of liquid hog manure which was statistically equal to the check treatment in early plant dry weight.

Grain Yield and Moisture: The grain yield (Table 1) on the fertilizer treatment was significantly higher than on all other treatments. Solid beef and liquid beef yielded more than the liquid hog and check treatments. The fertilizer treatment has now yielded more than the manure treatments the last 6 years with the effects being significant in 1986, 1989, 1990, and 1991. The effect of the 1970-71 manure applications on grain yield has decreased to the extent that the fertilizer treatment now has higher yields than the manure treatments and the liquid hog manure treatment grain yield is the same as the check treatment.

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

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

Silage Yields: Solid beef and liquid beef silage yields (Table 1) are intermediate between the fertilized and liquid hog/check treatments yields, but are substantially lower than the fertilizer treatment yields. There was no significant difference in silage yield between the check and liquid hog treatments.

Soil Nitrate-N and Ammonium-N Analysis: The results of nitrate and ammonium analyses are given in Table 2. Nitrate-N levels generally increased with depth while NH_4-N levels decreased with depth. Nitrate-N levels found in the fertilizer treatment were significantly greater than NO_3-N levels found in the manure treatments. Ammonium-N levels in all treatments were essentially the same. Low NO_3-N levels in the manure treatments, similar to those found in the check treatment, indicate mineralization of nitrogen from added organic material (manure) has decreased substantially, but not completely, as indicated by taller and heavier plants in the manure treatments than in the check treatment.

Table 1. Summary of plant measurements - 1991.

Treatment	Early Plant Height	Early Plant (10) Dry Weight	Grain: Moisture at Harvest	Grain: Yield at 15.5% Moisture	Grain: Dry Matter at Harvest	Silage: Silage Yield (D.M)	Silage: Ear Wt. as a % of Silage
	- cm -	- grams -	--%--	-bu/ac-	- % -	-lb/ac-	- - % - -
Check	23.9	49.3	33.4	77.0	50.4	8,037	52.0
Fertilized	32.6	138.7	29.8	162.6	50.8	14,448	59.1
Solid Beef Manure	31.6	116.0	30.4	107.2	49.8	10,741	53.1
Liquid Beef Manure	32.4	154.3	30.0	114.9	49.2	11,566	55.3
Liquid Hog Manure	28.5	87.0	31.7	86.8	49.8	9,216	53.1
Signif. Level (%)	>99	>99	>99	>99	26	99>	99
LSD (.05)	2.3	43.2	1.4	14.5	NS	1,773	3.9
CV (%)	4.2	21.0	2.5	7.5	3.0	9.0	3.6

Table 2. Nitrate and ammonium nitrogen concentration of a Tara soil 21 years (Fall, 1991) after application of high rates of manure.

Depth Incr.	CK	Fert	Solid Beef Manure	Liquid Beef Manure	Liquid Hog Manure	Mean	CK	Fert	Solid Beef Manure	Liquid Beef Manure	Liquid Hog Manure	Mean
ft.	- - - - - - - ppm NO_3 - N - - - - - - - - -						- - - - - - - ppm NH_4 - N - - - - - - - - -					
0-1	4.1	4.9	4.9	4.7	3.7	4.4b	4.5	6.6	3.1	7.5	6.9	5.5a
1-2	0.8	1.2	0.8	0.9	0.6	0.9c	2.2	2.6	1.5	3.8	2.6	2.5b
2-3	1.9	20.5	1.5	1.5	1.1	4.5b	1.6	1.4	1.4	1.8	1.6	1.6c
3-4	4.3	33.0	3.2	5.8	2.9	8.4a	1.7	1.4	1.3	1.4	1.6	1.4c
Mean	2.8b	14.9a	2.6b	3.2b	2.1b		2.5	3.0	1.8	3.6	3.2	

Signif Level (%):

Replication	- 72	Replication	- 55
Treatment	- 98, LSD (.05) = 8.1	Treatment	- 88
Depth	- >99, LSD (.05) = 3.3	Depth	- >99, LSD (.05) = 0.4
Trt x Depth	- >99	Trt x Depth	- >99

EFFECT OF NITROGEN APPLICATION RATE ON GRAIN YIELD IN CORN AND SOIL WATER NITROGEN IN MORRIS, MN[1]

A. Bhattacharjee, S.D. Evans, J.F. Moncrief, S.C. Gupta, B.J. Johnson, and G.N. Nelson[2]

Abstract

Experiment is being conducted at Morris, MN to study the effect of rate of application of nitrogenous fertilizer on the concentration of nitrate nitrogen in soil water in reduced tillage system. Results of 1991 shows that there was increase in the grain nitrogen uptake with the increase rate of nitrogen application. The grain yield and the total dry matter also increased with the increase in the nitrogen rate. However all the treatments except the control treatment (no nitrogen) were on par with each other with respect to grain yield and total dry matter. The treatment with 100 lbs/A nitrogen showed the maximum concentration of soil water nitrate over the other treatments. There was an increase in the mean soil water nitrate nitrogen from initial stage to the harvest stage of the crop. The increase in the mean nitrate nitrogen concentration in the soil water was 12 ppm with the first increament of the nitrogen fertilizer and an additional 17 ppm with second fertilizer increament.

Introduction

With the advent of the high yielding varieties of the crops in 1960 's, there was an increased application of chemical fertilizers. A major component of many fertilizers is nitrogen,a very mobile nutrient, which can find its way to the groundwater and streams by leaching and with the surface runoff water,respectively. With the increased concern for wind and water erosion, interest has also increased in reduced tillage system and their effect on nitrogen fertilizer movement in the soil. A Minnesota survey has found nitrate in 43% of the 500 wells tested in 51 counties. Therefore it has become increasingly necessary to know the effect of rate of application of nitrogenous fertilizer on the concentration of nitrate in the soil water in reduced tillage systems. With these in mind the present study is being conducted at the West Central Experiment Station, University of Minnesota, Morris,MN.

Methods and Materials

The experimental design is a randomized complete block design with rates of nitrogen application as treatments (0, 50, 100, 150 lbs/A)and corn as the test crop. The study is being conducted on a LaPrairie loam. This soil series is formed in alluvium underlain by stratified sand and gravel. The surface layer in a typical profile is black loam about 24 inches thick. The subsoil is very dark grayish-brown to dark grayish-brown,friable loam in the upper part and dark-brown to olive-brown loam the lower part. Water moves through these soils at a moderate rate. Prior to establishing the study, test holes were made in the potential plot area. The experiment was established where the depth to fine sand varied from 40 - 60 inches. These soil samples were saved and will be analyzed for NO_3-N. The plot size are 65 feet in length and 30 feet in width (12-30 inches row). The area was in corn in 1990 and was moldboard plowed that fall. In the spring of 1991 the area was field cultivated and urea fertilizer was broadcast, the area was field cultivated again, and planted to Pioneer 3788 @ 27,800 seeds per acre on 05/10/91. On 06/12/91 two suction samplers were placed in each plot. The samplers were installed in the corn row and the bottom of the sampler was placed at the loam-fine sand interface. Therefore, the sampling depth varied from 40 to 60 inches, depending on the depth to the fine sand layer. Samples were taken on a 7- day interval throughout the growing season. The soil water collected was analyzed for total, nitrate, and ammoniacal nitrogen. The corn was cultivated twice during the season; on 06/03/91 and 06/13/91. On 09/19/91 four rows were harvested with a 2-row Almaco plot combine. Yields and soil moisture were determined electronically and recorded. A grain sample was saved for nitrogen analysis. Shortly afterwards on 09/25/91, one row was harvested with a forage chopper to assess total dry matter and total nitrogen uptake. The remainder of the corn was harvested and corn stalks were chopped. The area will be maintained in the future in a ridge-till system.

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Results and Discussion

Grain and total nitrogen content. The grain and the total N content are given in the table 2. As evident from the table there were significant differences between the treatments. The highest grain nitrogen was observed in the treatment with 150 lbs/ac nitrogen (1.43%) which was followed by the treatment with 100 lbs/ac of nitrogen(1.30 %). Though the grain nitrogen percent was higher in the treatment with 50 lbs/A nitrogen, it was on par with the control treatment (No nitrogen i.e. 0 lbs/A).

Grain and total nitrogen uptake. The grain and the total N uptake are shown in the table 3 and Fig. 1. The maximum nitrogen uptake in grain was observed in the treatment with 150 lbs/A nitrogen (119.9 lbs/A). The treatments with 50 and 100 lbs/A of nitrogen was on par with each other. The minimum grain nitrogen percent was observed in the control treatment as expected. It is interesting to note that the treatment with 50 lbs/A nitrogen was on par with the control treatment (0 lbs/A).
There were no significant difference between 50, 100, and 150 lbs/A nitrogen treatments for total nitrogen uptake. However the maximum total nitrogen uptake was obtained in the treatment with 150 lbs/A nitrogen (163.46 lbs/A).

Grain Yield and total dry matter. The yield of both grain and total dry matter is shown in the table 4 and Fig. 2. There were no significant differences in grain yield and total dry matter of corn between the nitrogen application rates. However with the increase in the application rate of nitrogen there was a corresponding increase in grain yield as well as in total dry matter yield. Grain yield increased by 8 bu/A (5 % by wt) in 150 lbs/A of nitrogen when compared to 50 lbs/A of nitrogen.

Soil water nitrogen . The mean values of soil water nitrogen over the sampling dates are given in the table 5 and Fig. 3. Nitrate was the primary form of nitrogen observed in the soil water. There was an increase in the mean soil water nitrate concentration from initial stage of the crop (46.2 ppm) to harvest stage (64.4 ppm). Though there was variation in the soil water nitrate within the growing season, it could not be attributed directly to the effect of precipitation that occurred within the growing season (Fig. 4).

The mean values of total, nitrate and ammoniacal nitrogen in soil water over the different treatments and the sampling dates are shown in the table 6 and Fig. 5. It is evident from the figure that the treatment with

100 lbs/A of nitrogen showed higher concentration of nitrate nitrogen concentration in the soil water over the other treatments. The increase in mean nitrate nitrogen was about 12 ppm with the first increament of nitrogen fertilizer and an additional 17 ppm with the second fertilizer increament. However it is interesting to note that the treatment with 150 lbs/A of nitrogen showed lower concentration of nitrate nitrogen than the check treatment (No nitrogen) over the entire period of the growing season. This could be attributed to some extent to the increased uptake of nitrogen shown in the grain nitrogen and total nitrogen uptake (Fig. 6). It could be also attributed to variation in residual nitrate existing in the soil from the 1990 crop.

Table 1.Cultural practices at Morris, MN in 1991.

Tillage
Fall Moldboard and
Field cultivated twice before planting

Cropping Pattern
Corn - Soybean rotation from 1991

1991 crop
Corn - Pioneer 3788

Planting and harvest dates

Corn - was planted with a two row Hiniker Series 1 EconoTill planter with 30 inches row spacing.

	Planting			
Crop	Date	Planter	Rate	Harvest date
Corn	May 10, 1991	Row	27,800 seeds/ac	September 25, 1991

Weed control

3.0 qt/A (3.0 lb/A) Lasso + 2.2 qts (4.0 l/A) Bladex 90 DF was broadcasted on May 10, 1991.
Furadan (9.8 lbs/A) with planter.

Table 2 Effect of nitrogen application rate on grain nitrogen percent and total nitrogen percent of corn at Morris ,MN, 1991

Nitrogen rate (lbs/A)	Grain N (%)	Total N (%)
0	1.20 a	0.87 a
50	1.22 a	1.01 b
100	1.30 b	0.82 b
150	1.43 c	0.89 ab

The p value for nitrogen rate on grain nitrogen percent and total nitrogen percent are 0.0001 and 0.101 respectively. The means within the same column with the same letters are not significantly different(α= 0.10).

Table 3 Effect of nitrogen application rate on grain nitrogen uptake and total nitrogen uptake of corn at Morris, MN, 1991

Nitrogen rate (lbs/A)	Grain N uptake (lbs/A)	Total N uptake (lbs/A)
0	89.1 a	125.3 a
50	97.9 ab	152.4 b
100	108.4 b	150.7 b
150	119.9 c	163.4 cb

The p value for nitrogen rate on grain nitrogen uptake and total nitrogen uptake are 0.0004 and 0.010 respectively. The means within the same column with the same letters are not significantly different(α= 0.10).

Table 4 Effect of nitrogen application rate on grain and total dry matter of corn at Morris ,MN, 1991

Nitrogen rate (lbs/A)	Grain Yield (bu/A)	Total dry matter (tons/A)
0	156.6 a	5.8 a
50	170.2 b	6.7 b
100	176.5 b	6.7 b
150	178.4 b	6.6 b

The p value for nitrogen rate on grain yield and total dry matter are 0.047 and 0.029 respectively. The means within the same column with the same letters are not significantly different(α= 0.10).

FIG.1 GRAIN , STOVER AND TOTAL NITROGEN UPTAKE AT DIFFERENT NITROGEN RATES ON CORN AT MORRIS,MN,1991

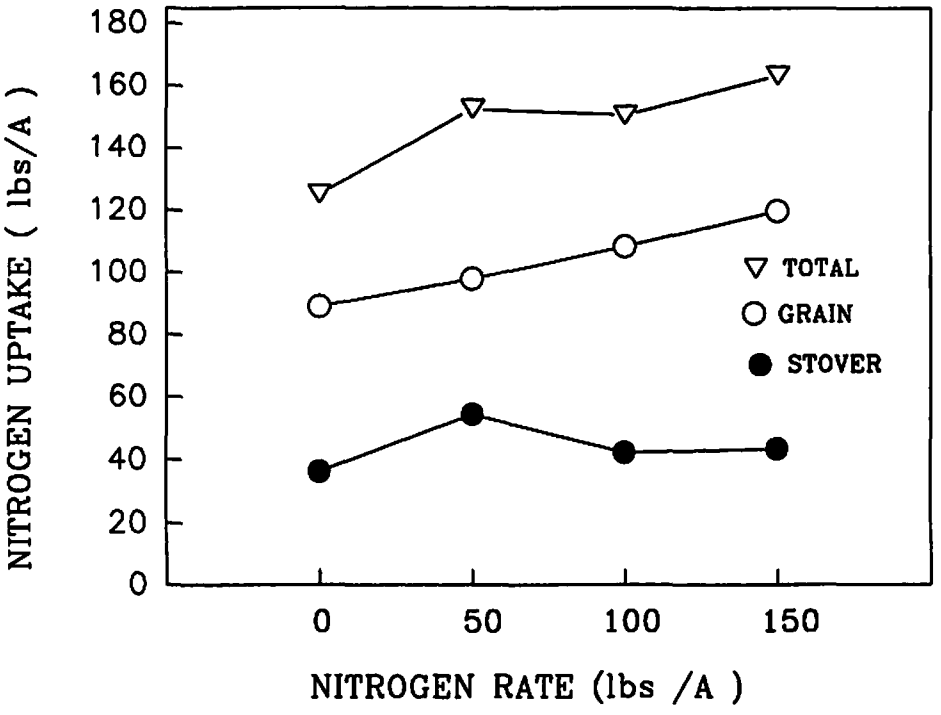


FIG. 2 GRAIN YIELD AND TOTAL DRY MATTER OF CORN AT DIFFERENT NITROGEN APPLICATION RATE AT MORRIS MN.

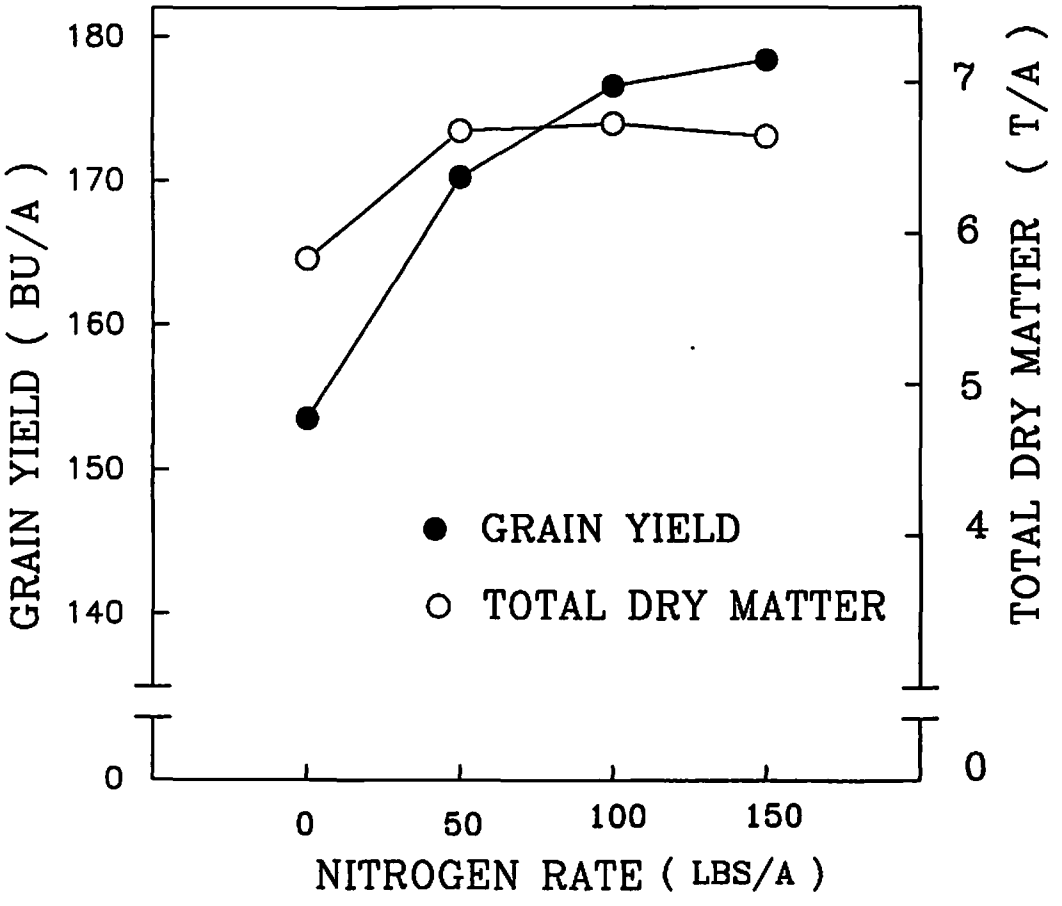


Table 5. Distribution of total, nitrate and ammoniacal nitrogen concentration[1] in soil water on different dates of sampling in Morris, MN, 1991.

Date	Total N (ppm)	Nitrate N (ppm)	Ammoniacal N (ppm)
06/18/91	46.5	46.2	0.27
07/03/91	52.2	52.1	0.16
07/09/91	62.8	62.5	0.03
07/16/91	57.8	57.7	0.11
07/23/91	59.9	59.8	0.02
07/30/91	70.3	70.2	0.01
08/06/91	69.9	68.8	0.05
08/13/91	59.9	59.8	0.05
08/20/91	69.8	69.7	0.03
08/26/91	72.8	72.7	0.05
09/04/91	66.4	66.3	0.04
09/20/91	64.5	64.4	0.13

1. Mean values over different treatments.

Table 6. Effect of nitrogen application rate on total, nitrate and ammoniacal N[1] in soil water over different sampling dates in Morris, MN, 1991.

Dates sampled	Total N(ppm) lbs/ac				Nitrate N (ppm) lbs/ac				Amm.-N (ppm) lbs/ac			
	0	50	100	150	0	50	100	150	0	50	100	150
06/18	43.3	50.9	57.3	35.4	43.1	50.8	56.9	35.2	0.18	0.2	0.49	0.22
07/03	51.3	52.9	72.2	35.5	51.2	52.6	71.9	35.4	0.09	0.34	0.15	0.09
07/09	61.1	72.5	74.1	44.6	61.0	72.4	74.0	43.6	0.02	0.03	0.04	0.05
07/16	58.5	57.6	63.8	48.5	58.4	57.3	63.7	48.4	0.04	0.31	0.05	0.03
07/23	54.4	76.1	64.7	48.8	54.3	76.0	64.6	48.7	0.01	0.04	0.01	0.04
07/30	64.9	91.4	77.4	50.2	64.8	91.4	77.4	50.1	0.01	0.00	0.00	0.02
08/06	70.5	68.4	87.1	29.5	70.4	68.3	87.0	29.4	0.05	0.06	0.02	0.09
08/13	60.6	64.7	68.1	46.3	60.5	64.6	68.0	46.2	0.04	0.05	0.04	0.05
08/20	68.4	83.0	90.4	46.9	68.3	82.9	90.3	46.8	0.03	0.02	0.03	0.03
08/26	61.4	83.2	89.5	54.6	61.4	83.1	89.4	54.6	0.00	0.002	0.01	0.00
09/04	59.8	66.6	90.1	46.6	59.7	66.5	90.0	46.5	0.04	0.02	0.02	0.09
09/20	47.7	84.7	87.2	42.9	47.6	84.5	87.0	42.8	0.12	0.14	0.14	0.13

1. Mean values over different replications.

FIG. 3 SOIL WATER-N DISTRIBUTION OVER TIME IN CORN AT MORRIS ,MN.

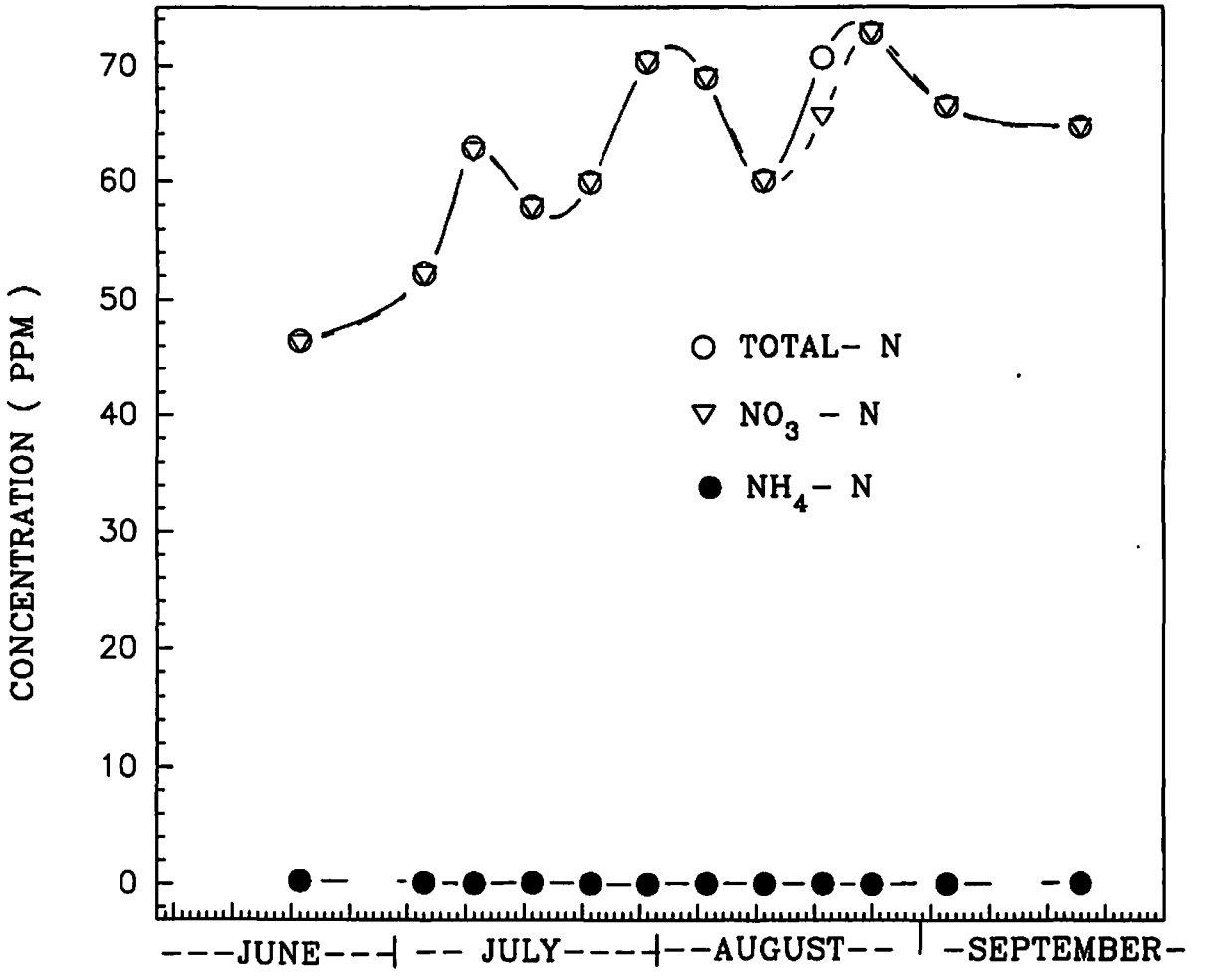


FIG. 4 DISTRIBUTION OF PRECIPITATION AND SOIL WATER-N CONCENTRATION IN CORN AT MORRIS, MN.
1991

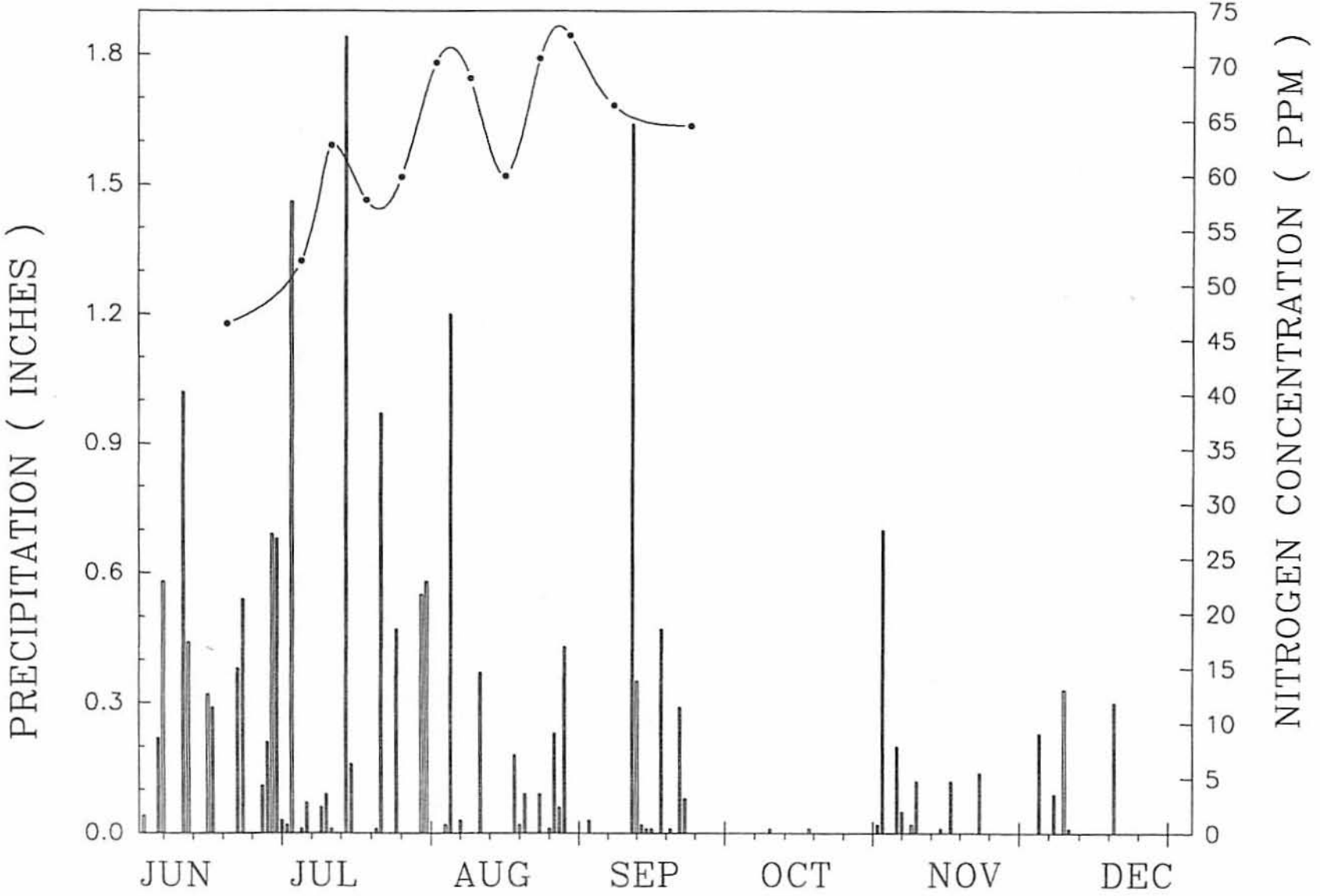


FIG. 5 SOIL WATER-N CONCENTRATION OVER TIME IN CORN AT MORRIS.MN

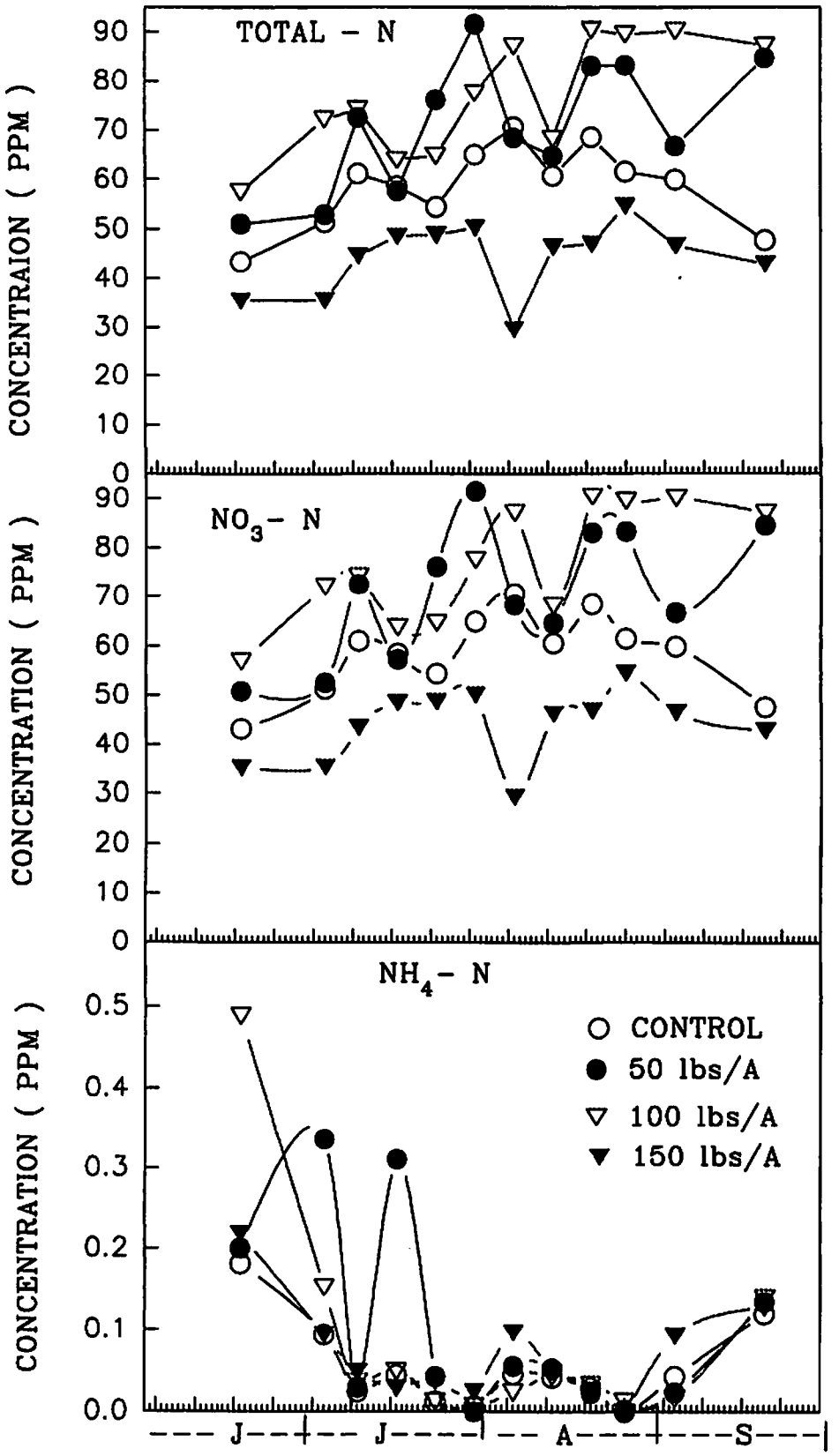
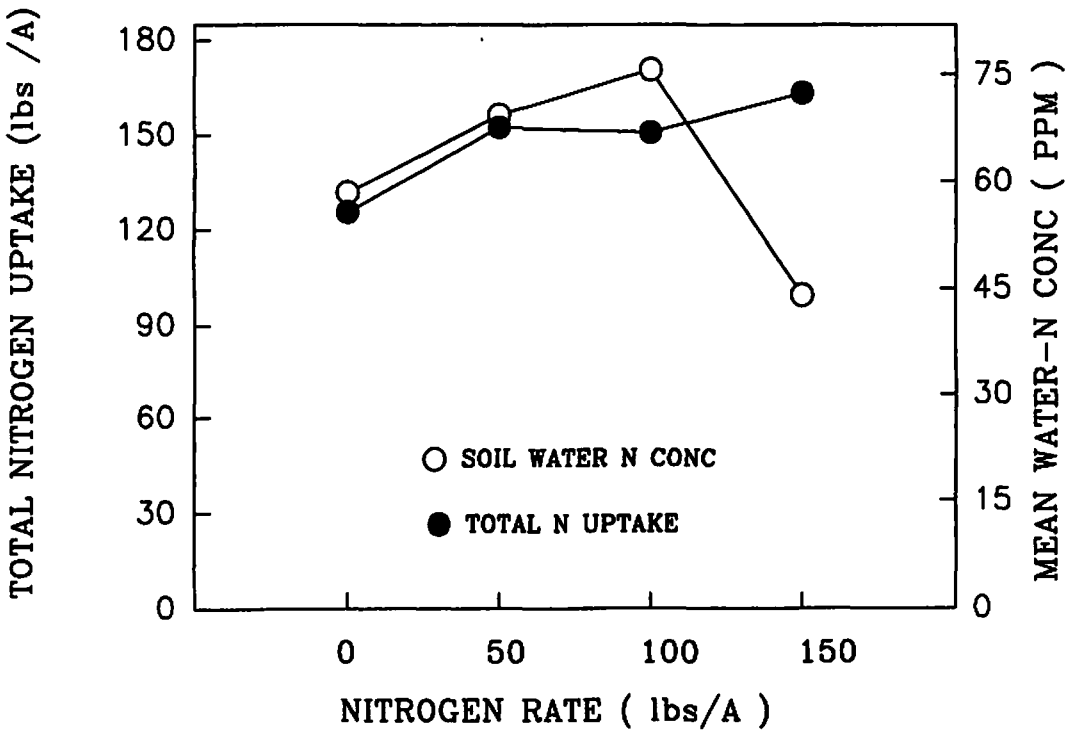


FIG. 6 TOTAL NITROGEN UPTAKE AND MEAN SOIL WATER NITROGEN CONCENTRATION OVER THE SAMPLING SEASON AT DIFFERENT NITROGEN RATE ON CORN AT MORRIS,MN, 1991



MATCHING PRECISION PLACEMENT OF POTASH FERTILIZER TO ROOT GROWTH DYNAMICS IN A RIDGE-TILL PLANTING SYSTEM[1]

Deborah Allan, George Rehm, and Sam Evans[2]

Potassium deficiency symptoms often appear in ridge-tilled corn even when soil test values for potassium are high. In this trial, we compared early growth, yield, K uptake and root activity for three tillage systems (chisel plow, ridge-till, and no-till), two hybrids (Pioneer 3732 and 3737), and two fertilizer treatments (control and 40 lb/A banded K_2O). Tillage system had no effect on grain yields, but there was greater early growth and K uptake with the chisel plow system. Banded K increased plant growth, K uptake and grain yield. Pioneer hybrid 3732 had higher early shoot growth, but significantly lower uptake of K, and tended to show less root activity at 6" and 12" depths than 3737.

Recent interest in ridge-till and no-till planting systems for corn has raised the question of appropriate fertilizer placement. Early season K deficiency symptoms have been repeatedly observed in ridge-tilled corn in diverse soil environments, even where K soil test values are high. Banding of fertilizer K has been shown to alleviate the K deficiency problem in ridge-tilled corn, but the reasons for occurrence of the deficiency are still unknown. The objectives of this study were to: 1) determine more precisely the effect of potash placement on root activity, K uptake, plant growth, and subsequent corn yield in a ridge-till planting system compared to fall chisel and no-till planting systems; and 2) quantify differences in K uptake and root activity in the three tillage systems for two corn hybrids.

Methods and Materials

This study was initiated at the West Central Experiment Station in Morris, Minnesota in the fall of 1990. Soil test values for K prior to fertilization are listed in Table 1. Fertilizer treatments were supplied as shown below:

control (no K_2O) + 124 lb/A 10-34-0 starter
200 lb/A 7-21-7 starter
40 lb/A K_2O in row-band (fall) + 124 lb/A 10-34-0 starter
80 lb/A K_2O broadcast (fall) + 124 lb/A 10-34-0 starter
40 lb/A K_2O in row-band (fall) + 200 lb/A 7-21-7 starter

Fall banded (40 lb/A) and broadcast (80 lb/A) applications were made on October 29, prior to any fall tillage. Adequate N was applied to all treatments as 82-0-0.

Corn was planted on May 13, 1991 at a population of 30,000 plants per acre. Two hybrids (Pioneer 3732 and 3737) were combined with the applied rates of K_2O and four tillage systems in a complete factorial arranged in a randomized complete block design with four replications. Weed control was achieved by Lasso EC (3.0 lbs/A a.i.) and Bladex 90 DF (2.2 lbs/A a.i.). Only the ridge-till plots were cultivated on June 13 and ridged on June 19. The plots were harvested September 26 and grain yields were corrected to 15.5% moisture.

A portion of the above experiment was chosen for more intensive study of root activity and K uptake. For three tillage systems (chisel plow, ridge-till and no-till), two K rates (0 and 40 lb K/A banded) and both hybrids, injections were made of three non-essential ions [rubidium (Rb), strontium (Sr) and lithium (Li)] to serve as tracers for root activity. Injections were made on June 2 with a syringe apparatus opposite each plant along 14 feet of the two center rows in each plot. Each plant in one row was labeled with Sr (at 3" depth) and Li (at 12" depth) at a distance of four inches from the plant, perpendicular to the row on the outer side. In the other row, each plant was labeled with Rb (at 6" depth) in a similar fashion. This labelling scheme allowed sampled plants from the first row to serve as controls for background levels of Rb, and in the second row for Sr and Li.

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Table 1. Soil test values for potassium at the experimental site.

Depth	Distance From Row (inches) 0	3	6	9	12	15
inches	ppm K					
Fall chisel:						
0 - 3	202	165	169	157	177	167
3 - 6	142	140	130	140	127	101
6 - 9	113	124	121	123	127	139
Fall Plow:						
0 - 3	134	139	145	143	141	122
3 - 6	128	124	132	135	132	117
6 - 9	145	137	145	118	126	116
No Till:						
0 - 3	195	200	204	212	216	176
3 - 6	139	132	122	133	118	132
6 - 9	123	120	117	123	123	131
Ridge Till:						
0 - 3	212	196	181	163	184	165
3 - 6	135	136	132	136	134	99
6 - 9	105	120	115	127	127	119

Plant samples were collected from these plots at four times during the growing season (6/12, 6/21, 7/15 and 9/18) approximately 30, 40, 60 and 120 days after planting. At each sampling time, 4 plants from each of the two labeled rows were harvested, dried, weighed, ground and analyzed for K, Rb, Sr, and Li. A border zone of 20" was left between each group of sampled plants.

In order to interpret the results and to convert all tracer uptake values to a common measure of root activity, an additional tracer study was established in the field border. In this case, the three tracer ions were injected to the same depth (6"), at the same distance from the plant (4"), in three subplots separated by border zones, and replicated four times. Five plant samples were taken from the middle of each subplot on June 21. By analysis and calculation of ion uptake, it was established that relative uptake of Rb:Sr was 9.7 and Rb:Li was 14.4. These numbers allowed us to convert all Sr and Li uptake values to equivalent Rb uptake rates. In this study, net uptake of Rb per plant is used as an index of root activity.

Bulk density and moisture content in the top 12 inches were measured on July 31, 1992. Twelve cores were taken from two plots in each tillage treatment in blocks 1 and 2, and twelve from blocks 3 and 4. All plots selected were controls planted to 3732. Gravimetric soil moisture content was sampled in two plots for each tillage and fertility treatment on 6/26, 7/18, 8/1, and 8/29. Soil levels of K, Rb, Sr, and Li in a sampling of injection points were determined to confirm that the injected tracers reached the intended location.

Results and Discussion.

Tillage effects on soil properties. Bulk density was similar for ridge-till and chisel plow, and greater for no-till when averaged over the top 12" (Table 2). However, moisture content was higher for both ridge-till and no-till planting systems. Below 6", the bulk density values were very similar for all three tillage treatments, but moisture contents remained lower for chisel from 6-12" (data not shown).

Table 2. Bulk density and soil moisture averaged over a soil depth of 12". Sampled 7/31/91. Significance calculated at the 5% level.

	Bulk Density (g/cm^3)	Moisture Content %
Tillage		
Chisel Plow	1.29 b	22.8 b
Ridge Till	1.30 b	24.5 a
No Till	1.37 a	24.7 a

When soil moisture was measured at 4 different times during the season in 4 plots for each tillage treatment, there were no significant differences in moisture content among any of the tillage systems at any date (Table 3).

Table 3. Soil moisture at 4 sampling times under 3 tillage systems.

	Sampling Date											
	6/26			7/18			8/01			8/29		
Depth in.	Chisel Plow	Ridge Till	No Till	Chisel Plow	Ridge Till	No Till	Chisel Plow	Ridge Till	No Till	Chisel Plow	Ridge Till	No Till
0-6	24.9	23.8	24.8	24.1	23.4	24.0	26.4	26.3	26.0	22.8	22.2	22.4
6-12	24.8	24.0	26.3	24.7	24.4	24.9	25.0	25.0	25.8	21.8	21.6	22.7
12-18	23.2	23.2	24.6	22.2	24.2	22.7	23.0	24.8	24.8	17.6	19.2	18.8
18-24	21.1	21.1	22.0	19.1	19.9	20.0	18.7	22.1	21.0	15.8	17.0	16.6

At a distance of 4" from the row, soil test values for K sampled in 2 plots for each tillage treatment (ridge and chisel, 9 samples per plot) were the same in the top two inches, but significantly lower for ridge tillage at the 10% confidence level for all other depths up to 15" (Table 4). Ridge-till K values were anywhere from 15-30% lower, but the values were in the medium range for both tillage systems.

Table 4. Soil test values for potassium in two tillage systems, using ammonium acetate extraction, n=18.

Depth in.	Chisel Plow	Ridge Till	Significance
	ppm K		
0-2	191	204	NS
2-4	218	168	*
4-6	199	134	*
6-8	156	119	*
8-10.5	149	111	*
10.5-13	139	119	*
13-15	169	122	*

NS = not significant; * = significant at 10%

Grain yields and plant growth during the season. As has been seen previously, there was a significant effect of banded K_2O on grain yield (Table 5). Application of K_2O and hybrid both significantly affected early growth (prior to physiological maturity at 120 DAP) and grain yield (Table 6). Pioneer 3732 had greater early season growth than 3737, but yields were significantly lower. At 60 DAP, there was a significant interaction between K application and hybrid for plant weight. Fertilizer application increased 3732 shoot growth by 18% compared to only 7% for 3737. Tillage treatment had no effect on grain yields, but early growth (from 30-60 DAP) was significantly higher for chisel plow than ridge-till or no-till. There were no significant interactions between tillage and the other variables.

Table 5. Effect of different K fertilizer treatments on grain yields. Significance calculated at the 5% level.

Treatment	Grain Yield bu/A
0	169.4 c
Starter K	169.7 bc
40 lb/A band	175.0 a
80 lb/A broadcast	171.0 abc
40 lb/A band and starter K	173.7 ab

K concentration and uptake. Tillage had a significant effect on K uptake at the first three sampling times, with chisel plow showing consistently higher K uptake than ridge-till or no-till (Table 7). Potassium concentration differed only at the 40 DAP sampling date, with ridge-till significantly lower. Concentration and uptake of K was significantly less for Pioneer 3732 at all sampling times. The banded K treatment resulted in significantly higher K uptake at all sampling times and higher K concentrations at 30 and 40 DAP. Significant interactions occurred for fertilizer treatment by hybrid at 60 DAP, where fertilizer application narrowed the differences between the two hybrids, and for tillage by hybrid at 40 DAP, where much greater differences occurred between the two hybrids in chisel plow and no till than for ridge-till.

Root activity. Almost no significant differences were measured in root activity due to tillage, fertilizer treatment, or hybrid, due to the large variability in both the tracer uptake and the tracer concentration in the soil (Table 8). Coefficients of variation for the tracer uptake averaged 80, 50, 35 and 45% for the 30, 40, 60 and 120 DAP sampling times. For tracer placement, cv's averaged 98, 150, and 66% for Sr, Rb and Li, respectively. Variability was lower later in the season, which indicates that this technique may not be appropriate for measuring early season root activity. The trends in the data suggest that at 3 and 6" depths, root activity tended to be higher with chisel plow than ridge-till or no-till, although at 12", ridge-till tended to be highest. Hybrid 3732 had more root activity at the 3" depth and less at 6" and 12", especially at later sampling times (60 and 120 DAP). Generally, K application tended to increase rooting with depth and decrease root activity at the surface.

Summary. Although tillage system had no effect on grain yields, there was greater early growth, K uptake, and a trend to greater root activity at 3 and 6" depths in the chisel plow system. Banded K_2O increased plant growth, K uptake and grain yield. Pioneer 3732, although it had higher early shoot growth and, possibly, root activity at the 3" depth, had significantly lower K concentration and accumulation and tended to have less root activity at 6" and 12".

Both soil properties as affected by tillage and hybrid differences appear to be involved in the observed early season K deficiency. Soil moisture for both ridge-till and no-till were greater than chisel plow, possibly affecting soil temperature and root growth. Less soil K may be available in ridge-till compared to chisel plow planting systems (15-30% less in this study). Some effect of the tillage system on root and/or soil properties seems likely, since ridge tillage causes significantly lower K uptake for both hybrids.

Clearly, hybrid 3732 is more prone to K deficiency, more sensitive to the ridge- and no-till systems, and more responsive to banded K_2O application. Possible causes for this may be greater early shoot growth at the expense of roots, or greater proliferation of surface roots at the expense of deeper rooting. In future growing seasons, we plan to investigate this question further by using a more intensive root sampling technique and attempting to reduce the variability in the tracer injection procedure.

Table 6. Growth at 4 sampling times and grain yield.

Tillage	K rate	Hybrid	Days After Planting 30	40	60	120	Grain Yield
	lb K/A		g per plant				bu./A
Chisel Plow	0	3732	5.1	18.9	102.9	130.8	163.0
	0	3737	4.1	20.0	94.6	129.2	169.9
	40	3732	6.2	21.2	112.0	152.6	164.1
	40	3737	5.2	23.0	96.2	144.0	182.4
Ridge Till	0	3732	4.3	13.7	80.1	134.7	159.2
	0	3737	3.3	13.6	85.4	130.7	175.5
	40	3732	5.5	17.2	105.9	144.9	178.5
	40	3737	4.3	15.1	92.8	141.7	178.0
No Till	0	3732	4.2	12.0	89.9	139.6	161.7
	0	3737	2.9	13.7	81.9	136.6	178.9
	40	3732	4.6	15.2	103.4	148.0	172.8
	40	3737	3.8	14.9	89.4	131.7	174.4
Analysis of Variance							
Tillage (T)							
Chisel Plow			5.2a	20.8a	101.4a	139.2	170.2
Ridge Till			4.4b	14.9b	91.0b	138.0	171.0
No Till			3.9b	13.9b	91.1b	138.9	172.5
Significance			**	**	**	NS	NS
K rate (K)							
0			4.0	15.3	89.1	133.6	169.4
40			4.9	17.8	99.9	143.8	175.0
Significance			**	**	**	NS	*
Hybrid (H)							
3732			5.0	16.4	99.0	141.8	166.7
3737			3.9	16.7	90.0	135.6	176.9
Significance			**	NS	**	NS	**
Interactions							
T X K			NS	NS	NS	NS	NS
T X H			NS	NS	NS	NS	NS
K X H			NS	NS	**	NS	NS
T X K X H			NS	NS	NS	NS	NS

NS = not significant; * = significant at 5%; ** = significant at 1%

Table 7. Potassium concentration in corn tissue and uptake by plants

			Days After Planting							
			30		40		60		120	
Tillage	K rate lb K/A	Hybrid	K Conc. %	K Uptake mg per plant	K Conc. %	K Uptake mg per plant	K Conc. %	K Uptake mg per plant	K Conc. %	K Uptake mg per plant
Chisel Plow	0	3732	1.96	98.9	1.93	372.0	0.90	924	0.52	682
	0	3737	3.48	141.9	3.53	700.5	1.57	1479	0.95	1237
	40	3732	3.26	203.0	2.77	603.3	1.19	1338	0.85	1303
	40	3737	4.20	222.5	4.03	942.5	1.58	1530	0.93	1294
Ridge Till	0	3732	1.77	77.0	1.66	226.9	0.79	639	0.64	876
	0	3737	3.16	105.4	2.16	301.3	1.44	1208	0.84	1078
	40	3732	3.08	166.7	2.55	440.4	1.00	1070	0.70	1025
	40	3737	3.88	168.7	3.03	457.7	1.29	1200	0.89	1259
No Till	0	3732	2.07	88.0	1.83	224.7	0.88	793	0.63	903
	0	3737	3.10	89.3	3.14	442.4	1.61	1316	0.97	1325
	40	3732	2.84	131.0	2.48	380.1	1.06	1040	0.75	1107
	40	3737	3.84	145.7	3.77	559.5	1.62	1439	0.99	1308
Analysis of Variance										
Tillage (T)										
Chisel Plow			3.22	166.6a	3.07a	654.6a	1.31	1318a	0.81	1129
Ridge Till			2.97	129.4b	2.35b	356.6b	1.13	1029b	0.77	1060
No Till			2.96	113.5b	2.81a	401.7b	1.29	1147b	0.83	1161
Significance			NS	*	**	**	NS	*	NS	NS
K Rate (K)										
0			2.59	100.1	2.37	378.0	1.20	1060	0.76	1017
40			3.52	172.9	3.11	563.9	1.29	1269	0.85	1216
Significance			**	**	**	**	NS	**	NS	*
Hybrid (H)										
3732			2.49	127.4	2.20	374.6	0.97	967	0.68	983
3737			3.61	145.6	3.28	567.3	1.52	1362	0.93	1250
Significance			**	**	**	**	**	**	**	**
Interactions										
T X K			NS	NS	NS	NS	NS	NS	NS	NS
T X H			NS	NS	**	*	NS	NS	NS	NS
K X H			*	NS	NS	NS	**	**	NS	NS
T X K X H			NS	NS	NS	NS	NS	NS	NS	NS

NS = not significant; * = significant at 5%; ** = significant at 1%

Table 8. Root activity at three depths as estimated by net rubidium uptake during the growing season.

Tillage	K rate lb K/A	Hybrid	3" Depth Days after planting 30	40	60	120	6" Depth Days after planting 30	40	60	120	12" Depth Days after planting 30	40	60	120
			mg net Rb uptake/plant				mg net Rb uptake/plant				mg net Rb uptake/plant			
Chisel Plow	0	3732	1.31	8.83	8.78	7.75	0.55	2.09	4.33	2.92	0.012	0.22	1.24	2.92
	0	3737	1.60	7.21	5.53	9.58	0.15	2.85	5.10	4.29	0.011	0.42	1.75	4.08
	40	3732	2.54	7.06	5.36	4.87	0.20	1.01	3.91	3.22	0.009	0.35	1.20	3.21
	40	3737	3.28	8.39	5.61	7.17	0.18	1.44	4.68	3.14	0.047	0.37	1.27	4.02
Ridge Till	0	3732	3.49	3.32	4.75	7.45	0.07	1.81	4.06	3.12	0.012	0.20	1.02	3.56
	0	3737	1.87	4.74	6.62	6.29	0.15	0.71	5.13	3.40	0.042	0.17	1.82	3.95
	40	3732	0.67	3.55	5.18	7.15	0.38	2.60	3.99	3.79	0.020	0.42	1.34	3.37
	40	3737	2.23	2.82	5.68	4.66	0.24	1.79	4.27	5.74	0.021	0.40	2.09	4.69
No Till	0	3732	1.48	2.92	4.76	6.56	0.15	1.12	3.57	2.98	0.011	0.26	1.09	1.89
	0	3737	1.46	5.58	3.38	4.16	0.13	0.69	3.11	4.52	0.003	0.24	1.02	3.23
	40	3732	2.93	3.67	8.63	6.47	0.17	1.20	3.24	3.28	0.006	0.27	1.27	2.22
	40	3737	1.74	3.83	3.35	3.34	0.14	0.98	4.70	4.75	0.010	0.14	1.52	2.74
Analysis of Variance														
Tillage (T)														
Chisel Plow			2.19	7.87a	6.32	7.34	0.27	1.85	4.51	3.39	0.020	0.34	1.36	3.56a
Ridge Till			2.07	3.61b	5.56	6.39	0.21	1.73	4.37	4.01	0.024	0.30	1.57	3.89a
No Till			1.90	4.00b	5.03	5.14	0.15	1.00	3.66	3.88	0.007	0.23	1.23	2.52b
Significance			NS	**	NS	NS	NS	NS	NS	NS	NS	NS	NS	*
K rate (K)														
0			1.87	5.43	5.64	6.97	0.20	1.54	4.22	3.54	0.016	0.25	1.32	3.27
40			2.23	4.89	5.64	5.61	0.22	1.50	4.13	3.99	0.019	0.33	1.45	3.38
Significance			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Hybrid (H)														
3732			2.07	4.89	6.25	6.71	0.25	1.64	3.85	3.22	0.012	0.29	1.19	2.86
3737			2.03	5.43	5.03	5.87	0.16	1.41	4.50	4.31	0.022	0.29	1.58	3.79
Significance			NS	NS	NS	NS	NS	NS	NS	*	NS	NS	**	*
Interactions														
T X K			**	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS
T X H			NS	NS	NS	NS	NS	*	NS	NS	NS	NS	*	NS
K X H			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
T X K X H			NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS

NS = not significant; * = significant at 5%; ** significant at 1%

Tillage effects on N available to irrigated corn from alfalfa-five year summary[1]

J.F. Moncrief, M.J. Wiens, J.J. Kuznia, N. Krause, and B.J. Johnson[2]

This study is designed to evaluate the effect of tillage on corn response following alfalfa. Tillage affected stand establishment and development rate.

The objective of this study is to evaluate the effect of full width tillage on corn growth following alfalfa in two separate studies at the Staples Area Technical School Irrigation Center. Alfalfa was killed with herbicide in the spring of 1987 and 1990 and planted to corn. This is the fifth and second year of these two studies. Tillage systems established in the spring were: moldboard with plow packer, discing twice, and no tillage. Nitrogen was applied as urea (from 12 to 224 lbs/acre) in three applications: 12 lbs/acre with the planter, and the remainder in two equal applications at the 4-6 and 8-12 leaf growth stage of corn. Urea was irrigated in to prevent volatilization losses. Irrigation amounts and timing as well as N responses are presented in a companion papers. The planter used was equipped with two inch fluted coulters in 1987 to 1989. In 1990 and 1991 clearing discs were used.

Planting and harvest dates are shown in table 1. Harvest was done after physiological maturity or frost occurrence. The cumulative growing degree days (base 10-30) from planting to harvest are also shown in table 1. Three years were very similar ('87, '89, and '91). The season was very warm in '88 and cold in '90.

The soil cover by corn residue after planting are shown in table 2. The planter equipped clearing discs were only partially successful in removing crop residue from the row area. In 1987 and 1990 soil cover is with alfalfa residues for studies 1 and 2 respectively. Soil cover ranged from 55 to 92% cover. The fluted coulter used to do tillage in the row area did not reduce the residue very much. Clearing discs were much more effective (1990 and 1991). It is recommended that "in row" cover by corn residue be less than 20% to minimize the potential of detrimental effects on corn emergence and early growth.

Emergence was delayed up to 10 days with a no till systems (data not shown). Cover by corn residue affected grain moisture in all years. Cover by alfalfa residue did not. As corn residue levels accumulated with time plant stands reduced with "in row" soil cover. The cool year of 1990 had the largest effect on stand mortality with soil cover in the row.

The effect of tillage on corn yield following alfalfa is shown in figure 1. There are two sets of curves, one for control plots (no applied nitrogen) and one for plots where N was not limiting yields (applied as urea, see companion papers).

After three years check plot yields stabilized at 65 and 40 bu/acre for the moldboard and disc, and no till treatments respectively. The yields with N applied are steadily decreasing over the length of the study. The yields of the conservation tillage systems in 1990 are primarily the result of the cool growing conditions and the subsequent stand loss and delayed growth.

Study two contrasts with study one in that the N benefits of first year corn are less even though the stand densities are greater (3 versus 8 plants per square foot). It also appears that yield levels without applied N have reached the base line after the first year.

These graphs show several trends. Firstly, the N benefits from the alfalfa are gone after the first or second year on coarse textured irrigated soils. Secondly the tillage effects on control plot yields due not change with time. Applied N the first year following alfalfa does result in similar grain yields irrespective of tillage. After the first year following alfalfa, N does not eliminate tillage affects on grain yields. Lastly, if one looks just at the moldboard lines to eliminate the confounding effects of tillage, the yields are still slowing declining even after five years of corn. The rotation effect is very prominent on these soils.

The average of the three tillage treatments are presented in figure 2. The residual N from alfalfa and declining yields following alfalfa without N limiting are apparent.

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Tillage study 1 data, five years of corn on corn after alfalfa, at Staples Irrigation Center. Staples, MN. Tillage study 2 data, 2 years of corn on corn after alfalfa at Staples.

Table 1. Growing Degree Days.

YEAR	1987		1988		1989		1990		1991	
Planted/Harvested	5/11	10/1	4/27	9/29	5/10	10/10	5/7	10/8	5/8	9/8
GDD	1248		1453		1237		1146		1237	

Table 2. Soil cover (%) as effected by tillage.

Tillage	1987		1988		1989		1990		1991		Mean	
	Residue Cover, %											
Study 1	In[1]	Bet.	In	Bet.	In	Bet.	In	Bet.	In	Bet.	In	Bet.
No Till	92a	97a	84a	90a	92a	98a	69a	80a	55a	84a	**78**	**90**
Disk	48b	41b	64b	57b	43b	46b	53b	49b	28b	40b	**47**	**46**
Moldboard	13c	11c	9c	6c	10c	10c	17c	18c	5c	3c	**11**	**10**
Mean	**51**	**49**	**52**	**51**	**48**	**51**	**46**	**49**	**29**	**42**	**45**	**49**
Study 2							In	Bet.	In	Bet.	In	Bet.
No Till							26a	72a	70a	85a	**48**	**79**
Disk							16b	14b	31b	37b	**23**	**25**
Moldboard							3c	7b	6c	7c	**4**	**7**
Mean							**15**	**31**	**36**	**43**	**25**	**37**

1. In = in-row cover, Bet.= between-row cover.

Table 3. Grain moisture of corn as effected by tillage.

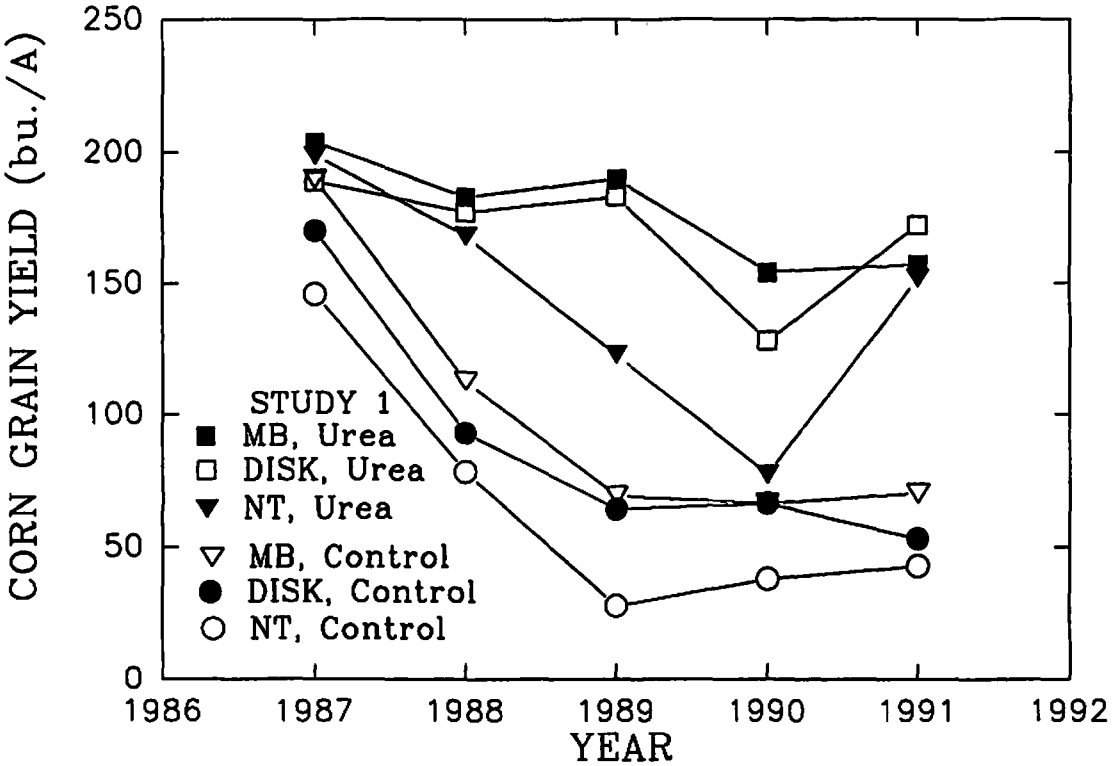
Tillage	1987	1988	1989	1990	1991	Mean
	Grain Moisture, %					
Study 1						
No Till	32.8a	28.4a	26.4a	34.6a	29.4a	**30.3**
Disk	32.3a	23.6b	21.6b	29.6b	26.8b	**26.8**
Moldboard	31.8a	22.7c	21.7b	26.5c	26.5c	**25.8**
Mean	**32.3**	**24.9**	**23.2**	**30.2**	**27.6**	**27.6**
Study 2						
No Till				27.2ab	32.8a	**30.0**
Disk				27.5a	29.7b	**28.6**
Moldboard				26.4b	27.5c	**27.0**
Mean				**27.0**	**30.0**	**28.5**

Table 4. Plant population stand as effected by tillage.

Tillage	1987	1988	1989	1990	1991	Mean
	Plant Population ($Ax10^{-3}$)					
Study 1						
No Till	29.0a	29.6a	23.3a	23.7a	38.4a	**28.8**
Disk	28.2a	31.7a	31.1b	27.1b	42.4b	**32.1**
Moldboard	28.4a	32.4a	33.0b	29.8c	42.1b	**33.1**
Mean	**28.5**	**31.2**	**29.1**	**26.9**	**41.0**	31.3
Study 2						
No Till				29.8a	35.1a	**32.4**
Disk				30.0a	37.7b	**33.8**
Moldboard				30.0a	38.5b	**34.2**
Mean				**29.9**	**37.1**	**33.5**

1. Values with the same letter, within the same column, are not significantly different.

FIG 1. THE EFFECT OF TIME AND TILLAGE ON NITROGEN AVAILABLE TO CORN FROM ALFALFA RESIDUES, SOIL ORGANIC MATTER, AND UREA AT STAPLES, MN



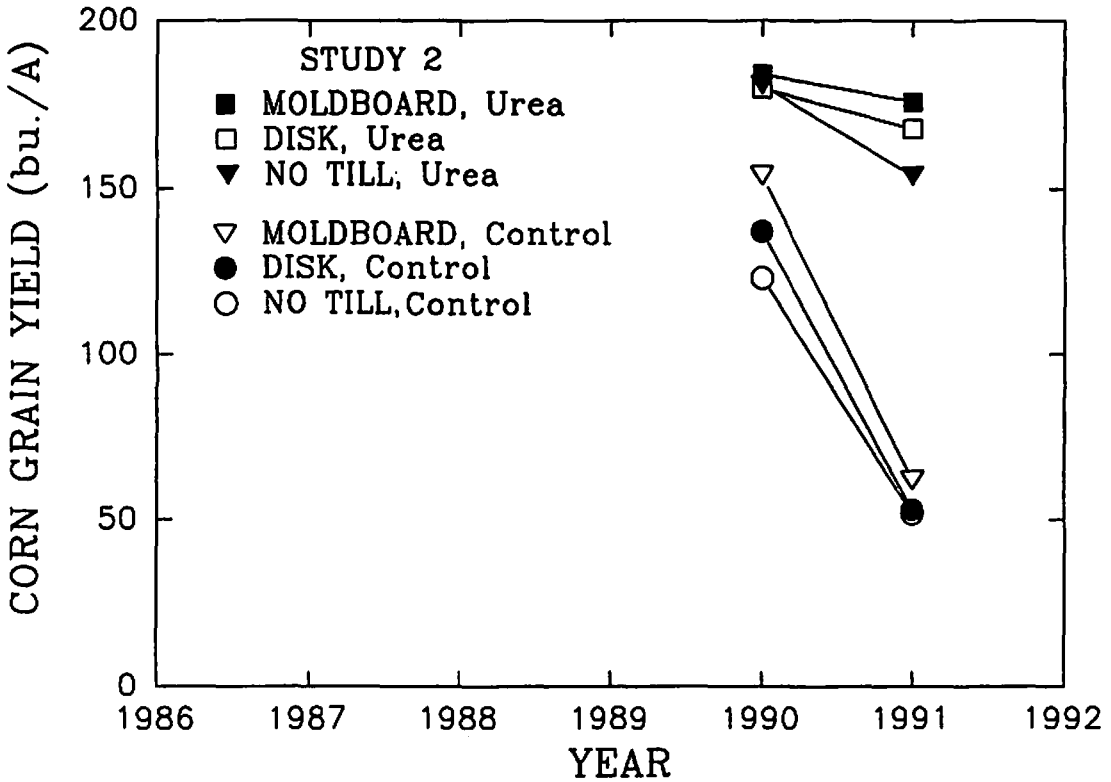
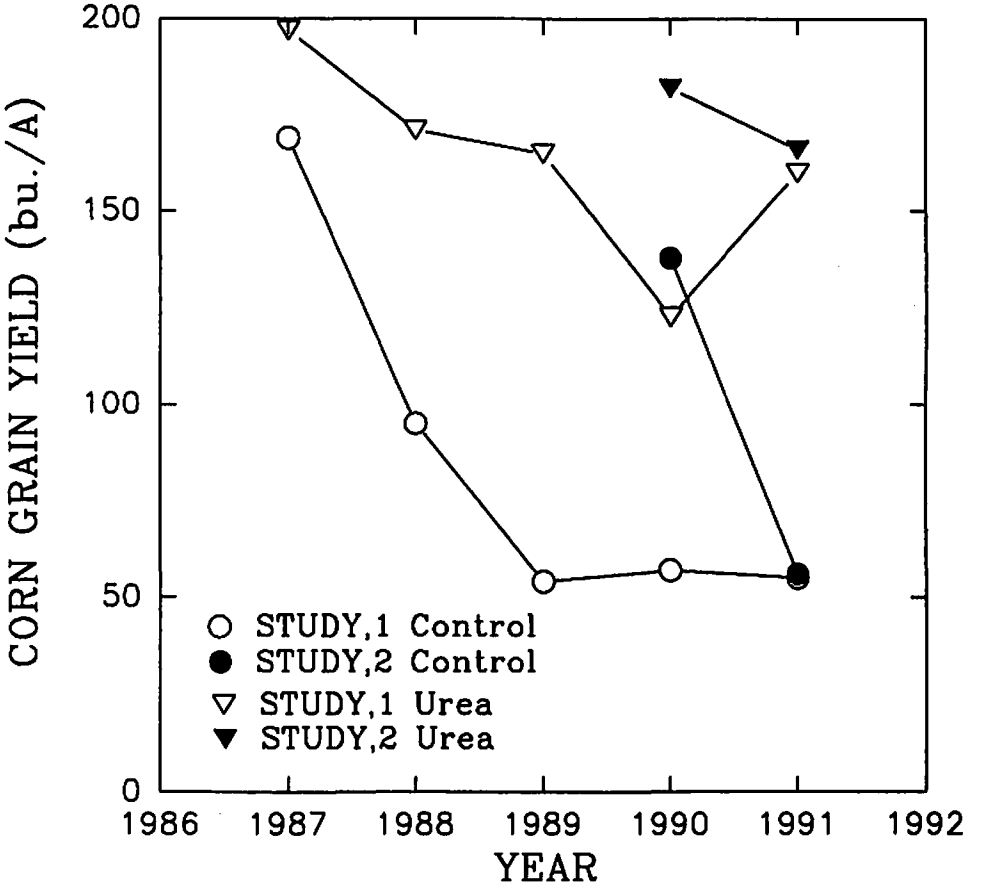


Fig 2. THE EFFECT OF TIME ON NITROGEN AVAILABLE TO CORN FROM ALFALFA RESIDUES, SOIL ORGANIC MATTER, AND UREA AT STAPLES, MN



Tillage effects on N available to irrigated corn from alfalfa and urea N sources[1]

J.F. Moncrief, M.J. Wiens, N. Krause, and B.J. Johnson[2]

This study is designed to evaluate full width tillage and row cultivation on the N available to second year corn following alfalfa. Tillage affected stand establishment and emergence rate. Corn grown under conservation tillage systems did not differ in their nitrogen repsonse. The cultivation response by corn interacted with tillage system. Cutivation increased N uptake most under no till conditions but also with moldboard plowing. Corn that was planted into spring discing plots did not result in increased uptake when cultivated.

The objective of this study is to evaluate the effect of full width tillage and row cultivation in June on the amount of nitrogen available to corn from alfalfa. Alfalfa was killed with herbicide in the spring of 1990 and planted to corn. This is the second year of a three year study. Tillage main plots are split with nitrogen subplots. Tillage systems established in the spring were: moldboard with plow packer, discing twice, and no tillage. Nitrogen was applied as urea (from 12 to 224 lbs/acre) in three applications: 12 lbs/acre with the planter, and the remainder in two equal applications at the 4-6 and 8-12 leaf growth stage of corn (table 1). Urea was irrigated in to prevent volatilization losses. Irrigation amounts and timing are presented in a companion paper.

The soil cover by corn residue after planting and corn emergence are shown in table 2. The planter equipped clearing discs were only partially successful in removing crop residue from the row area. It is recommended that "in row" cover by corn residue be less than 20% to minimize the potential of detrimental effects on corn emergence and early growth. The emergence rate is shown in figure 1. Emergence was delayed six and three days with no till and spring discing systems respectively. This is in contrast to 1990 with similar cover levels but by alfalfa residues when emergence was only delayed by 2 days with the no till treatment and not at all with the spring disc treatment. Final stands were reduced significantly under no till conditions. This is also in contrast to 1990 following alfalfa when final stands were not affected by tillage.

Treatment means and statistical significance are shown in table 3. Soil cover in the row of 70% increased grain moisture 5% over moldboard plowing grown corn with 6% soil cover in the row. This is graphically presented in figure 2. The fifth year corn results are reported elsewhere. These results are in contrast to 1990 results for first year corn following alfalfa. In 1990 tillage affected grain moisture, but only slightly. The tillage delay in development also is reflected in the stover moisture levels. Grain yields were reduced under no till conditions by 16 bushels per acre. Although final stands were affected by tillage, they are above the level expected to affect yields.

Although there were no consistent effects of tillage on tissue nitrogen content, total uptake was lower with conservation tillage systems. Corn grain yields responded to 170 lbs/acre N. About 20 lbs/acre N was applied with irrigation water (figure 3). This study received water from the Irrigation Center Pit. Stover yields did not respond beyond the second rate of N.

Although cultivation did not affect grain yields, it did increase N uptake by stover and grain. There was an interaction between tillage and cultivation for stover and total N uptake. The cultivation response was greatest with the no till system intermediate with moldboard plowing and absent with spring discing.

There were no interactions between tillage and N rate for measured variables. This is also in contrast to 1990 when tillage affected grain response to applied N for first year corn. Three way interactions between tillage, cultivation, and N rate also do not show any consistent trends (tables 4a and 4b).

Figures 4 and 5 show the soil water nitrate at 3 and 5 feet under moldboard and no till conditions. Figure 4 shows the individual sampler duplicates within the plots. The variability within plots makes it difficult to identify any treatment trends. The moldboard system appeared to have higher levels of nitrate through out the season (figure 5). This was consistent with 1990 data.

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[1] *Support for this project was provided by the Agricultural Utilization and Research Institute, the Staples Irrigation Center, and the Soil Conservation Service. Their support is greatly appreciated.*

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Table 1. Cultural practices at Staples Irrigation Center, Wadena County, MN. 1991.

Tillage

No Till
Spring Disced and moldboard plowed May 7, 1991
Cultivated with a Hiniker 5000 conservation cultivator on June 13, 1991

Previous Crop

Alfalfa 1987-89
Corn 1990

1991 Crop

Corn-Pioneer 3790

Planting and Harvest Date

The planter is a 4 row Deutz-Allis Model 385 with 30 inch row spacing, equipped with 2 inch fluted coulters and disc row cleaners.

	Planting		Harvested	
Crop	Date	Rate	Grain	Stover
Corn	May 8, 1991	44,000 seeds/A	September 18, 1991	September 20, 1991

Soil

The soil is a Verndale sandy loam (coarse-loamy mixed, Udic Argiborolls) with a slope of 0 to 2 percent. The soil is well drained.

Fertilizer 1990

Material Analysis	Rate[3]	Actual N	P_2O_5	K_2O	S	Date Applied
	--------- lb/A -------					
20-5-30-10[1]	87	17	4	26	9	May 7, 1990
46-0-0[2]	0	0	0	0	0	June 29, 1990
46-0-0[2]	26	12	0	0	0	June 29, 1990
46-0-0[2]	85	39	0	0	0	June 29, 1990
46-0-0[2]	143	66	0	0	0	June 29, 1990

1. Planter applied 2" below and 2" beside row.
2. Broadcast as urea and irrigated in.
3. The resulting N rates are: 17, 29, 56, and 83 lb/A.

Weed Control

3.0 pt/A (3.0 lb/A) Bladex + 1.5 pt/A (1.5 lb/A) Dual on 5/10/91.
1.0 qt/A (1.0 lb/A) Roundup spot sprayed on 5/22/91.
2.0 qt/A (2.0 lb/A) Ranger + 1.25 qt/A (1.25 lb/A) 2,4-D Amine on 9/6/91.

Fertilizer 1991

Material Analysis	Rate[3]	Actual N	P_2O_5	K_2O	S	Zn	Date Applied
	------ lb/A ------						
8-12-28-4-1[1]	150	12	18	11	6	2	5/8/91
46-0-0[2]	0	0	0	0	0	0	5/29/91
46-0-0[2]	65	30	0	0	0	0	5/29/91
46-0-0[2]	152	70	0	0	0	0	5/29/91
46-0-0[2]	239	110	0	0	0	0	5/29/91
46-0-0[2]	0	0	0	0	0	0	6/13/91
46-0-0[2]	65	30	0	0	0	0	6/13/91
46-0-0[2]	152	70	0	0	0	0	6/13/91
46-0-0[2]	239	110	0	0	0	0	6/13/91

1. Planter applied 2" below and 2" beside row.
2. Broadcast as urea and irrigated in.
3. The resulting N rates are: 12, 72, 152, and 232 lbs/A.

Table 2. Effect of tillage on soil cover by corn residue, and emergence from 5-15-91 to 5-29-91 at Wadena Co[1].

Tillage	Date 5/08/91 Residue[2] In Row	Bet Row	Date 5-15	5-17	5-20	5-21	5-23	5-29
			---------- plants/acre x 10^{-3} ----------					
No Till	70.2a	85.1a	1.8b	9.1a	24.1a	27.9a	33.3a	35.6a
Disk	30.7b	36.9b	3.6b	31.9b	41.7b	42.2b	42.5a	43.2a
Moldboard	5.7c	7.4c	12.1a	40.1c	42.6b	42.8b	43.1a	43.8a
Mean	35.5a	43.2b						
Signif. (Pr > F)			.006	.002	.001	.001	.004	.001

1. Means within the same column when followed by the same letter are not significantly different (α=.10).
2. The p value for residue location, tillage, and tillage by location interaction are .023 (n=48), .001 (n=32), .838 (n=16).

Fig 1. Effect of Tillage on corn emergence at Staples, Wadena Co., MN. 1991

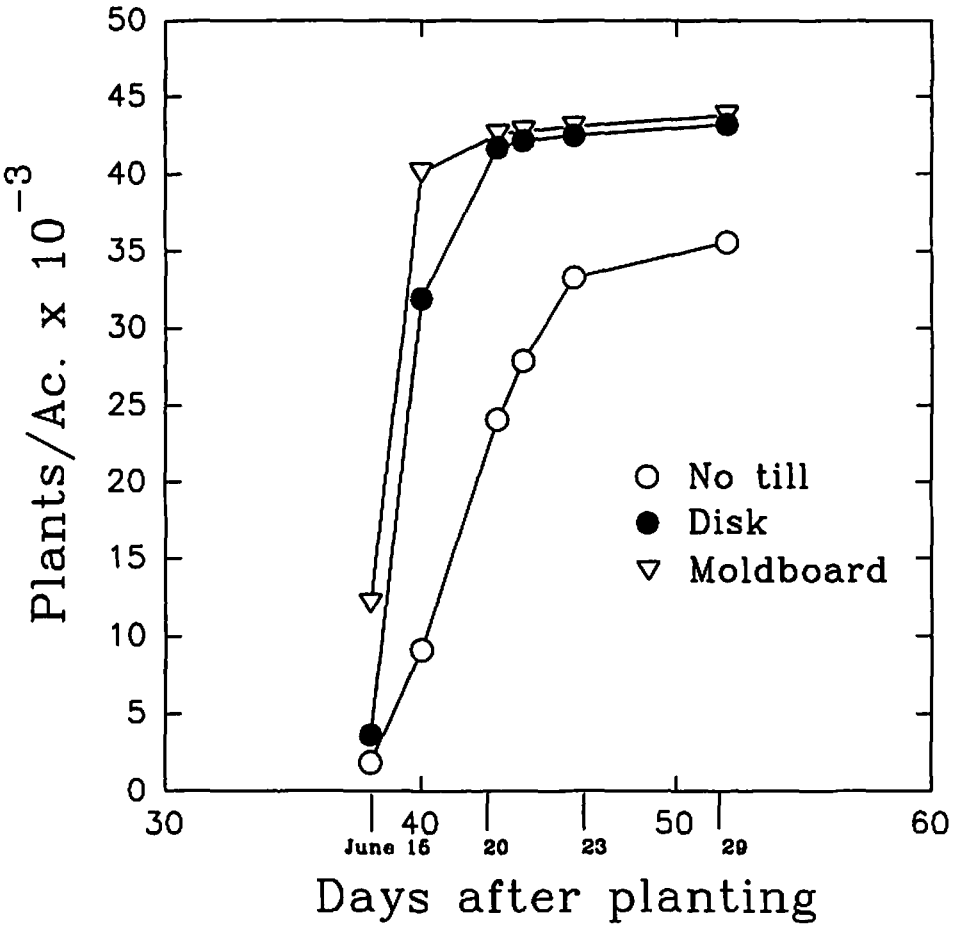


Fig 2. RESIDUE COVER VS. GRAIN MOISTURE
STAPLES, MN., 1991

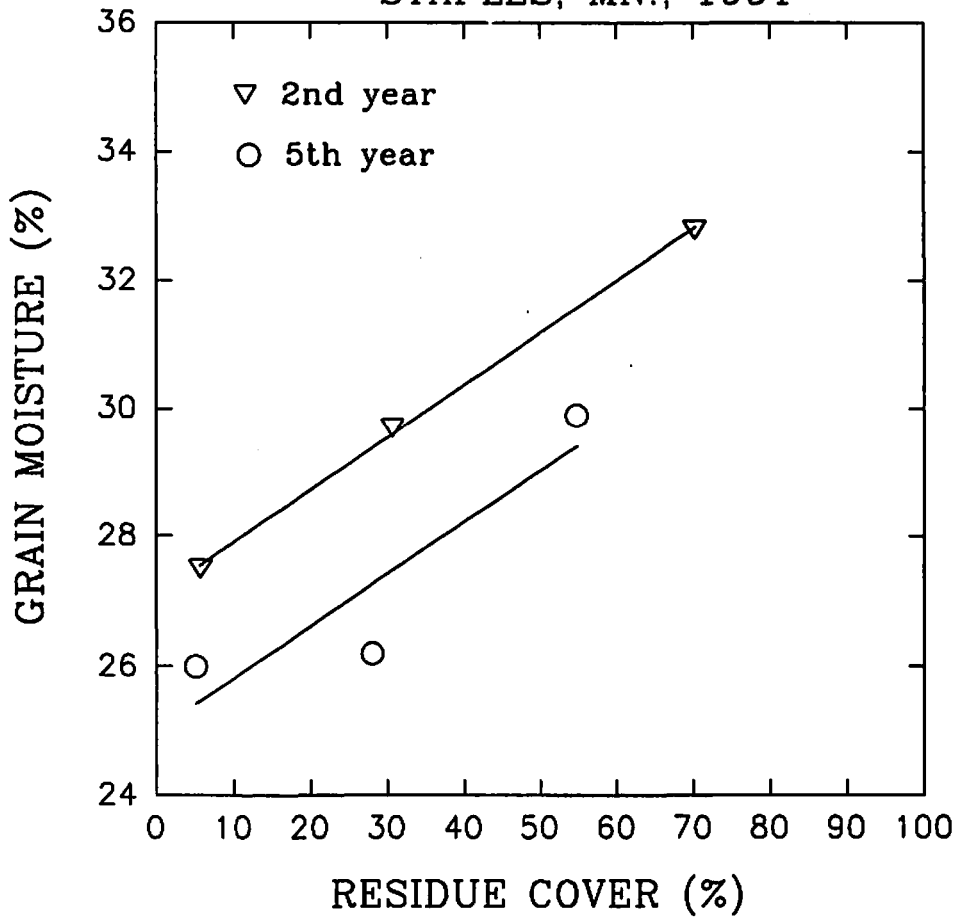


Figure 3.

STAPLES 1991 WATER NO3-N ANALYSIS
TILLAGE PLOTS

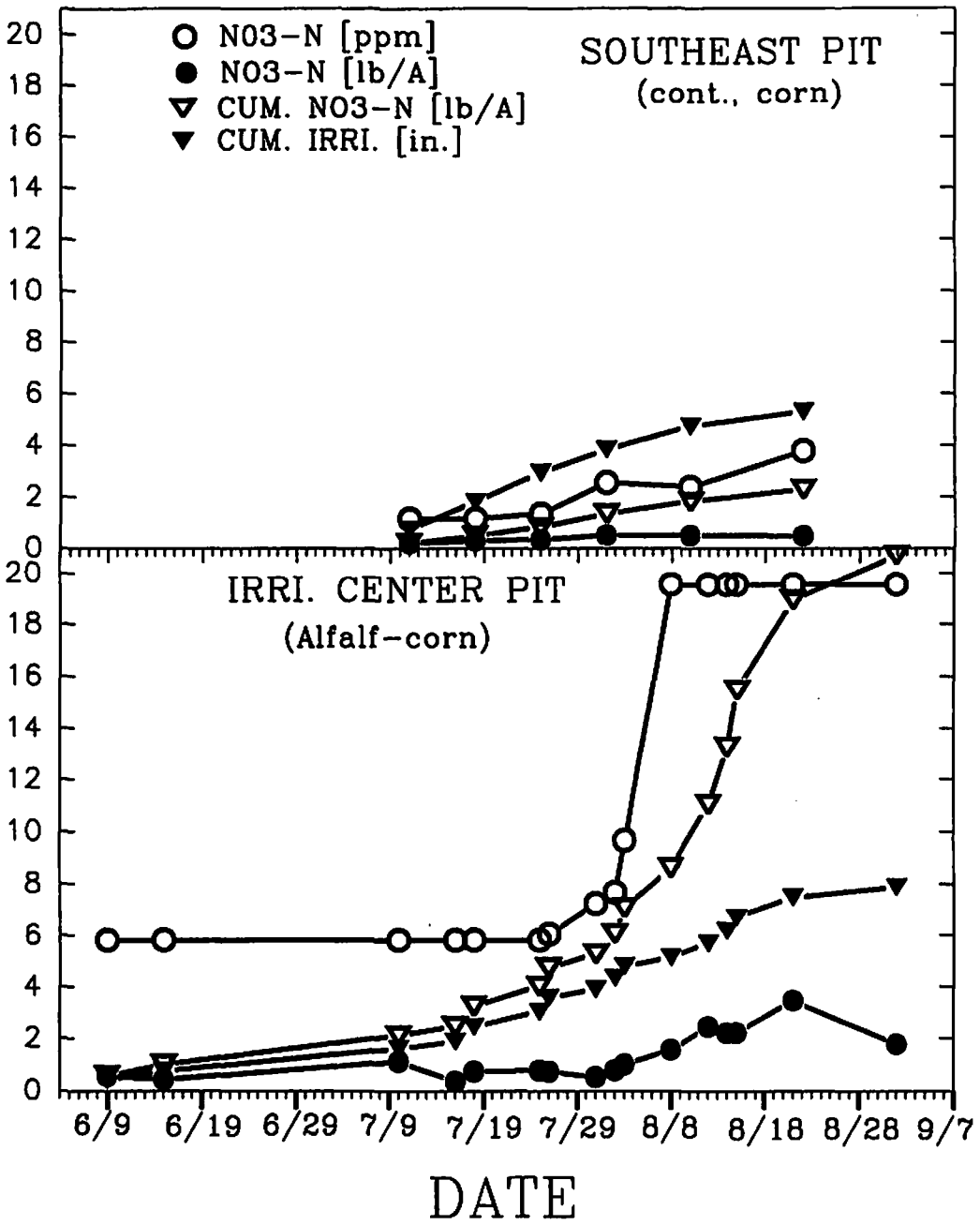


Table 3. Effect of tillage, nitrogen rate, and cultivation on corn response., 1991[1].

Treatment	Stover Moisture	Stover Yield	Grain Moisture	Grain Yield	Total D.M.	Harvest Index	Final Stand	Grain Protein	Grain N	Stover N	N uptake Grain	N uptake Stover	N uptake Total
	--%--	-T/A-	--%--	-bu/A-	-T/A-		Plants Ax10^{-3}	-------%---------			---------lb/A---------		
Tillage (n=32)													
No Till	56.5a	2.5a	32.8a	119.9a	5.4a	0.52a	35.1a	7.1a	1.14a	1.08a	67.6a	54.9a	122.5a
Disk	53.5b	2.4a	29.7b	127.1ab	5.4a	0.54a	37.7b	7.0a	1.13a	1.15b	71.0b	55.7a	126.7ab
Moldboard	49.0c	2.6a	27.5c	136.5b	5.8a	0.54a	38.5b	7.4a	1.18a	1.09a	79.8b	55.8a	135.6b
Sig. (Pr > F)	.003	.373	.000	.153	.241	.252	.006	.279	.276	.025	.022	.924	.084
N Rate lb N/A (n=24)													
12	57.8a	1.6a	33.3a	55.8a	3.0a	0.44a	37.0a	6.1a	.981a	1.07a	26.0a	35.0a	61.0a
72	56.9a	2.6b	29.7b	124.1b	5.6b	0.53b	37.7a	6.0a	.960a	.878b	56.7b	46.1b	102.8b
152	49.3b	2.9b	28.5b	168.6c	6.9c	0.58c	37.4a	8.1b	1.29b	1.18a	103.4c	68.2c	171.6c
232	48.0b	2.8b	28.5b	162.8c	6.7c	0.58c	36.2a	8.5c	1.36c	1.29c	105.2c	72.6c	177.8c
Sig. (Pr > F)	.000	.000	.000	.000	.000	.000	.754	.000	.000	.000	.000	.000	.000
Cultivation (n=48)													
Cultivation	52.5a	2.5a	29.8a	129.2a	5.6a	0.53a	36.6a	7.3a	1.17a	1.11a	74.8a	56.2a	131.0a
No Cultivation	53.5a	2.5a	30.3a	126.5a	5.5a	0.53a	37.5b	7.1b	1.13b	1.09a	70.9a	54.7b	125.0b
Sig. (Pr > F)	.402	.538	.195	.383	.362	.818	.099	.071	.070	.547	.115	.279	.036
Interactions													
Tillage X Cultivation (n=16)													
No Till W/	55.9	2.6	32.9	120.3	5.4	0.513	34.1	7.4	1.19	1.10	71.5	57.2	128.7
No Till W/O	57.2	2.5	32.7	119.4	5.3	0.519	36.0	6.8	1.08	1.06	63.7	52.6	116.4
Disk W/	53.8	2.4	29.5	129.0	5.4	0.544	37.3	7.1	1.13	1.13	72.5	53.7	126.2
Disk W/O	53.1	2.4	29.9	125.1	5.4	0.528	38.0	7.0	1.12	1.16	69.5	57.7	127.3
Mldbd W/	47.7	2.6	26.9	138.1	5.8	0.535	38.4	7.4	1.18	1.11	80.3	57.7	138.0
Mldbd W/O	50.3	2.5	28.2	134.9	5.7	0.541	38.5	7.4	1.18	1.06	79.3	53.8	133.2
Sig. (Pr > F)	.562	.421	.263	.916	.920	.230	.381	.050	.050	.566	.504	.020	.099
Tillage X N Rate lb N/A (n=16)													
Notill 12	59.1	1.6	35.5	52.5	2.8	0.44	35.1	6.0	.960	1.06	23.9	33.4	57.3
Notill 72	58.9	2.7	32.2	119.1	5.5	0.51	36.6	5.9	.946	.890	53.5	48.2	101.7
Notill 152	54.6	2.9	31.8	156.8	6.6	0.56	35.7	8.2	1.32	1.16	98.7	67.1	165.8
Notill 232	53.5	2.9	31.6	151.0	6.5	0.55	32.6	8.2	1.32	1.22	94.4	70.9	165.3
MEAN	56.5	2.5	32.8	119.9	5.4	0.52	35.1	7.1	1.14	1.08	67.6	54.9	122.5
Disk 12	56.6	1.6	33.0	52.6	2.8	0.44	36.1	6.1	.978	1.13	24.3	34.9	59.2
Disk 72	58.4	2.5	30.3	120.3	5.4	0.53	38.9	5.9	.941	.831	53.7	41.8	95.5
Disk 152	50.6	2.8	28.0	164.6	6.7	0.58	36.3	7.6	1.22	1.20	95.0	65.8	160.7
Disk 232	48.4	2.8	27.6	170.8	6.9	0.59	39.4	8.6	1.37	1.42	111.1	80.4	191.5
MEAN	53.5	2.4	29.7	127.1	5.4	0.54	37.7	7.1	1.13	1.15	71.0	55.7	126.7
Mldbd 12	57.7	1.8	31.4	62.3	3.3	0.44	39.9	6.3	1.01	1.03	29.7	36.6	66.4
Mldbd 72	53.4	2.6	26.7	132.8	5.8	0.54	37.5	6.2	.991	.911	62.9	48.3	111.3
Mldbd 152	42.8	3.1	25.9	184.2	7.4	0.59	40.2	8.3	1.33	1.17	116.4	71.7	188.1
Mldbd 232	42.0	2.7	26.1	166.7	6.6	0.59	36.2	8.8	1.40	1.24	110.1	66.5	176.6
MEAN	49.0	2.6	27.5	136.5	5.8	0.54	38.5	7.4	1.18	1.09	79.8	55.8	135.6
Sig. (Pr > F)	.262	.598	.824	.582	.624	.809	.340	.642	.642	.720	.420	.360	.315

1. Means within a column followed by the same letter are not significantly different at α=0.10 according to Duncan's Multiple Range Test. Means within the same column with the same mean are not significantly different.

Table 4a. Interaction of tillage, nitrogen rate, and cultivation on corn response., 1991.

Treatment		Stover Moisture		Stover Yield		Grain Moisture		Grain Yield		Total D.M.		Harvest Index		Final Stand	
		---%---		-T/A-		---%---		-bu/A-		-T/A-				Plants Ax10^{-3}	
Till x N Rate(lb/A)x Cult, n=4															
		C[1]	NC[2]	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC
NT	12	59.2	59.1	1.7	1.5	35.9	35.1	55.0	50.0	3.0	2.7	0.44	0.44	34.6	35.6
NT	72	59.4	58.4	2.6	2.8	32.3	32.1	120.5	117.8	5.5	5.6	0.52	0.50	33.3	39.8
NT	152	53.8	55.5	3.0	2.8	32.1	31.5	158.3	155.4	6.7	6.5	0.56	0.57	35.3	36.0
NT	232	51.4	55.6	3.0	2.9	31.3	32.0	147.4	154.5	6.5	6.5	0.54	0.56	33.1	32.7
MEAN		55.9	57.2	2.6	2.5	32.9	32.7	120.3	119.4	5.4	5.3	0.51	0.52	34.1	36.0
DISC	12	57.1	56.0	1.5	1.7	32.3	33.8	53.8	51.4	2.8	2.9	0.46	0.42	34.6	37.6
DISC	72	57.8	59.1	2.6	2.5	30.7	29.8	121.0	119.6	5.4	5.3	0.53	0.53	39.3	38.5
DISC	152	52.3	48.8	2.7	2.9	27.9	28.0	166.8	162.4	6.6	6.7	0.60	0.57	36.4	36.1
DISC	232	48.1	48.6	2.8	2.8	27.2	28.0	174.6	166.9	7.0	6.8	0.59	0.58	38.9	39.8
MEAN		53.8	53.1	2.4	2.4	29.5	29.9	129.0	125.1	5.5	5.4	0.54	0.53	37.3	38.0
MB	12	57.5	58.0	1.7	1.8	31.2	31.6	56.3	68.2	3.1	3.5	0.42	0.45	38.9	40.9
MB	72	52.2	54.6	2.7	2.6	25.7	27.7	141.6	124.0	6.1	5.5	0.54	0.53	37.5	37.6
MB	152	40.4	45.3	2.9	3.2	24.6	27.1	184.3	184.2	7.3	7.6	0.60	0.58	40.5	39.8
MB	232	40.6	43.5	2.9	2.5	26.0	26.3	170.4	163.1	6.9	6.3	0.60	0.61	36.7	35.7
MEAN		47.7	50.3	2.6	2.5	26.9	28.2	138.1	134.9	5.8	5.7	0.54	0.54	38.4	38.5
SIG. (Pr> F)		.960		.171		.603		.677		.409		.329		.242	

1. C = cultivated.
2. NC= not cultivated.

Table 4b. Interaction of tillage, nitrogen rate, and cultivation on various corn response at Wadena Co., 1991.

Treatment		Grain Protein		Grain Nitrogen		Stover Nitrogen		N uptake Grain		N uptake Stover		N uptake Total	
		----------%----------						----------lb/A----------					
Till x N Rate(lb/A)x Cult, (n=4)													
		C	NC	C	NC	C	NC	C	NC	C	NC	C	NC
NT	12	6.0	6.0	.955	.965	1.03	1.10	25.0	22.8	34.4	32.5	59.3	55.3
NT	72	6.1	5.7	.982	.910	.932	.848	56.1	50.8	49.4	47.1	105.5	97.9
NT	152	9.0	7.4	1.44	1.19	1.15	1.16	95.2	87.7	68.6	65.6	163.8	153.3
NT	232	8.5	8.0	1.36	1.27	1.28	1.15	109.7	93.6	76.4	65.4	186.1	159.0
MEAN		7.4	6.8	1.19	1.08	1.10	1.06	71.5	63.7	57.2	52.6	128.7	116.4
DISC	12	6.1	6.1	.975	.980	1.19	1.08	24.7	23.9	33.8	36.1	58.5	59.9
DISC	72	5.9	5.9	.942	.940	.870	.792	54.0	53.4	44.5	39.0	98.5	92.4
DISC	152	7.7	7.6	1.23	1.21	1.23	1.17	97.1	92.9	64.9	66.6	162.0	159.5
DISC	232	8.6	8.6	1.38	1.37	1.24	1.60	114.2	108.0	71.5	89.2	185.8	197.2
MEAN		7.1	7.0	1.13	1.12	1.13	1.16	72.5	69.5	53.7	57.7	126.2	127.3
MB	12	6.3	6.3	1.01	1.00	1.02	1.03	26.9	32.6	35.2	38.1	62.0	70.7
MB	72	6.2	6.1	1.00	.982	.938	.885	67.8	58.1	51.0	45.7	118.8	103.8
MB	152	8.2	8.4	1.31	1.35	1.24	1.10	114.2	118.7	72.6	70.8	186.8	189.4
MB	232	8.8	8.8	1.40	1.40	1.25	1.23	112.3	107.9	72.1	60.9	184.4	168.8
MEAN		7.4	7.4	1.18	1.18	1.11	1.06	80.3	79.3	57.7	53.8	138.0	133.2
SIG. (Pr> F)		.373		.376		.064		.546		.012		.222	

1. C = cultivated.
2. NC= not cultivated.

FIGURE 4.

SOIL WATER NITRATE BY DEPTH IN 2nd YEAR CORN FOLLOWING ALFALFA

STAPLES 1991

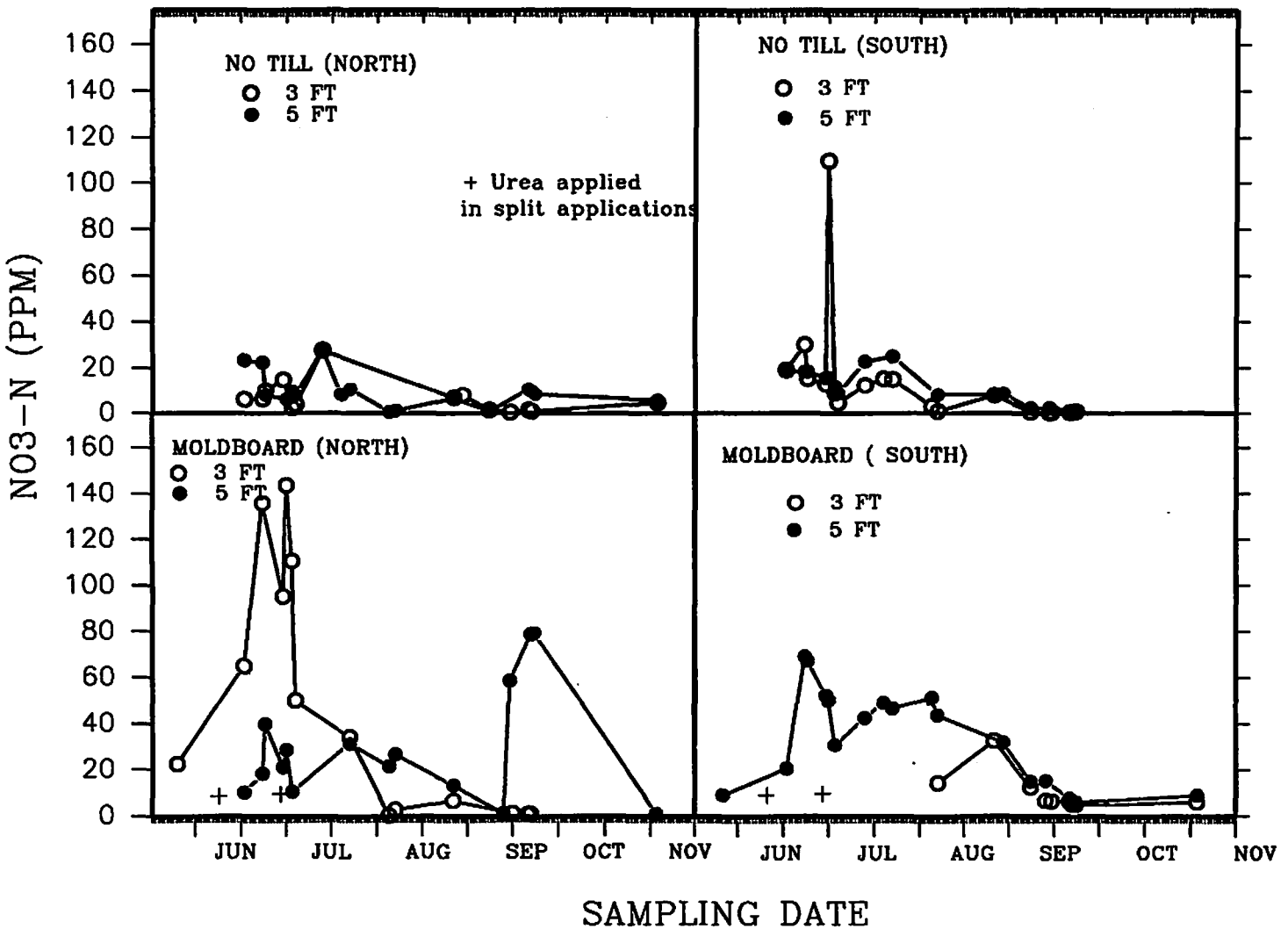
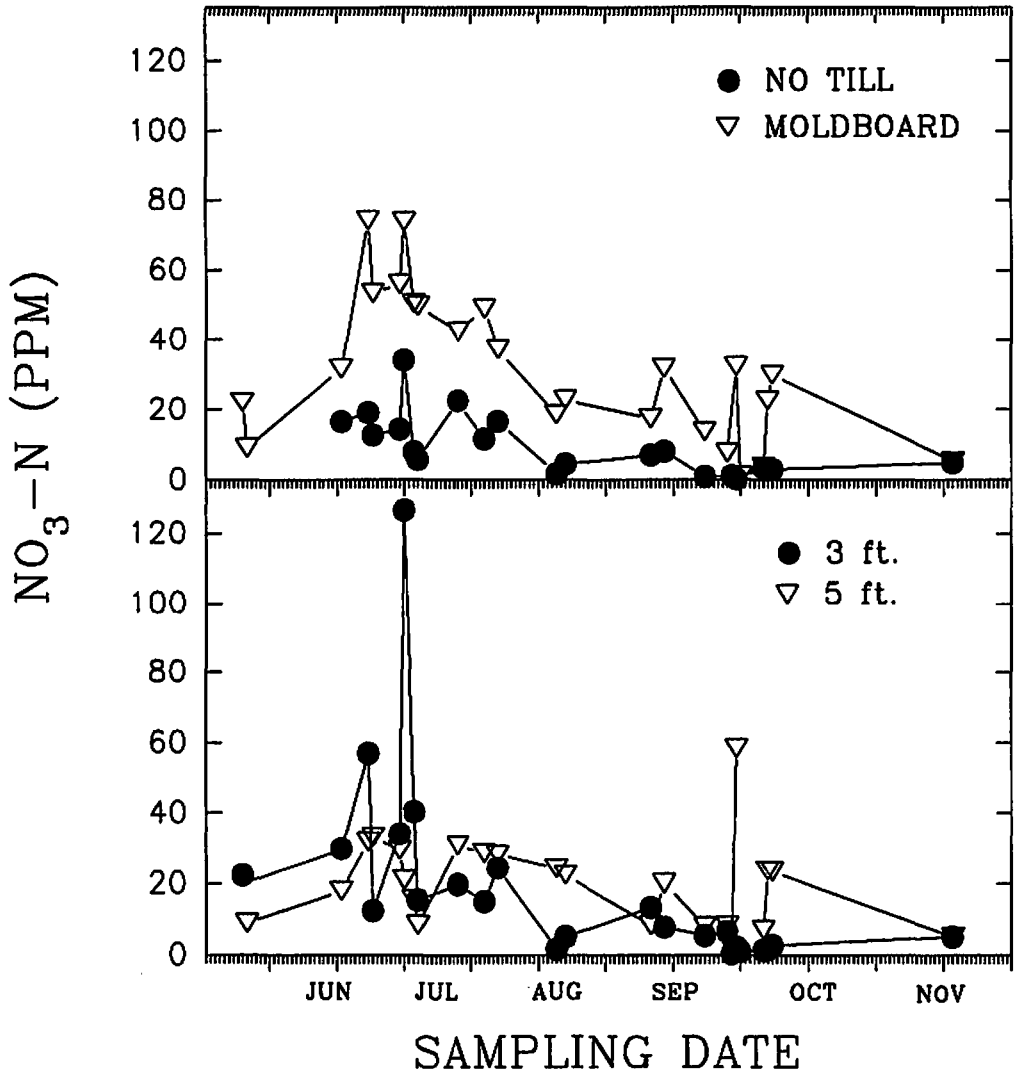


FIGURE 5.

SOIL WATER NITRATE IN 2nd YEAR CORN FOLLOWING ALFALFA AT STAPLES 1991



Tillage effects on N available to irrigated corn from turkey manure and urea N sources[1]

J.F. Moncrief, M.J. Wiens, N. Krause, and B.J. Johnson[2]

This is the fifth year of a tillage and urea study on irrigated corn on a sandy soil that has had a turkey manure treatment introduced in 1990. In 1991 residual benefits of manure applied in 1990 was evaluated. This study is divided into two substudies: tillage by manure rate by cultivation and tillage by urea rate. The presence of corn residue in the row area over 59% delayed corn phenology by two weeks. It did not reduce plant stands if residue was shallowly incorporated with discing. Stands were reduced less if row cleaners were used to clear the row area. Turkey manure performed better in supplying N to corn as tillage was increased to incorporate it. Cultivation also increased the N available to corn from turkey manure, although only subtly. Corn did not respond beyond the 137 pound per acre rate of applied urea. Tillage limited the N response with the conservation treatments. Disc row cleaners increased stands and phenology although effects on soil cover were small.

This is the second year of a two year study to investigate the effect of tillage on the availability of N to corn from urea and turkey manure. Previous to the introduction of the manure variable (since 1987) urea fertilizer was the sole N source and this field was in alfalfa in 1986. Tillage treatments are shown in table 1 (moldboard plowing, spring discing, and no tillage). A small amount of urea was applied with the planter (24 lbs/acre) and the remainder split between 4-6 and 8-12 leaf growth stage of corn. Turkey manure was applied in the spring of 1990 before tillage. There was no additional nitrogen applied to turkey manured plots in 1991. Manure analysis is shown in tables 2 and 3. It is estimated that 12 and 20 lbs N/acre will be crop available in 1991 for the two rates of turkey manure applied in 1990.

Irrigation amounts for this and the companion study evaluating second year corn following alfalfa (summarized separately) are shown in figure 1. The water source for this study is the southeast pit. About 2 lbs N/acre was applied with irrigation water (see companion study paper).

This is the fifth year of corn. The previous three years averaged about a 190 bushel per acre grain yield. This left corn residue levels quite high under no till conditions. Row cleaners reduced soil cover by corn residue from 84 to 55% (table 4). Spring discing plots had soil cover reduced from 40 to 28% with the planter mounted clearing discs. The cover by corn residue in the row affects corn emergence and growth.

Corn Response to Residual Turkey Manure

Final stands were reduced 4 thousand plants per acre under no till conditions and only slightly affected by discing (table 5). Conservation tillage systems reduced yield and N uptake from residual turkey manure. Even though the differences in estimated crop available N were small, there was a measurable difference in yield and N uptake between the two rates of turkey manure applied in 1990.

Cultivation also increased yields and N uptake. There was a significant interaction between tillage and cultivation on grain yields. The cultivation response was greatest under no till conditions, followed by moldboard plowing, with the smallest response under spring discing. This is consistent with the response from residual alfalfa N in a companion study.

Corn Response to Urea

Tillage and N rate effects on corn are shown in table 6. No tillage increased grain moisture by about 4%. Yields and grain moisture were similar for the moldboard and discing systems. Tillage did not affect the N uptake from applied urea. Corn responded to about 160 lbs N/acre. There were no significant interactions between tillage and N rate.

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[1] *Support for this project was provided by the Agricultural Utilization and Research Institute, the Staples Irrigation Center, and the Soil Conservation Service. Their support is greatly appreciated.*

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Soil Water Nitrate

Soil water access tubes (PVC with ceramic cup) were installed in duplicate at 3 and 5 feet deep in one replication of the high urea and turkey manure treatments. Water samples were taken by applying 1/2 bar of suction on the sample tubes. Samples were taken from June until December. Since only one replication was monitored the values are graphically presented over time but no statistical test are possible.

Figure 2 shows the effect of tillage, N source, and depth on the concentration of nitrate over the 1990 (year of application of turkey manure) growing season. Concentrations declined with the season for both sources. Individual plot data are shown in figure 3. There are large differences between plots which make it difficult to establish treatment trends.

Soil water nitrate concentration data for 1991 are similarly shown in figures 4 and 5. Concentrations are generally lower than in 1990. Urea resulted in higher soil water concentrations as would be expected since no further N was applied to turkey manure plots.

Table 1. Cultural practices at Staples Irrigation Center, MN. 1991.

Tillage
No Till
Spring Disc and Moldboard Plow: 5/7/91
Cultivation on: 6/13/91

Previous Crop
1984-86 Alfalfa, 1987-90 Corn

1991 Crop
Corn-Pioneer 3790

Soil
The soil at this site is a Verndale sandy loam (Udic Argiborolls, coarse-loamy, mixed) with a slope of 0 to 2 percent. The soil is well drained.

Planting and Harvest Date

The planter is a 4 row Deutz-Allis Model 385 with 30 inch row spacing, equipped with 2 inch fluted coulters and disc row cleaners.

	Planting	
Crop	Date	Rate
Corn	May 8, 1991	44,000 seeds/A

Harvested	
Grain	Stover
September 8, 1991	September 20,1991

Fertilizer 1987

Material	Rate[3]	Actual N	P_2O_5	K_2O	S	
Analysis	--------	lb/A	--------			Date Applied
17-7-23-6[1]	93	16	6	21	6	5/11/87
46-0-0[2]	0	0	0	0	0	6/16/87
46-0-0[2]	75	35	0	0	0	6/16/87
46-0-0[2]	146	67	0	0	0	6/16/87
46-0-0[2]	221	102	0	0	0	6/16/87

1. Planter applied 2" below and 2" beside row.
2. Broadcast as urea and irrigated in.
3. The resulting N rates are: 16, 51, 83, and 118 lbs/A.

Fertilizer 1988

Material	Rate[3]	Actual N	P_2O_5	K_2O	S	
Analysis	--------	lb/A	--------			Date Applied
24-8-15-8[1]	85	20	7	13	7	4/27/88
46-0-0[2]	0	0	0	0	0	6/1/88
46-0-0[2]	137	63	0	0	0	6/1/88
46-0-0[2]	254	117	0	0	0	6/1/88
46-0-0[2]	400	184	0	0	0	6/1/88

1. Planter applied 2" below and 2" beside row.
2. Broadcast as urea and irrigated in.
3. The resulting N rates are: 20, 83, 137, and 204 lbs/A.

Fertilizer 1989

Material	Rate[3]	Actual N	P_2O_5	K_2O	S	
Analysis	-------	lb/A	------			Date Applied
20-7-20-7[1]	95	19	7	19	7	5/10/89
46-0-0[2]	0	0	0	0	0	5/6/89
46-0-0[2]	72	33	0	0	0	5/6/89
46-0-0[2]	139	64	0	0	0	5/6/89
46-0-0[2]	207	95	0	0	0	5/6/89
46-0-0[2]	0	0	0	0	0	5/30/89
46-0-0[2]	70	32	0	0	0	5/30/89
46-0-0[2]	139	64	0	0	0	5/30/89
46-0-0[2]	200	92	0	0	0	5/30/89

1. Planter applied 2" below and 2" beside row.
2. Broadcast as urea and irrigated in.
3. The resulting N rates are: 19, 84, 147, and 206 lb/A.

1990 Fertilizer

Material Analysis	Rate[3]	Actual N	Actual P_2O_5	Actual K_2O	Actual S	Date Applied
	-------- lb/A -------					
20-5-30-10[1]	87	17	4	26	9	5/7/90
46-0-0[2]	0	0	0	0	0	6/29/90
46-0-0[2]	113	52	0	0	0	6/29/90
46-0-0[2]	261	120	0	0	0	6/29/90
46-0-0[2]	457	210	0	0	0	6/29/90

1. Planter applied 2" below and 2" beside row on all plots.
2. Broadcast as urea and irrigated in.
3. The resulting N rates are: 17, 69, 137, and 227 lb/A.

Fertilizer 1991

Material Analysis	Rate[3]	Actual N	Actual P_2O_5	Actual K_2O	Actual S	Date Applied
	------ lb/A ------					
16-5-25-8[1]	150	24	6	38	12	5/8/91
46-0-0[2]	0	0	0	0	0	5/29/91
46-0-0[2]	65	30	0	0	0	5/29/91
46-0-0[2]	152	70	0	0	0	5/29/91
46-0-0[2]	239	110	0	0	0	5/29/91
46-0-0[2]	0	0	0	0	0	6/13/91
46-0-0[2]	65	30	0	0	0	6/13/91
46-0-0[2]	152	70	0	0	0	6/13/91
46-0-0[2]	239	110	0	0	0	6/13/91

1. Planter applied 2" below and 2" beside row.
2. Broadcast as urea and irrigated in.
3. The resulting N rates are: 24, 84, 164, and 244 lbs/A.

Weed Control

3.0 pt/A (3.0 lb/A) Bladex + 1.5 pt/A (1.5 lb/A) Dual on 5/10/91.
1.0 qt/A (1.0 lb/A) Roundup spot sprayed on 5/22/91.
2.0 qt/A (2.0 lb/A) Ranger + 1.25 qt/A (1.25 lb/A) 2,4-D Amine on 9/6/91.

Table 2. Analysis and rate of application of manure (4/24/90).

Manure Source	Date Applied	Rate	Solids	NH_4	NO_3	Total Mineral N	Organic N	Total N	Total P	Total K
		t/A	- % --	----------	----------	%	----------	----------	----------	----------
Turkey[1]	4/24/90	4.0	55.1	.87	.05	.91	1.01	1.92	.35	.42
		6.7	55.1	.87	.05	.91	1.01	1.92	.35	.42

1. Collected in the fall of 1989 and stored untill application at Staples Irrigation Center.

Table 3. Rate applied, and value[1] of nitrogen[2], phosphorus, and potassium(4/24/90).

Manure Source	Mineral	Organic	Total Nitrogen	Value	Available N Manure '90	Available N Manure '91	Available N + Starter '90	Available N + Starter '91	P_2O_5	Value	K_2O	Value
	-- Applied N lb/acre ---			$	---- lb/A -------				lb/A	$	lb/A	$
Turkey	73	81	154	20.02	97	12	114	36	64	13.22	40	4.59
	122	136	258	33.54	163	20	180	44	107	22.10	68	7.81

1. It is assumed that fertilizer cost .13, .21, and .12 per pound of N, P_2O_5, and K_2O, respectively.
2. It is assumed that all of the mineral N and 30% of the organic N will be available during the year of application and 15% of organic N in the year after application.

Table 4. Effect of tillage on soil cover by corn and litter residue at Wadena County[1].

Location	Tillage No Till	Tillage Disk	Tillage Moldboard	Avg
	----------	% cover	----------	- % -
In Row	54.8a	28.0b	5.1c	29.3b
Between Row	83.9a	39.9b	3.0c	42.3a
Average	69.3a	33.9b	4.0c	35.8

1. The p value for residue location, tillage, and tillage by location interaction are .001 (n=48),.001 (n=32), .019 (n=16). Means within the same row with the same letter are not signficantly different (α=.10).

Table 5. Effect of tillage and nitrogen rate as manure on corn response, 1991[1].

Treatment	Grain Moisture	Grain Yield	Final Stand	Stover Moisture	Stover Yield	Total D.M.	Harvest Index	Grain Prot.	Grain N	Stover N	N uptake Grain	N uptake Stover	N uptake Total
	--%--	bu/A	Plant Ax10^{-3}	--%--	-T/A-	-T/A-		-------%--------			-------lb/A--------		
Tillage													
No Till	29.4a	41.0a	38.4a	59.2a	1.4a	2.4a	.385a	5.8a	.929a	.883a	17.8a	25.1a	42.2a
Disk	26.8b	46.1a	42.4b	55.0a	1.6b	2.7b	.398a	5.8a	.932a	.792b	20.5b	24.9a	45.9a
Mldbd	26.5c	63.7b	42.1b	56.2a	2.0c	3.4c	.423a	5.9a	.948a	.819ab	25.8b	32.1b	60.2b
Sig. (Pr > F)	.026	.008	.070	.169	.000	.002	.613	.509	.509	.126	.003	.016	.003
N Rate (n=48)[2]													
36 lb N/A	27.2a	46.9a	41.2a	56.8a	1.6a	2.7a	.380a	5.9a	.942a	.820a	20.8a	26.8a	47.0a
44 lb N/A	27.9a	54.3b	40.7a	56.8a	1.7a	3.0b	.425b	5.8a	.931a	.873a	23.8b	27.9a	51.8b
Sig. (Pr > F)	.212	.022	.614	.962	.486	.032	.040	.343	.343	.297	.030	.183	.047
Cultivation													
W/ Cult	27.4a	58.4a	41.5a	57.4a	1.6a	3.0a	.443a	5.8a	.929a	.810a	25.6a	26.7a	51.7a
W/O Cult	27.7a	42.7b	40.0a	56.1b	1.6a	2.7b	.361b	5.9b	.944b	.853a	19.0b	28.1a	47.2b
Sig. (Pr > F)	.653	.000	.283	.145	.890	.002	.000	.085	.085	.155	.000	.269	.036

1. Means within the same column with the same letter are not significantly different.
2. N rate was determined from Table 3.

Interactions

Tillage x N Rate (lb/A, n=16)														
Notill	36	29.0	36.8	39.0	58.9	1.4	2.2	.361	5.9	.944	.820	16.3	23.1	38.1
Notill	44	29.7	45.3	37.8	59.4	1.4	2.5	.409	5.7	.914	.946	19.4	27.1	46.3
Disk	36	26.1	41.8	43.1	54.7	1.6	2.6	.351	5.7	.918	.819	17.8	26.2	43.4
Disk	44	27.5	52.1	41.6	55.2	1.5	2.8	.445	5.9	.946	.766	23.2	23.7	48.4
Mldbd	36	26.4	62.0	41.6	56.8	1.9	3.4	.426	6.0	.963	.821	28.2	31.3	59.6
Mldbd	44	26.6	65.4	42.6	55.7	2.0	3.5	.420	5.8	.933	.816	28.8	32.9	60.8
Sig. (Pr > F)		.675	.570	.588	.633	.250	.811	.148	.074	.074	.017	.304	.015	.424
Tillage x Cultivation (n=16)														
No Till W/		29.2	52.1	39.1	59.4	1.4	2.6	.456	5.7	.912	.816	22.4	23.2	44.8
No Till W/O		29.5	29.9	37.7	58.8	1.4	2.1	.314	5.9	.945	.950	13.4	27.0	39.7
Disk W/		27.1	51.0	42.4	55.2	1.6	2.7	.412	5.8	.931	.822	22.2	25.7	47.1
Disk W/O		26.5	43.0	42.3	54.7	1.6	2.7	.383	5.8	.932	.762	18.8	24.1	44.7
Mldbd W/		26.0	72.3	42.8	57.6	2.0	3.7	.462	5.9	.942	.791	32.2	31.0	63.2
Mldbd W/O		27.0	55.1	41.3	54.8	2.0	3.2	.385	6.0	.954	.846	24.8	33.1	57.1
Sig. (Pr > F)		.483	.034	.791	.480	.954	.101	.061	.321	.321	.042	.047	.216	.739
Nrate (Lb N/A) x Cultivation (n=24)														
36 W/Cult		27.1	56.1	41.5	57.4	1.6	2.9	.434	5.8	.932	.800	24.7	26.2	50.5
36 W/O Cult		27.2	37.6	40.9	56.2	1.6	2.5	.325	5.9	.950	.840	16.8	27.5	43.6
44 W/Cult		27.7	60.8	41.4	57.4	1.7	3.1	.453	5.8	.925	.820	26.4	27.2	52.9
44 W/O Cult		28.1	47.8	40.0	56.1	1.7	2.8	.396	5.9	.937	.866	21.2	28.6	50.8
Sig. (Pr > F)		.848	.216	.664	.998	.897	.313	.156	.735	.735	.921	.160	.978	.245
Till X N Rate X Cultivation (n=8)														
NT	36 W/	28.7	47.3	39.2	57.9	1.3	2.3	.430	5.9	.939	.735	21.0	19.5	38.4
NT	36 W/O	29.4	26.2	38.8	59.9	1.5	2.1	.293	5.9	.949	.905	11.6	26.7	37.8
NT	44 W/	29.7	56.9	39.1	61.0	1.5	2.9	.482	5.5	.886	.898	23.8	26.9	51.1
NT	44 W/O	29.7	33.6	36.6	57.8	1.4	2.1	.336	5.9	.941	.995	14.9	27.2	41.5
Disk	36 W/	26.4	50.1	42.2	56.3	1.6	2.8	.403	5.6	.904	.880	21.1	28.6	49.3
Disk	36 W/O	25.8	33.6	43.9	53.0	1.6	2.3	.299	5.8	.931	.758	14.4	23.8	37.5
Disk	44 W/	27.8	50.1	42.6	54.1	1.5	2.6	.422	6.0	.959	.765	23.2	22.9	44.8
Disk	44 W/O	27.2	51.8	40.7	56.4	1.6	3.0	.467	5.8	.934	.768	23.2	24.5	51.9
Mb	36 W/	26.2	71.0	43.1	58.1	1.9	3.7	.470	6.0	.955	.785	32.1	30.5	63.7
Mb	36 W/O	26.6	53.0	40.1	55.5	1.9	3.1	.383	6.1	.971	.858	24.3	32.1	55.4
Mb	44 W/	25.7	73.6	42.6	57.1	2.0	3.7	.454	5.8	.930	.797	32.3	31.6	62.7
Mb	44 W/O	27.4	57.2	42.6	54.2	2.0	3.3	.386	5.8	.936	.835	25.4	34.1	58.8
Sig. (Pr > F)		.774	.174	.346	.054	.121	.022	.186	.074	.074	.355	.329	.108	.034

Table 6. Effect of tillage and urea nitrogen rate on corn response.,1991[1].

Treatment	Grain Moisture	Grain Yield	Final Stand	Stover Moisture	Stover Yield	Total D.M.	Harvest Index	Grain Protien N	Grain N	Stover N	N uptake Grain	N uptake Stover	N uptake Total
	--%--	bu/A	Plant Ax10^{-3}	--%--	-T/A-	-T/A-		-------%---------			---------lb /A---------		
Tillage (n=16)													
No Till	29.9a	113.8a	37.5a	57.9a	2.1a	4.8a	.532a	6.3a	1.01a	1.05a	56.2a	45.6a	101.8a
Disk	26.2b	128.8b	41.6b	55.2a	2.2a	5.3ab	.555a	6.3a	1.06a	1.04a	67.6ab	46.5a	114.1a
Moldboard	26.0b	131.8b	38.6b	52.9a	2.4a	5.5b	.531a	6.7a	1.07a	1.08a	70.3b	53.2a	123.5a
Sig. (Pr > F)	.005	.039	.127	.277	.199	.077	.262	.532	.532	.801	.138	.395	.214
N Rate (n=12)													
24 lb N/A	26.6a	55.4a	41.5a	55.8ab	1.8a	3.1a	.400a	5.7a	.915a	.880a	24.4a	31.9a	56.3a
84 lb N/A	26.9a	123.5b	41.1a	55.9ab	2.4b	5.3b	.546b	5.8a	.929a	.872a	54.8b	42.0b	96.8b
164 lb N/A	26.7a	164.6c	39.2ab	53.0a	2.5b	6.4c	.612c	7.0b	1.12b	1.10b	88.1c	54.4c	142.5c
244 lb N/A	29.3b	155.9c	35.1b	56.6b	2.3b	6.0ab	.601ab	7.6c	1.22c	1.38c	91.6c	65.3d	156.9c
Sig. (Pr > F)	.011	.000	.055	.218	.000	.000	.000	.000	.000	.000	.000	.000	.000

1. Means within the same column with the same letter are not significantly different.

Interactions													
Tillage X N Rate Lb N/A (n=8)													
No Till	24	28.3	43.4	39.5	56.3	1.6	2.6	.398	5.6	.898	.915	18.4	28.4	46.9
No Till	84	29.3	107.4	39.3	57.8	2.3	4.9	.524	5.5	.880	.892	44.7	41.0	85.7
No Till	164	29.9	158.5	38.8	57.5	2.5	6.3	.599	6.7	1.07	1.20	80.4	60.9	141.3
No Till	244	32.2	145.9	32.4	60.1	2.2	5.7	.609	7.4	1.18	1.19	81.2	52.1	133.3
Disk	24	24.8	52.6	45.5	54.9	1.9	3.2	.387	5.7	.908	.778	22.6	30.7	53.3
Disk	84	26.1	119.5	43.6	55.4	2.3	5.1	.551	5.9	.940	.850	53.2	39.2	92.4
Disk	164	25.8	177.5	41.8	52.4	2.4	6.6	.638	7.3	1.17	1.09	98.0	52.1	150.1
Disk	244	28.4	165.5	35.4	57.9	2.2	6.1	.644	7.7	1.23	1.44	96.7	63.8	160.5
Mldbd	24	26.9	70.0	39.6	56.0	1.9	3.6	.413	5.9	.940	.948	32.1	36.7	68.8
Mldbd	84	25.4	143.5	40.5	54.5	2.6	6.0	.562	6.0	.968	.875	66.4	45.8	112.2
Mldbd	164	24.4	157.7	36.9	49.2	2.5	6.2	.599	7.1	1.14	1.01	85.8	50.2	135.9
Mldbd	244	27.4	156.2	37.5	51.9	2.6	6.3	.549	7.8	1.25	1.50	96.9	80.1	176.9
Sig. (Pr > F)		.510	.868	.860	.478	.608	.903	.777	.967	.967	.051	.928	.114	.763