1991 were low (< 5 in) in all years with the exception of 1985 and 1986 where they were moderate (Fig. 4). The estimated nitrate-N available for leaching (NAL) was generally high (>80 lb N/ac) across all N rates and timings in 1969 and 1989 (Fig. 5). However, despite a high NAL, the estimated nitrate-N leached (NLy) was low (<40 lb N/ac) for most treatments (Fig. 6). The exceptions were treatments with the highest N rates which had moderate or high NLy. The annual leaching risk potential (ALRP) was low for 1989 across all N rates and timings (Table 4). Using the highest LI in the past 32 years, the ALRP was still low for intermediate rates of applied N, however, high rates of applied N had a high ALRP rating. This analysis indicates that excessive N rates present the largest risk for groundwater contamination with nitrate-N under the environmental conditions of the study.

Table 1. 1992 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. Corn yields (bu/ac) in 1992.

Application Time	Ammonium Nitrate (lbs/ac)			Urea (lbs/ac)		
	40	80	160	40	80	160
Fall Incorporated	89	110	120	97	111	122
Fall Plowed Surface	87	---	---	89	---	---
Spring Pre-plant	97	111	---	106	122	---
Side Dress	107	115	135	106	122	---
Check: 54						

$LSD_{0.05}$ = 17 bu/ac

Table 3. Long-term average yields (bu/ac) from 1960-1992.

Application Time	Ammonium Nitrate (lbs/ac)			Urea (lbs/ac)		
	40	80	160	40	80	160
Fall Incorporated	83	104	114	91	105	114
Fall Plowed Surface	87	---	---	88	---	---
Spring Pre-plant	93	108	---	93	110	---
Side Dress	98	105	119	98	113	---
Check: 62						

$LSD_{0.05}$ = 4 bu/ac

Table 4. NLEAP screening procedure for assessing nitrate-N leaching risk potential (Pierce et al., 1991).

NLy (lb/ac)	NLy Score	TT	TT Score	PA	PA Score	VA	VA Score	ALRP	ALRP Rating
<40	1	>15 yr	1	deep/conf	1	Cls III	1	0-2	vlow
40-<80	2	5-15 yr	2	medium	2	CLS IIB	2	3	low
>80	4	<5 yr	4	shallow	4	Clsl, IIA	4	4	mod
								5	high
								6	vhigh
								7	extreme
								8	vextreme

Abbreviations: NLy, nitrate-N leached; TT, travel time; PA, position of aquifer; VA, vulnerability of aquifer; ALRP, annual leaching risk potential.

Table 5. Estimate of nitrate-N leaching risk potential, 1989.

Treatment	--- NLy Score --- High LI	1989 LI	TT Score	PA Score	VA Score	Score Product	-------- ALRP -------- High LI	1989 LI
Control	1	1	2	2	2	8	3 (LOW)	3 (LOW)
Fall N								
94 lb/ac	1	1	2	2	2	8	3 (LOW)	3 (LOW)
174 lb/ac	4	1	2	2	2	32	5 (HIGH)	3 (LOW)
Spring N								
94 lb/ac	1	1	2	2	2	8	3 (LOW)	3 (LOW)
Sidedress N								
94 lb/ac	1	1	2	2	2	8	3 (LOW)	3 (LOW)
174 lb/ac	4	1	2	2	2	32	5 (HIGH)	3 (LOW)

Abbreviations: NLy, nitrate-N leached; TT, travel time; PA, position of aquifer; VA, vulnerability of aquifer; ALRP, annual leaching risk potential; LI, leaching index.

Fig. 1. Influence of N timing and rate on soil nitrate-N distribution.

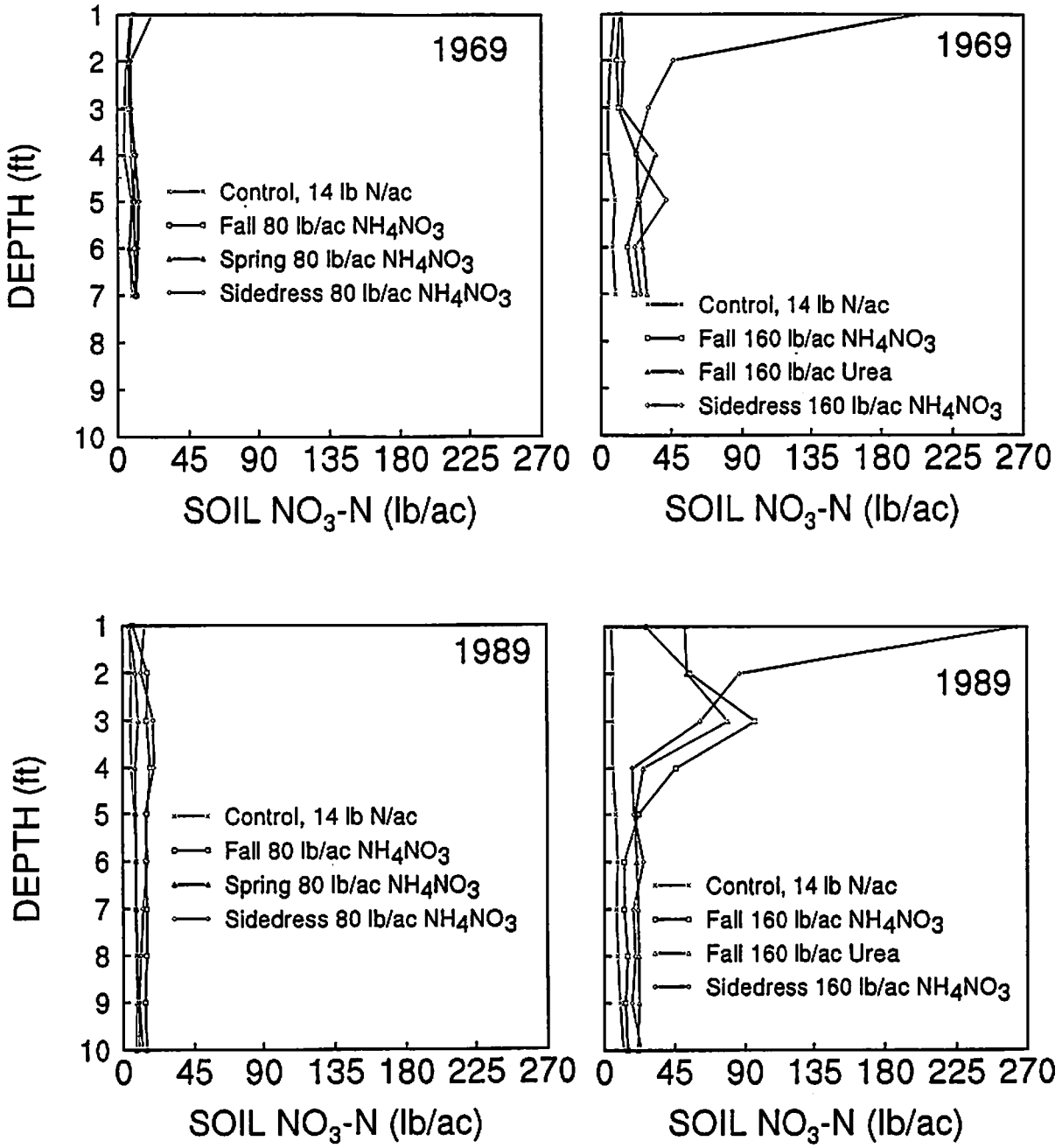


Figure 2. Soil nitrate-N in the root zone, fall 1989.

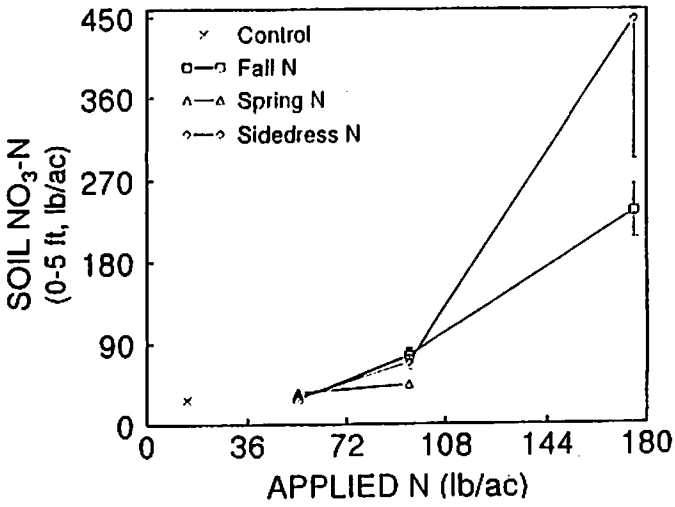


Figure 3. Soil nitrate-N below the root zone, fall 19

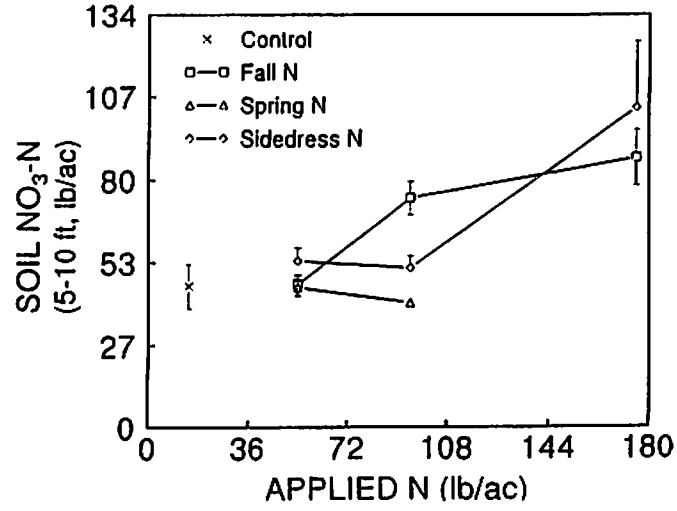


Fig. 4. Leaching index (LI)

SWES, Lamberton, MN

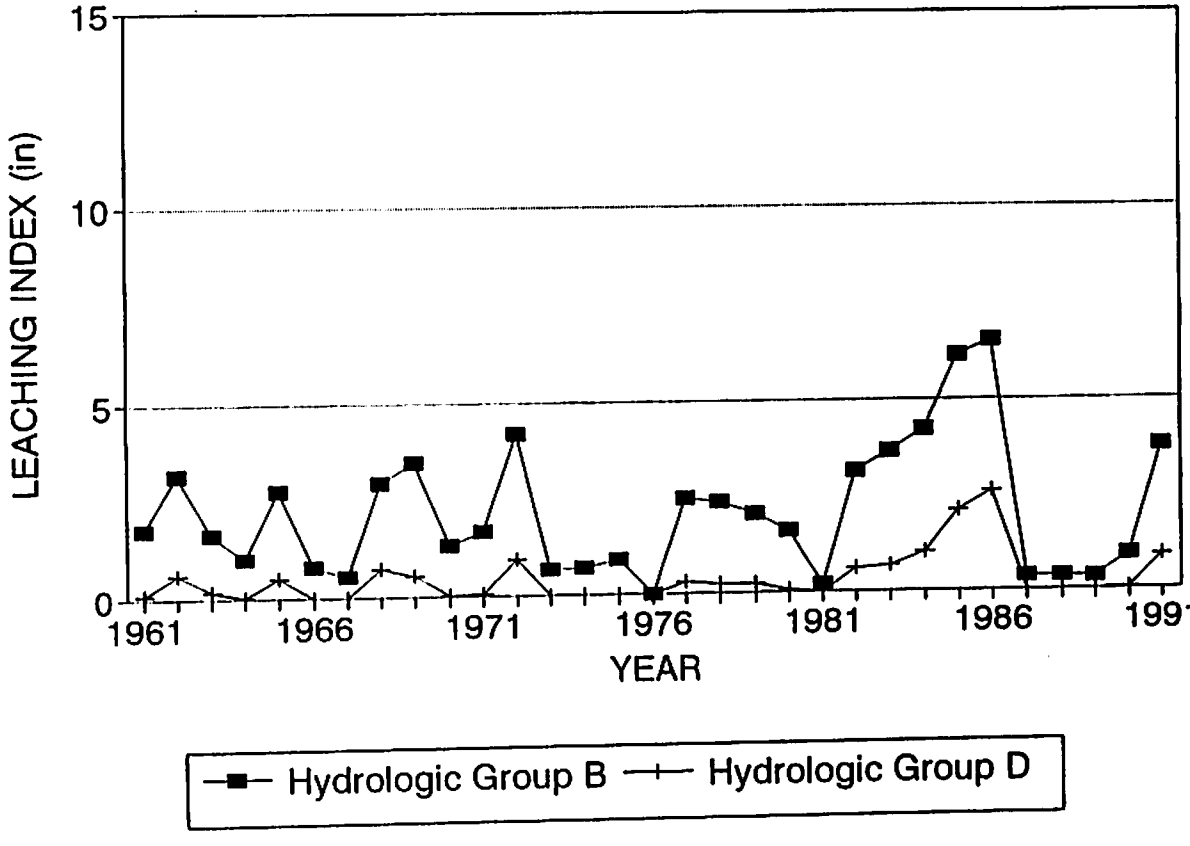


Fig. 5. Estimated nitrate-N available for leaching.

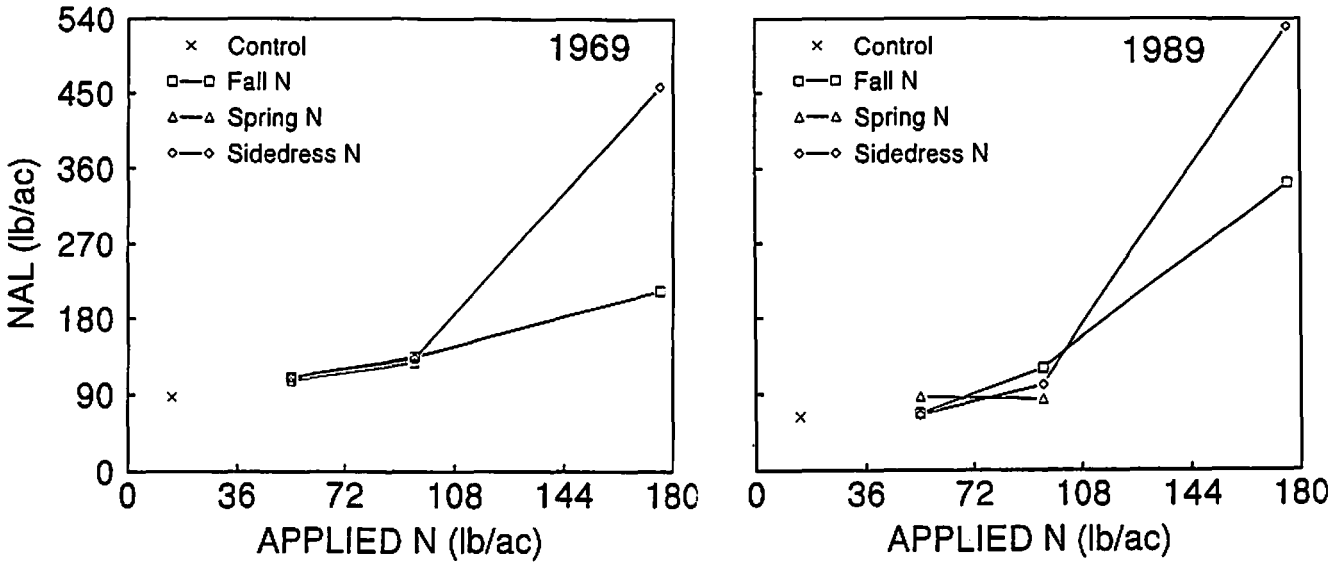
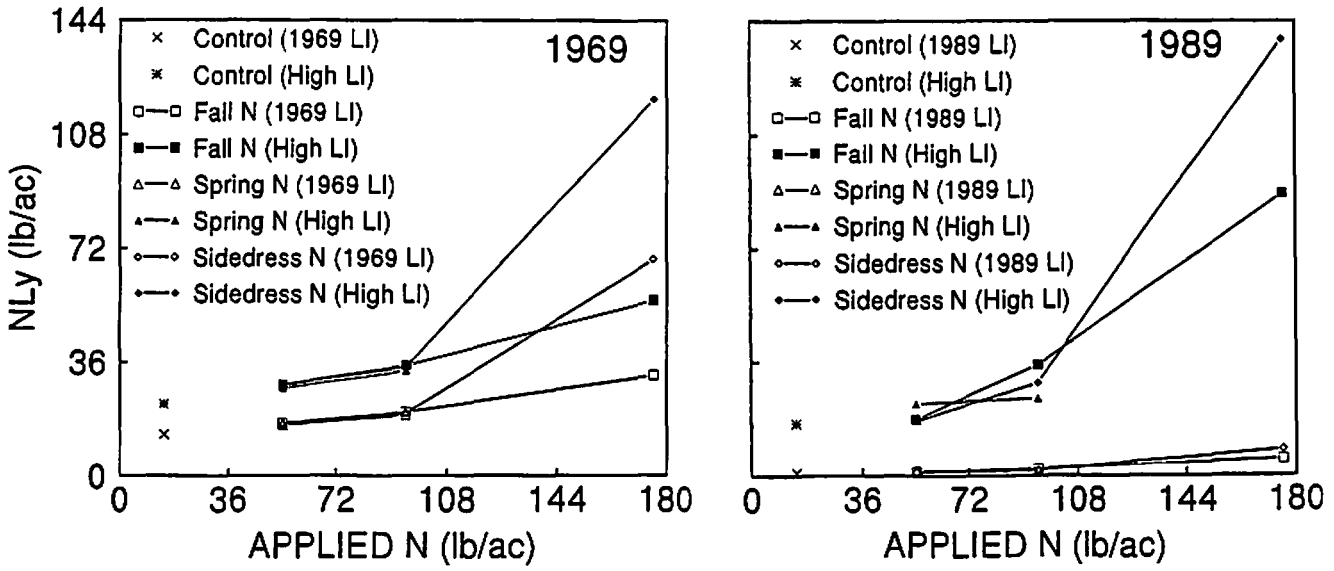


Fig. 6. Estimated nitrate-N leached from the root zone.



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

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

Field data is needed to evaluate crop growth simulation models. The objective of this study is to determine the interactive effect of tillage and soil erosion level on corn yields. 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 1992, tillage and erosion levels had a significant effect on corn yields. Corn yields with conventional tillage yielded 12 percent more than with ridge tillage. Corn on the severely eroded soil yielded 13 percent less and on the moderately eroded soil 9 percent less than corn grown on soil that was only slightly eroded. Over the course of the experiment, the effect of erosion class on corn yields has been consistent with the higher yields occurring on the less eroded treatments. Tillage effects on corn yields have been inconsistent over the course of the experiment.

METHODS AND MATERIALS

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 (fine-silty, mixed mesic Typic Hapludalf). The soil type on the severely eroded area is a Storden (fine-loamy, mixed (calcareous), mesic Typic Udorthent). The two tillage systems used on each erosion class were fall moldboard plow and ridge tillage.

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 row cultivator, but because of wet field conditions, they were not ridged with the ridge cultivator. In the fall of 1991, the ridge area was paraplowed. Additional management information is given in Table 1. Analysis of variance, using a split plot design (tillage = whole plot, erosion class = split plots) is given in Table 2. If treatments were significantly different (0.05 level), means were separated using 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 1992, corn yields on the severely eroded soil yielded 13 percent less and on the moderately eroded soil 9 percent less than corn grown on soil that was only slightly eroded (Table 2 and 3). Over the past eight years, erosion levels have affected corn yields with the greatest yields occurring on the least eroded soil. In 1992, corn in moldboard plow treatments yielded 12 percent more than the ridge tillage system (Table 2 and 3). In the past, tillage effects on corn yields have been inconsistent. More information may be obtained from Dr. Mike Lindstrom, USDA-ARS, Morris, Minnesota 56267, ph. 612-589-3411.

ACKNOWLEDGEMENTS

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

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

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

Table 1. 1992 Management Information.

Item	Type	Rate	Date
Primary Tillage (MP)	Moldboard Plow	1	Fall 1991
Secondary Tillage	Disc Digger	1 pass 1 pass	4/29 4/30
Seed	Dekalb 535	29,000 seeds/ac	4/30
Fertilizer	Urea	150-0-0 lbs/ac ($N-P_2O_5-K_2O$)	4/29
Herbicides	Eradicane Bladex	2.5 lbs/ac 1.5 lbs/ac	4/29
Insecticides	Furadan	1.0 lbs/ac	4/30
Row Cultivation Ridging		once once	5/20 5/29

Table 2. Analysis of Variance.
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	385.99	128.66	1.02	0.42
Tillage	1	1821.78	1821.78	14.48	**0.00
Whole plot error	3	204.48	68.16	0.54	0.66
Erosion Class	2	1487.76	743.88	5.91	*0.02
Tillage*Erosion	2	831.73	415.87	3.30	0.07

* significant at alpha = 0.05, ** significant at alpha = 0.01

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

Tillage[2]	Erosion Class[1]			Overall average
	Slight	Moderate	Severe	
Moldboard plow	158.4	149.8	130.0	146.0
Ridge area	137.6	119.0	128.4	128.6
Overall average	148.0	134.8	129.2	137.3

1/ $LSD_{0.05}$ = 12.2 (bu/ac) for comparing erosion classes (averaged over both tillage treatments)
2/ $LSD_{0.05}$ = 10.7 (bu/ac) for comparing tillage systems (averaged over erosion classes)

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

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

Field research is needed to evaluate soil movement under different crop production practices and its consequent effect on crop yield. This study was conducted to examine soil movement and crop yields on three different slope percentages (1%, 4%, and 8%), three tillages (ridge tillage, moldboard plow, and chisel), and tillage/planting directions (up and down the slope, or contour to the slope) in a corn - soybean rotation. In 1992, tillage treatments had a significant effect on corn yield on all slope percentages. Yields with moldboard plow and chisel plow treatments were significantly greater than yields with ridge tillage in all cases. No other treatments significantly affected corn yield.

MATERIALS AND METHODS

This study began in the spring of 1985 to examine the effect 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, or bottom). Treatments at the site with 4 percent slope are tillage, and plant row direction while the site with 1 percent slope has only 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 1992, corn yields for the various tillage treatments were significantly different for each slope percentage. The moldboard plow and chisel plow treatments significantly yielded more than the ridge tillage in all cases (Table 2-8). Yields with moldboard plowing were 2.0 percent greater than yields with the chisel plowing on the 8 percent slope (Table 2 and 3). In addition, corn yields with moldboard plowing were 12.8 percent and chisel plowing 10.6 percent greater than ridge tillage (Table 3). No significant yield differences occurred on the 8 percent slope between row direction or position (Table 2 and 4).

On the 4 percent slope area, moldboard plow corn yielded 15.7 percent and chisel plow 12.8 percent more than the ridge tillage treatment (Table 6). There was no significant effect of row direction on corn yield on the site with 4 percent slope (Table 5). On the 1 percent slope area, moldboard plow corn yielded 6.6 percent and chisel plow 10.5 percent more than the ridge tillage treatment (Table 8). The different slope percentages (8, 4 & 1%) were not compared with an analysis of variance, however, the overall average corn yield on the 8, 4, and 1 percent slopes were 153.1 (bu/ac), 164.0 (bu/ac), and 162.6 (bu/ac), respectively. In 1992, there was little difference between corn yields on the 1 and 4 percent slopes (Table 6 and 8). In the past, there has been a trend of decreasing yield with increasing slope percentage.

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

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

Table 1. 1992 Management Information.

Item	Type	Rate	Date
Primary Tillage[1]	CP and MP	Once	Fall 1991
Secondary Tillage[1]	Field Cultivator	2 passes	4/29
Seed	Pioneer 3615	29,000 seeds/ac	4/30
Fertilizer	Urea	125 lbs N/ac	6/10
	Starter	7-20-7 lbs $N-P_2O_5-K_2O$/ac	4/30
Herbicides	Lasso	3.0 lbs/ac (ai)	5/1
	Bladex	1.5 lbs/ac (ai)	5/1
Row Cultivation		Once	6/10

1/ No primary or secondary tillage on ridge tillage plots.

Table 2. Analysis of Variance for the 8 Percent Slope.
Variable: Corn 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	328.75	164.37	0.90	0.41
Row Direction	1	81.47	81.47	0.45	0.51
Whole Plot Error	2	296.34	148.17		
Tillage	2	6743.60	3371.80	18.47	** 0.00
Row*Tillage	2	3.11	1.55	0.01	0.99
Sub-Plot Error	8	1053.80	131.73		
Position	2	136.93	68.47	0.38	0.69
Row*Position	2	1417.20	708.60	3.88	0.02
Tillage*Position	4	688.52	172.13	0.94	0.44
Row*Tillage*Position	4	524.73	131.18	0.72	0.58

** significant at alpha = 0.01

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

Tillage	Average yield[1]	Standard deviation
	bu/ac	
Moldboard Plow	160.2 a	11.2
Chisel	157.0 b	12.7
Ridge Tillage	142.0 c	15.8

1/ $LSD_{0.05}$ = 1.3 bu/ac
Means in a column with the same letter do not differ significantly using Fischer's LSD (0.05 probability level).

Table 4a. Corn Yields on the 8 Percent Slope by Tillage-Row Dir.-Slope Position Interaction.

Row direction	Tillage	Slope Position	Average yield	Standard deviation
			-------- bu/ac -------	
Up & Down	Moldboard Plow	Top	161.3	12.2
		Middle	159.8	9.5
		Bottom	161.7	13.1
	Chisel Plow	Top	149.3	10.5
		Middle	160.9	6.9
		Bottom	163.1	6.3
	Ridge Tillage	Top	136.2	11.7
		Middle	140.8	11.2
		Bottom	152.5	6.1
Contour	Moldboard Plow	Top	163.1	14.7
		Middle	157.3	8.8
		Bottom	157.8	11.7
	Chisel Plow	Top	156.1	13.6
		Middle	157.9	19.0
		Bottom	154.8	15.5
	Ridge Tillage	Top	151.8	16.5
		Middle	133.8	12.1
		Bottom	137.2	25.3

Table 4b. Corn Yields on the 8 Percent Slope by Row Direction-Slope Position Interaction (sig. at alpha = 0.05).

Row direction	Slope Position	Average yield	Standard deviation
		---------- bu/ac ----------	
Up & Down[1]	Top	148.9 b	3.6
	Middle	153.8 ab	3.0
	Bottom	159.1 a	2.3
Contour[2]	Top	157.0 a	3.5
	Middle	149.7 a	4.1
	Bottom	149.9 a	4.6

1/ $LSD_{0.05}$ = 8.6 (bu/ac)
2/ $LSD_{0.05}$ = 11.8 (bu/ac)

Table 5. Analysis of Variance for the 4 Percent Slope.
Variable: Corn 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	115.28	115.28	0.51	0.48
Row direction	1	9.88	9.88	0.04	0.84
Whole plot error	1	170.67	170.67		
Tillage	2	2490.09	1245.04	5.55	** 0.01
Row*Tillage Interaction	2	68.40	34.20	0.15	0.86

** significant at alpha = 0.01

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

Tillage	Avg. Yield[1]	Row Direction	Average yield	Standard deviation
	-- bu/ac--		---------- bu/ac----------	
Moldboard Plow	173.3 a	Up & Down	173.6	14.2
		Contour	173.0	6.9
Chisel Plow	169.0 a	Up & Down	169.8	15.0
		Contour	168.2	14.7
Ridge Tillage	149.8 b	Up & Down	146.8	23.1
		Contour	152.9	8.2

1/ $LSD_{0.05}$ = 15.9 (bu/ac) averaged over row directions
Means in a column with the same letter do not differ significantly using Fischer's LSD (0.05 probability level).

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

Source	DF	SS	MS	F	P
Block	1	155.5	155.5	5.99	0.04
Tillage	2	531.1	265.6	10.23	** 0.01

** significant at alpha = 0.01

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

Tillage	Average yield[1]	Standard deviation
	---------- bu/ac ----------	
Moldboard Plow	163.9 a	3.5
Chisel Plow	170.0 a	1.9
Ridge Tillage	153.8 b	10.3

1/ $LSD_{0.05}$ = 8.3 (bu/ac)
Means in a column with the same letter do not differ significantly using Fischer's LSD (0.05 probability level).

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

B.R. Khakural, P.C. Robert, D.R. Huggins, D.J. Fuchs and W.C. Koskinen[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. Alachlor concentration of runoff (water, water+sediment) was lower for soil-specific than for uniform rate in both Ves soils. Alachlor was not detected in soil samples obtained from greater than 6 in depths in any soil or treatment after the first sampling. During the first sampling (7 days after application), alachlor was detected to deeper depths in treatments receiving higher alachlor rates. Detectable amount of alachlor was observed in soil water samples from all three soils during some sampling dates. There was no particular trend in soil water alachlor concentration due to soil or alachlor rates.

Introduction:

Growing concerns about crop management sustainability and surface and ground water pollution by agricultural chemicals have initiated soil-specific management system (SSMS). Effects of SSMS on runoff and leaching of chemicals were studied on landscape plots (runoff, micro-plots) at the Southwestern Experiment Station, Lamberton, MN.

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 were presented in a 1992 report.

Runoff plots were arranged as a split plot design with soil (landscape position) as main plot and herbicide rate as sub-plot (30 ft X 2.5 ft) with three replications. Stainless steel sampling gutters attached to vertically installed nalgene carboys were used to receive runoff samples. Six leaching microplots (7 ft X 7 ft: 2 on each soil type) were established. Each plot was isolated vertically with polyethylene sheets (0.0059 in) to a depth of 5 ft. Suction cups were installed in duplicates at 2- and 4 ft depths. Three plots across the landscape received a uniform rate of alachlor (Lasso) herbicide (UR) and the remaining half received soil-specific rates (SSR).

Plot Management

Crop: soybean variety: Kato — Planting Date: 5-13-1992
Herbicide used: alachlor — Date application: 5-13-92
Herbicide rate:

Uniform rate: 3 lb/A

Soil-specific rate	lb/A
Ves (1-4%)	2.50
Ves (6-12%)	2.00
Webster (0-3%)	3.25

Sampling and Laboratory Procedure:

Soil samples (0-4 ft) were collected using a soil probe with a plastic liner. Runoff samples were obtained by placing the stainless steel sampler at the end of a 30 ft crop row (30 ft X 30 in). Soil water suction samples were collected after each significant rainfall. Soil, soil water and runoff (water and sediment) samples were analyzed for alachlor concentration in the laboratory using gas chromatographic procedures.

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[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 Associate Professor respectively in the Soil Science Department at the University of Minnesota, St. Paul, MN 55108. D.R. Huggins and D.J. Fuchs are Assistant Professor and Scientist, Southwest Experiment Station, University of Minnesota. W.C. Koskinen is a Soil Scientist, USDA-ARS, St. Paul, MN.

Results and Discussion

Runoff

Three runoff events occurred during the 1992 cropping season. The second runoff event (34 days after application) had a higher concentration of alachlor in runoff water in the Ves soil than the first event. The second event occurred on the same day, 19 hours after the first event.

Alachlor concentration of the runoff water and runoff (water+sediment) was consistently lower for soil-specific rate (SSR) than for uniform rate (UR) in both Ves soil conditions and were statistically significant during the second and third runoff events (Table 1). A similar trend was observed in sediment alachlor concentration except in the Ves (6 to 12%) soil in event 2. The differences in concentrations between SSR and UR however, were not statistically significant. No significant difference in concentration was observed in the Webster soil due to alachlor rates.

Alachlor concentration was very high in the runoff sediment (0.7 to 22 ppm) compared to its concentration in runoff water (6 to 110 ppb). Runoff water contributed 88% (71 to 98%) of the bulk concentration. The contribution from the sediment phase increased as slope gradient increased. On an average, runoff sediment of the Ves (1 to 4%), Ves (6 to 12%) and Webster soils contributed 12.5, 14.5, and 9% to the bulk concentration, respectively.

Soil-specific rates, compared to the uniform rate, reduced alachlor concentration in runoff sediment, water, and water+sediment by 10, 24, and 22% (average of events 1 and 2), respectively. The reduction in runoff water and bulk (water+sediment) concentration was statistically significant at the p= 0.1 level.

Leaching and Soil Alachlor Concentration

At the first sampling (7 days of alachlor application), alachlor was found in soil samples taken from deeper depths in treatments receiving higher rates (Table 2). Maximum depths of detections were 1.5 and 3 ft in the Ves and Webster soils, respectively. Alachlor was not detected in soil samples obtained from greater than 6-in depths in any soils or treatments after the first sampling.

Alachlor was detected in soil water samples from all three soils during some sampling dates except Ves (6 to 12%) at 2-ft depth (Table 3). Alachlor concentration varied from 0.2 to 9.4, and 0.1 to 2.4 ppb at 2- and 4-ft depths, respectively. No particular trend was observed with alachlor rates.

Surface soil alachlor concentration was significantly lower for SSR compared to UR in the Ves (6-12%) soil during the second and third samplings and in the Ves (1-4%) soil only during the second sampling (Figure 1).

Table 1. Average alachlor concentration in runoff sediment and water from Ves and Webster soils.

Event (Date)	Soil	Sediment		Water		Sediment+Water	
		UR	SSR	UR	SSR	UR	SSR
		----- ppm ----		---------- ppb ----------			
1 (5-16-92)	Ves (1-4%)	7.32	5.05	33.8	24.0	40.1	30.3
	Ves (6-12%)	5.40	2.81	35.1	28.8	37.7	34.1
	Webster (0-3%)	2.27	1.91	34.3	43.5	36.1	48.5
2 (5-16-92)	Ves (1-4%)	6.23	5.23	84.9a	65.9b	90.4a	72.3b
	Ves (6-12%)	3.47	6.57	104.8a	63.5b	110.1a	64.6b
	Webster (0-3%)	2.69	3.06	26.7	16.2	29.5	19.0
3 (7-2-92)	Ves (1-4%)	6.61	2.67	29.1a	14.0b	33.3a	17.2b
	Ves (6-12%)	22.17	12.35	33.5a	12.4b	47.1a	17.5b
	Webster (0-3%)	-	0.66	-	6.0	-	6.4
Management (UR, SSR) Avef		4.56	4.11	53.3	40.31	57.32	44.8

Within a soil and runoff phase (water, water+sediment), means followed by different letters are significantly different at the p= 0.05 level. An absence of letters indicates no significant difference.

†Averaged across soils and events (1 and 2).

UR= Uniform rate SSR= Soil-specific rate

Table 2. Soil alachlor concentration of the first sampling (7 days after application).

Soil	Depth	Uniform rate		Soil-specific rate	
		Mean†	Sd‡	Mean	Sd
	in	ppb			
Ves (1-4%)	00-06	411	182	424	188
	06-12	16	28(2)	-	-
	12-18	9	22(1)	-	-
Ves (6-12%)	00-06	434	299	294	53
	06-12	18	29(2)	21	32(2)
	12-18	8	19(1)	-	-
Webster (0-3%)	00-06	422	228	469	674
	06-12	11	27(1)	71	121(3)
	12-18	-	-	12	28(1)
	18-24	-	-	18	45(1)
	24-36	-	-	35	85(1)

†Six observations were used to calculate mean and Sd.
‡Numbers in parenthesis indicate number of observations with a detectable amount of alachlor out of six observations. - Alachlor not detected.

Table 3. Alachlor concentration in soil water at 2 and 4 feet depths.

Soil	Date:	7-2-92		7-14-92	
		UR	SSR	UR	SSR
		ppb			
		2 feet			
Ves (1-4%)		ND	9.4	ND	2.0
Ves (6-12%)		ND	ND	ND	ND
Webster (0-3%)		ND	2.6	ND	ND
		4 feet			
Ves (1-4%)		ND	ND	ND	2.4
Ves (6-12%)		ND	ND	0.9	0.8
Webster (0-3%)		2.2	-	0.8	0.9

†ND = Not detected - Unable to get samples

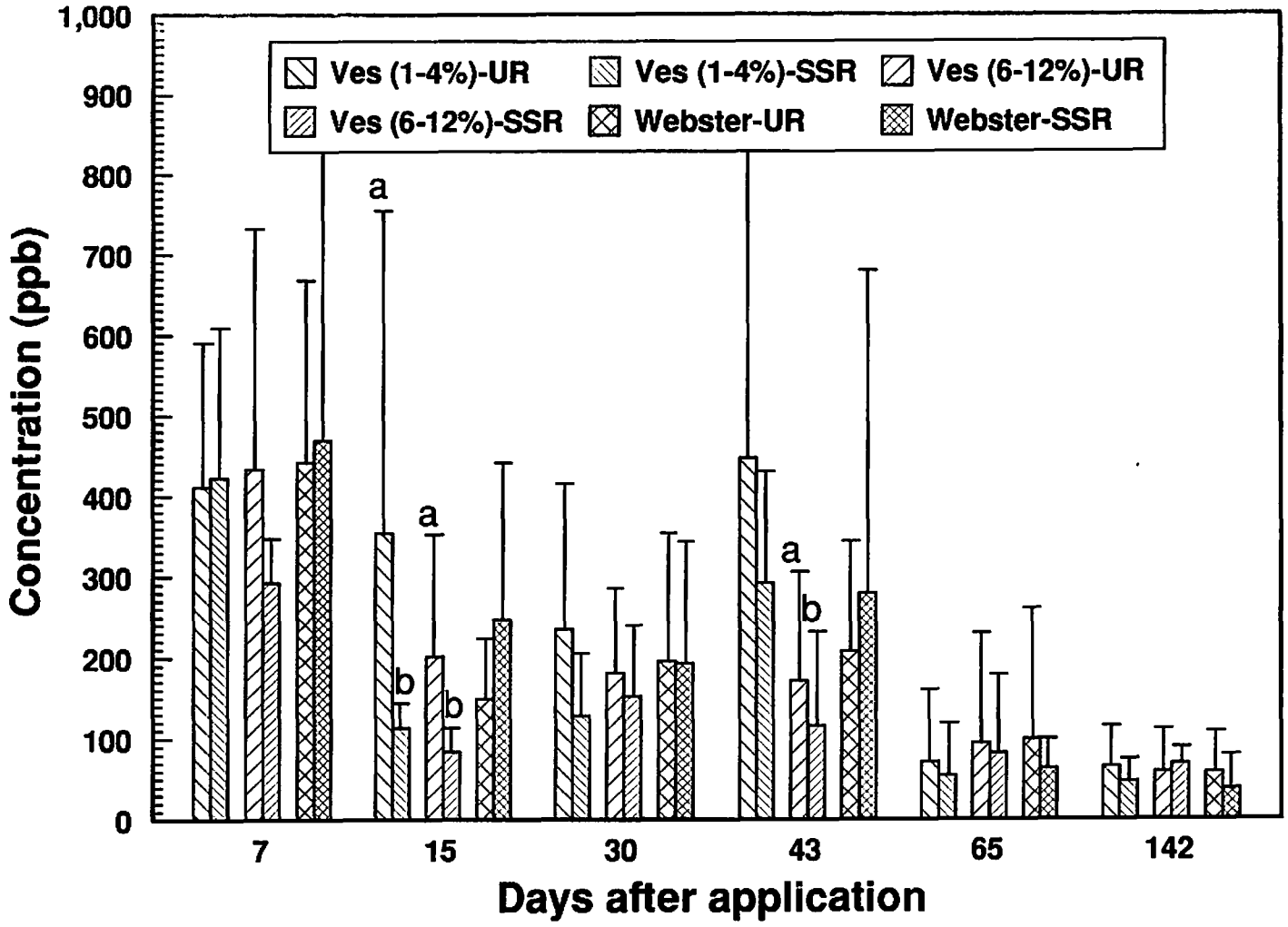

Figure 1. Surface (0-6 in.) soil alachlor concentration under uniform and soil-specific rates during the 1992 growing season. Means within a soil condition and sampling date followed by different letters are significantly different at the p= 0.05 level. An absence of letters indicate no statistical difference. UR= Uniform rate SSR= Soil-specific rate

THE MOVEMENT OF SURFACE APPLIED TRACERS BY SECONDARY, RIDGE, CHISEL, AND MOLDBOARD PLOW TILLAGE SYSTEMS

D. J. Fuchs, J. A. Staricka and D. R. Huggins[1]

Broadcasted phosphorus and potassium fertilizers may be positionally limiting to plants in reduced tillage systems. This study was conducted to determine the placement of broadcasted granular fertilizers by using ceramic spheres as tracers. The ceramic spheres ranged in diameter from 1 to 3 mm and were similar in size to fertilizer granules. The area chosen had three different primary tillage systems moldboard plow (MP), chisel plow (CP), and ridge tillage (RT) in a corn soybean rotation. Spheres were applied at a rate of 2.7 spheres/cm^2 in the spring of 1990 and 1991 after primary tillage and before any secondary tillage. Soil samples were collected after the last row cultivation. Two transects of 40 cores each (4-cm spacing, 160 cm total transect) were collected perpendicular to the corn rows (75-cm spacing) to a depth of 30 cm in each plot. Cores were then sectioned into 2-cm increments. Measurements on individual samples included tracer count, plant residue mass, and bulk density. The RT treatment had the greatest concentration of tracers near the surface with an average tracer depth of 3 cm. The CP and secondary tillage (2 passes with a field cultivator or disc) had similar tracer depths. The MP treatment had an average tracer depth of tracer depth of 14 cm. There was not a visual difference in horizontal distribution of the tracers between tillages. RT treatment had higher bulk densities throughout the measured soil profile in comparison to MP and CP. Little vertical movement of surface applied materials occurred with RT.

Introduction

Tillage systems used for crop production in southwest Minnesota can effect corn and soybean yield. Corn and soybean yields may be reduced by several factors, including soil compaction, weed pressure, and disease pressure. Another factor that may limit crop yield in reduced tillage systems is decreased nutrient uptake induced by poor fertilizer placement. Corn growing in ridge tillage systems showed visual K deficiency symptoms during the drought of 1988 in southwestern Minnesota, whereas the conventional tillage systems displayed no K deficiency symptoms.

The objectives of this study were to: (i) evaluate placement of fertilizer in reduced and conventional tillage systems using ceramic spheres as a tracer, (ii) estimate bulk density differences between tillage systems.

Materials and Methods

This study was conducted in 1990 and 1991 at the University of Minnesota Southwest Experiment Station. Plots were established in April 1990 on a Ves loam (fine-loamy, mixed, mesic Udic Haplustolls) with 4 percent slope. The site has been alternately planted with corn and soybean since 1985 with corn being the crop for 1990 and soybean in 1991. The chosen area had three different tillages: fall moldboard plow with spring secondary tillage (MP), fall chisel plow with spring secondary tillage following (CP), and ridge tillage (RT). All tillage was performed across the slope.

Tillage areas were 24.32 m by 15.20 m. Located within the tillage areas, plots 6.08 by 6.08 m were established for application of tracers. Ceramic spheres, 1 to 3 mm in diameter with a density of 0.42 g cm^{-3}, were used as tracers to simulate surface applied material. The spheres applied in 1990 were painted with fluorescent red paint, and spheres applied in 1991 were painted with fluorescent green. This aided in tracer recovery, and in 1991, the separation of each year's movement. The tracers were applied in the spring of 1990 and 1991 at a rate of 2.7 per cm^2 before any secondary tillage.

In the fall of 1989, primary tillage was performed after harvest on the MP and CP plots. The MP area was moldboard plowed to a depth of 10 inches, with an 18-inch cutting width. The CP area was chisel plowed to a depth of 8 inches, with 3.25-inch wide twisted shovels.

On 23 April 1990, secondary tillage was performed twice on the chisel and moldboard treatments with a field cultivator, working depth of 6 in. No secondary tillage was performed on the ridge tillage plots. Corn was planted in 30-in. rows. The MP and CP area was planted with a four-row John Deere 7000

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planter with 16-in. dia. fluted residue-cutting coulters. The ridge tillage plot was planted using a four-row John Deere 7000 Conservation planter with 14-in. dia. horizontal disk, attached in front of the planting unit to removed the previous year's crop residue and to clear the ridge.

In 1990, on 6 June all treatments were cultivated with a John Deere 875 4-row cultivator with 3 shanks per row. The middle shank is a 12-in. wide sweep. The outer two shanks were sweeps with a 6-in. width. On 22 June 1990 the MP and CP treatments were cultivated with John Deere 885 for the second time, and the RT treatment was ridged with a John Deere 875 4-row cultivator with 1 12-in. sweep in the middle of the row, and two outer 14-in. vertical concave discs for ridging soil into the row, creating 6-in. ridges.

Primary tillage was performed in the fall of 1990 after chopping corn stalks on the MP, CP and RT plots. The MP area was moldboard plowed to a depth of 10 inches, with an 18-inch cutting width. The CP area was chisel plowed to a depth of 8 inches, using 4-inch wide twisted shovels. RT received no primary tillage.

In 1991, secondary tillage was performed once using a disk with a working depth of 6 in. On 22 May 1991, soybeans were planted with the same planters as in 1990. In 1991, all tillage treatments were row cultivated on 17 June and 1 July with same cultivation method as in 1990.

In both July 1990 and September 1991, soil samples were collected, with two transects per tillage treatment, perpendicular to crop rows (75-cm spacing), using a straight template with 40 holes at a 4-cm spacing. Microrelief measurements were taken at time of sampling for each hole in the template. A soil core (1.8-cm diam.) was taken from each hole to a depth of 30 cm, and then sectioned into 2-cm increments. Each 2-cm increment was stored in coin envelope air dried and weighed. Measurements on individual samples included tracer count, residue mass, root mass, and bulk density.

Figures 1, 2, and 3 are from data collected in 1991. Data collected in 1990 was very similar to the tracer distribution seen for tracers applied in 1991 tracer application. Figures 4 and 5 are average bulk density measurements for 1990 and 1991.

Table 1. Management information.

Tillage System	Primary Tillage	Apply Tracers	Secondary Tillage	Plant	Row Cultivate	Collect Samples
	----------Date----------					
1990						
Secondary Tillage (following CP and MP)	Fall 1989	4/23/90 (AM)	4/23/90 (PM)[1]	4/24/90	6/6/90, 6/22/90	7/13/90
Ridge Tillage	None					
1991						
Chisel Plow & Moldboard Plow	Fall 1990	5/21/91 (AM)	5/21/91 (PM)[2]	5/22/91	6/17/91, 7/1/91	9/25/91
Ridge Tillage	None					

1. Field cultivator two passes.
2. Disc one pass.

Results and Discussion

Tracers

In 1990 and 1991, there was no visual horizontal distribution differences of the tracers between tillage systems (Fig 1-3). In 1990 and 1991, there was significant vertical distribution differences between tillage treatments. In the ridge tillage system depth of tracers for the year of application was 2.3 cm (Table 2). After one year, the tracers applied in 1990 in the ridge tillage area had an average tracer depth of 4.1 cm, resulting in less than 2 cm incorporation. The average depth of tracers was 6.4 cm in 1990 after secondary tillage (two passes with a field cultivator) and 2 passes with a row cultivator in the MP and CP area (Table 2). The average depth of tracers was 5.3 cm in 1991 after one pass with a disc and two passes with a row cultivator in the MP and CP area. The surface roughness differences between the moldboard plow and chisel plow treatment at time of tracer application did not effect resultant vertical position (Fig. 1, 2, and Table 2). The average depth of tracers was 5.8 cm in 1991 for the chisel plowing treatment (Table 2). The chisel plow placed the tracers at about the same depth as the

secondary tillage treatments. The average depth of tracers was 14.0 cm in 1991 for the moldboard plow treatment, resulting in the deepest tracer placement.
Recovery of the tracers ranged from 56.7 percent to 128.8 percent with the greatest recovery occurring in 1990 in the ridge tillage system.

Bulk density

The ridge tillage system had higher bulk densities in the upper 30 cm than the chisel plow and moldboard plow treatments (Fig. 4 and 5). The ridge tillage treatment had the highest bulk density measurements occurring where a majority of the tracers were located (Fig. 3 and 4). The differences in bulk density measurements between tillages systems decreased with depth (Fig. 4). Wheel track areas had higher bulk densities than non-wheel track areas in all tillage systems (Fig. 5).

Microrelief

There was no difference in microrelief between tillages at time of sampling in 1990. In 1991, the ridge tillage system showed more relief at time of sampling than the moldboard plow and chisel plow treatments (Fig. 1-3).

Little movement of surface applied materials occurred with the ridge tillage treatment. Moldboard plowing resulted in the deepest placement of tracers. Chisel plowing did not incorporate the tracers deeper than secondary tillage. In ridge tillage systems, broadcast fertilizer availability may be limited because of poor resultant position and higher soil bulk densities, reducing root interception and uptake of fertilizer.

Table 2. Tracer average placement and percent recovery.

			Tracers (year = year of application)			
					Recovery	
			Mean Depth		All depths	
Tillage System	Rep	Year	1990	1991	1990	1991
			------ cm-----		------- % -------	
Field Cult.-2X (following CP)	1	1990	6.6	--	87.2	--
	2		6.3	--	62.8	--
Field Cult.-2X (following MP)	1		5.9	--	79.3	--
	2		6.7	--	74.2	--
Ridge Tillage	1		1.7	--	128.8	--
	2		2.2	--	112.3	--
Chisel (or Disc 1X)	1	1991	6.0	5.8	69.9	76.4
	2		5.6	5.2	68.5	68.1
M. Plow (or Disc 1X)	1		13.5	4.6	71.7	62.4
	2		14.4	5.7	98.3	68.9
Ridge Tillage	1		2.7	2.8	90.0	75.3
	2		5.4	2.6	76.4	56.7

Fig. 1. Location of Tracers in Chisel Plow (rep. 1)

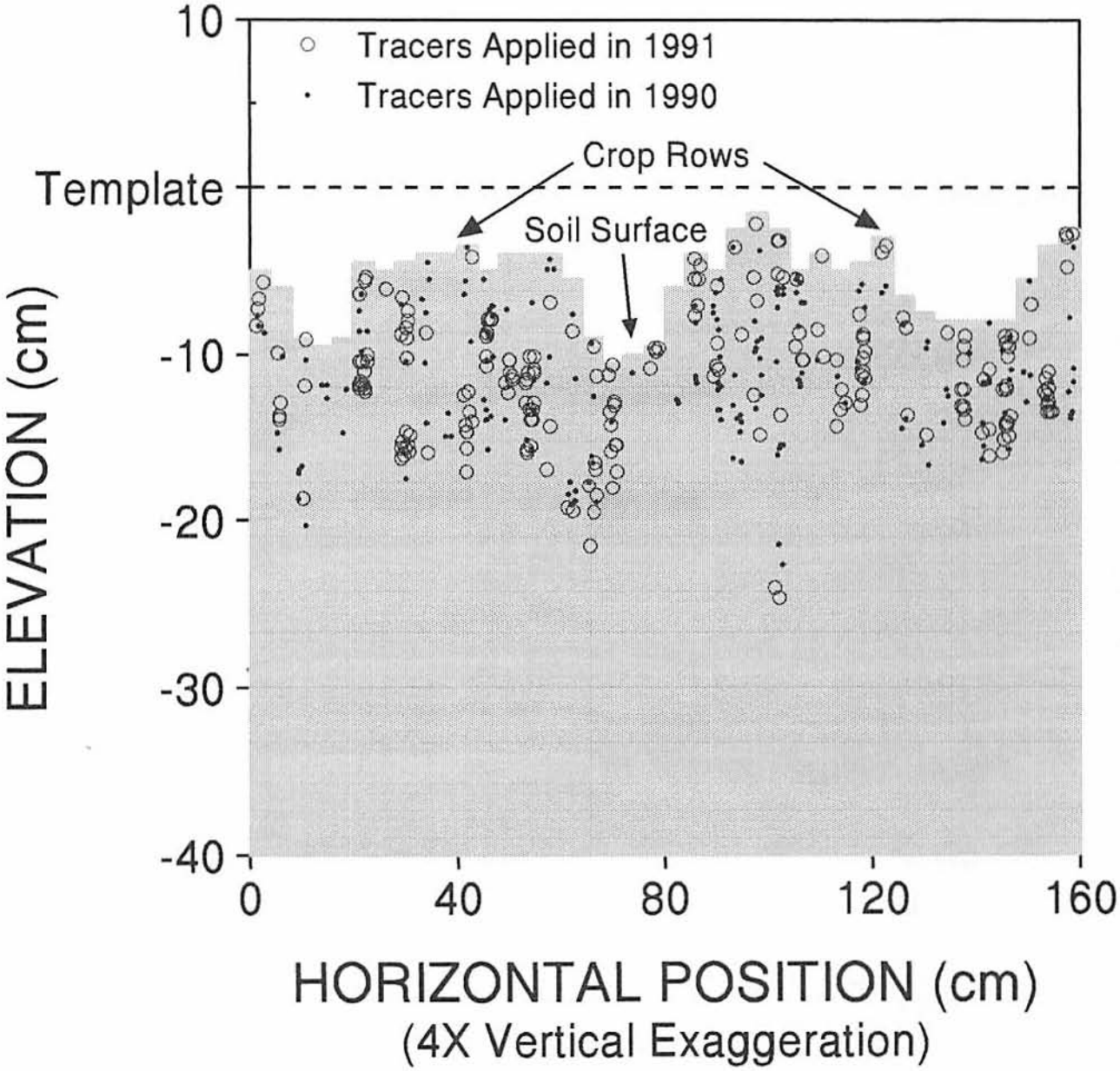


Fig. 2. Location of Tracers in Mlbrd. Plow (rep. 1)

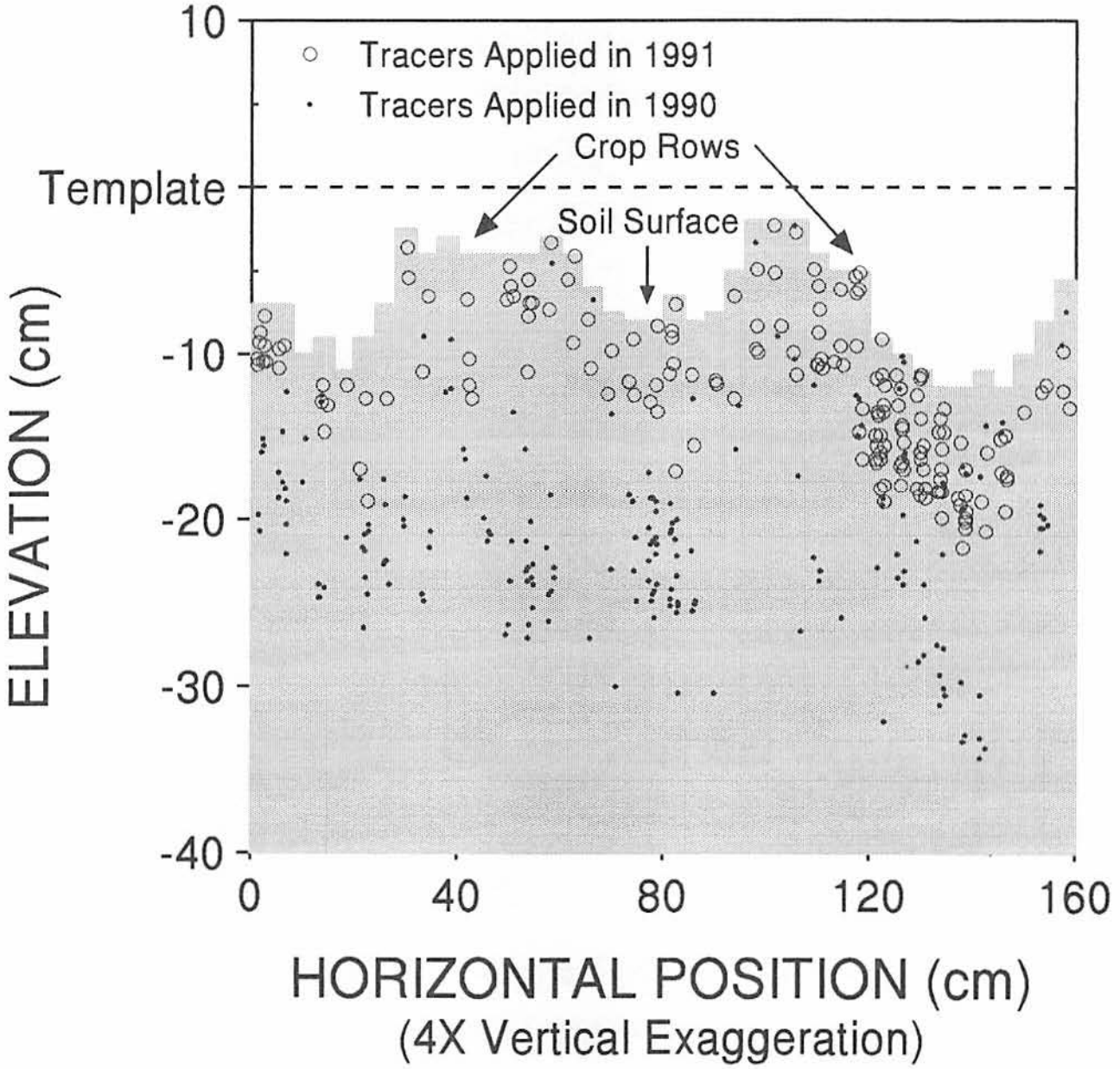


Fig. 3. Location of Tracers in Ridge Tillage (rep. 1)

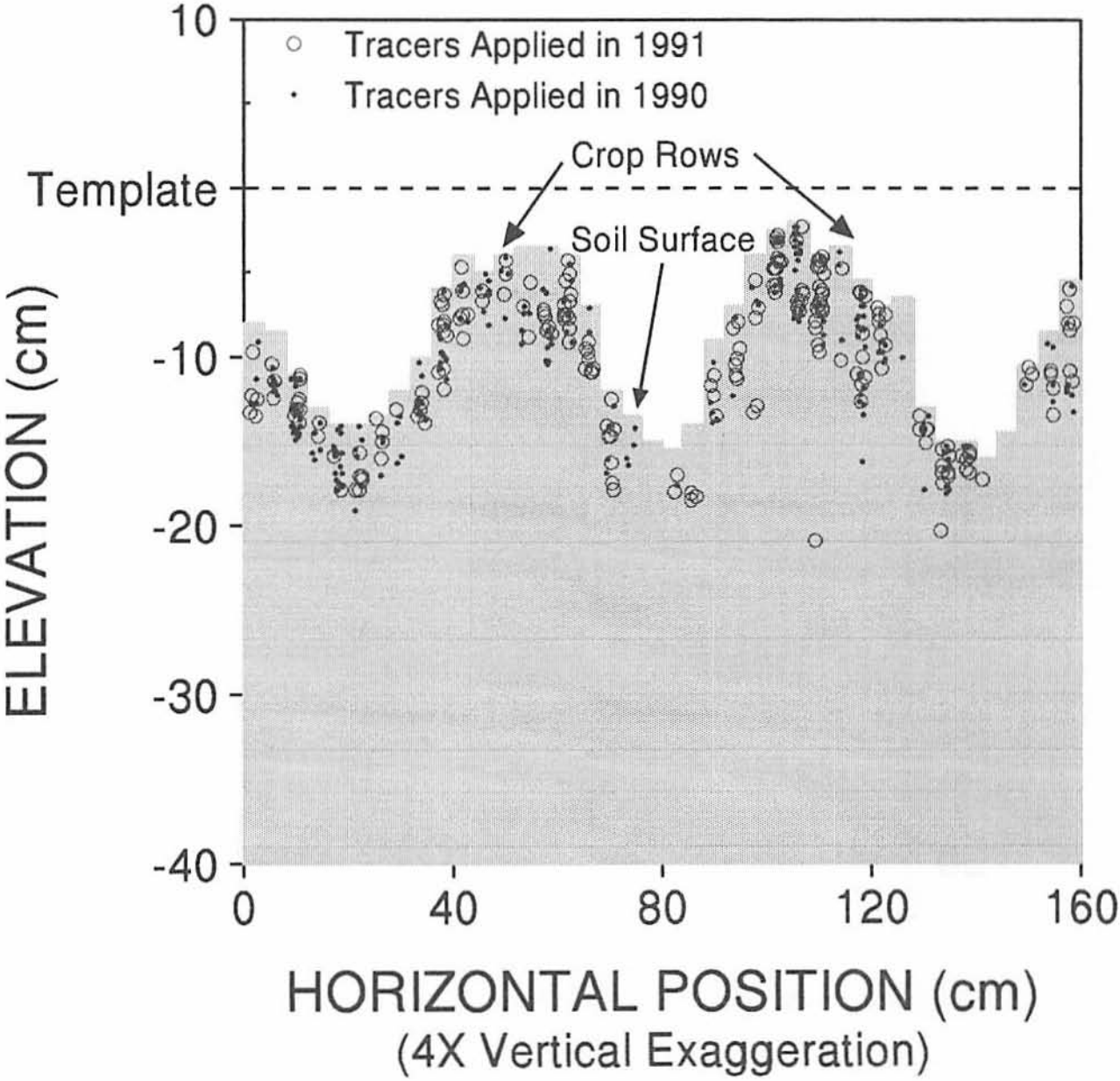


Figure 4. Bulk Density - Vertical Trends

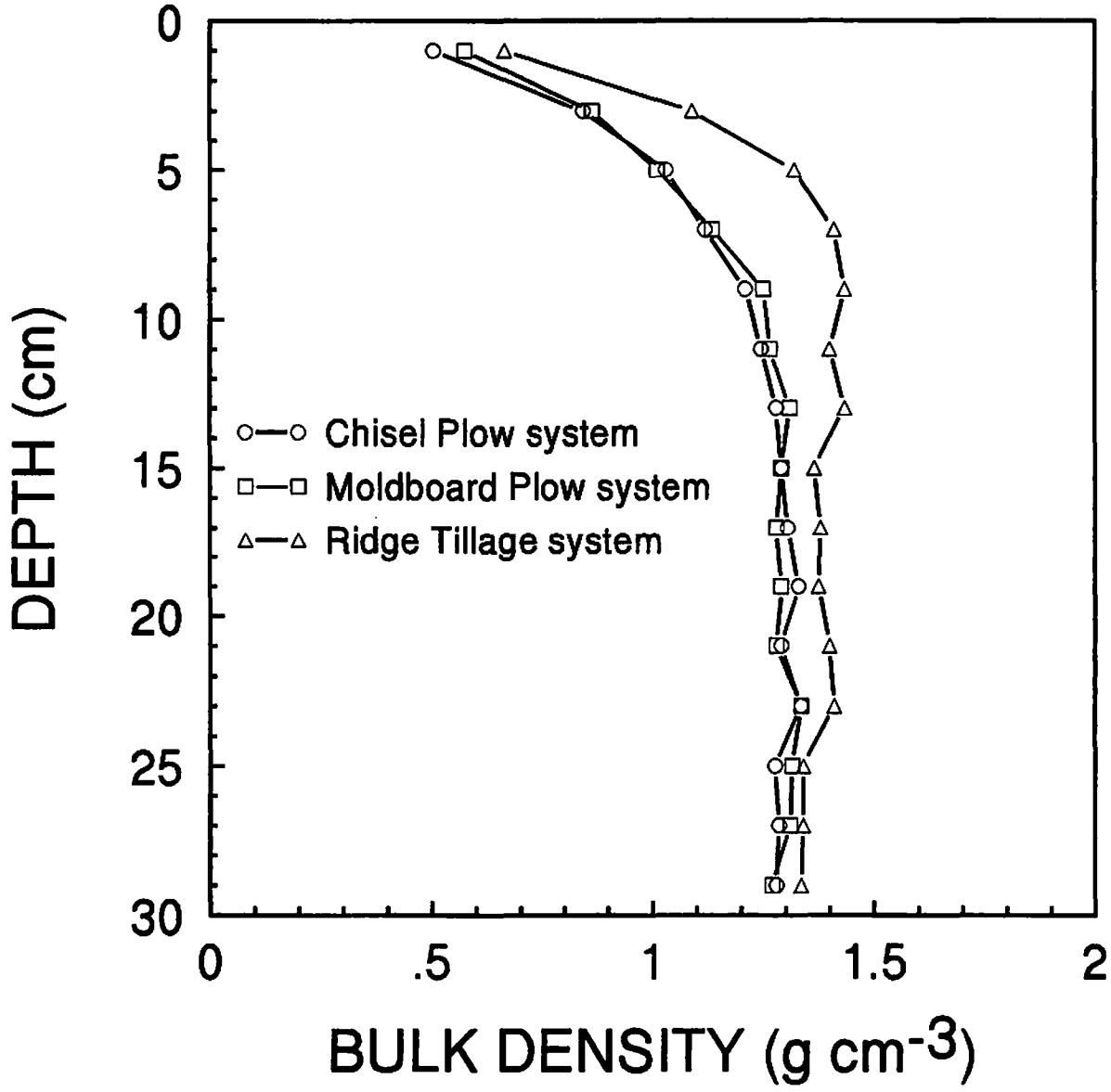
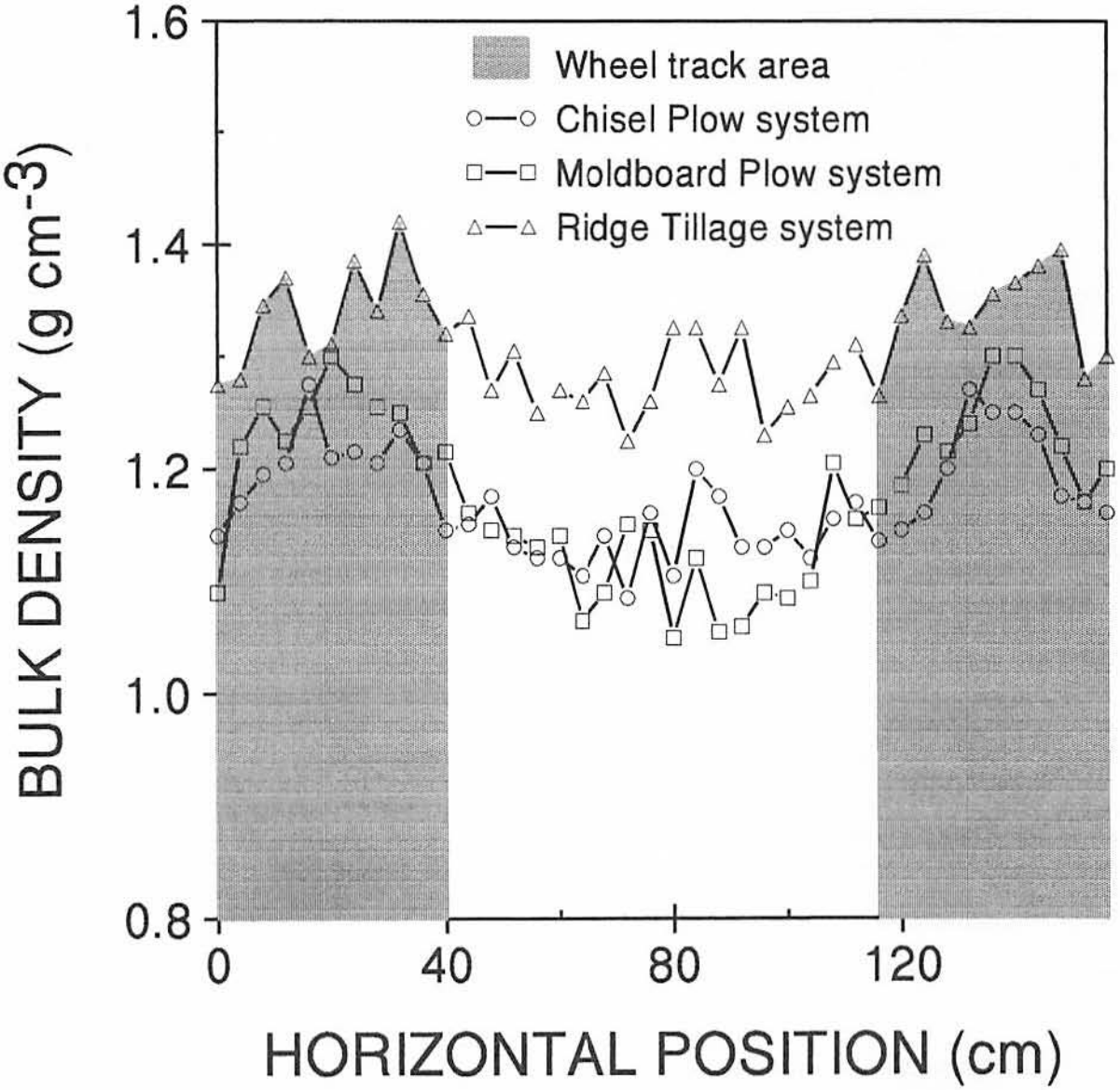


Figure 5. Bulk Density - Horizontal Trends



NITRATE AND PESTICIDE LOSSES TO TILE DRAINAGE, RESIDUAL SOIL N, AND N UPTAKE AS AFFECTED BY CROPPING SYSTEMS[1]

Lamberton, 1992

G. W. Randall, D. Fuchs, W. W. Nelson, D. D. Buhler,
M. P. Russelle, and J. L. Anderson

ABSTRACT: Four cropping systems (continuous corn, a corn-soybean sequence, alfalfa, and CRP) were established in 1988 to determine biomass yields, N uptake, residual soil NO_3 and NO_3 and pesticide losses to tile drainage water as influenced by cropping system. Corn and alfalfa yields in this fifth year of the study were very good while soybean yields were average. Nitrogen removed by the continuous corn, corn-Sb, soybean, and alfalfa crops totaled 140, 109, 167 and 307 lb/A, respectively. Residual soil NO_3-N remaining in the 0-5' profile in October totaled 95, 59, 44, 16 and 10 lb/A for the continuous corn, corn-soybean, soybean-corn, alfalfa and CRP systems, respectively. Available water in the 0-5' profile in late October with the row-crop systems ranged between 5.6 and 6.1 inches while the perennial crops had 5.1" (alfalfa) and 4.7" (CRP). Tile water drainage from the row-crop systems ranged from 4.9 to 7.0 acre-inches while only 2.1 to 3.4 acre-inches drained from the perennial crops. Flow-weighted NO_3-N concentrations ranged from 26 to 40 mg/L for the 6-month drainage period with the corn and soybean systems but averaged <3 mg/L with the alfalfa and CRP systems. Nitrate-N losses ranged from only 1.5 lb/A with the alfalfa and CRP systems to 46 lb/A with continuous corn. Alachlor was detected in 17 of 69 tile water samples, but cyanazine was not found in any.

Nitrate and pesticide losses to tile drainage water have been monitored in the last few years for continuous corn systems at the Lamberton and Waseca branch experiment stations. However, very little information exists on the N and pesticide losses from other cropping systems, especially those involving alfalfa or CRP grass:legume plantings. The purpose of this study was to determine the effect of four cropping systems on the:

1) above-ground biomass yields, N concentrations in the biomass, and N removal,
2) residual NH_4 and NO_3 in the 0 to 10' soil profile after harvest, and
3) NO_3 and pesticide losses in the tile drainage water.

Background

Fifteen tile drainage plots each measuring 45' x 50', surrounded with plastic sheeting to a depth of 6', were installed in 1972 at the Southwest Experiment Station at Lamberton. Nitrogen rates from 18 to 400 lb N/A were applied annually to corn from 1973 through 1979 on this Nicollet clay loam. Since 1979, continuous corn without N in 1980-1985 and with only 50 lb N/A in 1986-87 was grown to "erase" the effects of the previous treatments.

Experimental Procedures

Four cropping systems [continuous corn, corn-soybean sequence, continuous alfalfa, and continuous CRP (Conservation Reserve Program) species] were established on these drainage plots in the spring of 1988. Each cropping system was randomly assigned to the drainage plots in a randomized, complete-block design with three replications. The detailed experimental procedures are shown in Table 1.

Soil samples taken from the 0 to 8" layer in 1988 indicate high soil test P&K values. Consequently, no broadcast nor starter fertilizer was used for the corn, soybeans or CRP systems. Potassium was broadcast at a rate of 120 lb K_2O/A following the first cutting of alfalfa. Samples taken to a 5-foot depth in late-April (Table 3) were used to determine the N fertilizer rates needed for corn. The 155-lb N rate used for continuous corn and the 120-lb N rate for corn after soybeans was based on the NO_3 concentration in the 0 to 24" and 24 to 48" layers and a yield goal of 140 bu/A.

Results and Discussion

Weather

Climatic conditions during the 1992 growing season were cooler than normal (Table 2). Rainfall over the 7-month growing season was 2.1" above normal with greatest departure from normal in August. Monthly temperature averages were markedly below normal in July and August while the 7-month seasonal average was 3° F below normal. These conditions resulted in good corn and alfalfa yields and average soybean yield.

Spring Soil Nitrate

Residual NO_3 in the 0 to 5-foot soil profile in late-April was moderately low for both the corn-soybean and soybean-corn systems and medium-high for the continuous corn system (Table 3). Nitrate-N distribution was relatively uniform throughout the profile in the corn-Sb system,

[1] Funding provided by the North Central Regional Research Comm. (NC-201), Southwest Experiment Station, Southern Experiment Station, and Center for Agricultural Impacts on Water Quality.

showed increased concentrations below one foot in the soybean-c system, and highest concentrations below two feet in the continuous corn system. This is in contrast to 1991 when NO_3 concentrations were uniform throughout the profile and in 1990 when most of the NO_3 was in the top two feet. Residual soil NO_3 in the cropping systems did not change by more than 22% between the October '91 sampling and the April '92 sampling. These changes between fall and spring sampling suggest little over-winter "losses" of NO_3 in this year.

Crop Yields

Crop yields shown in Table 4 were above the yield goal for continuous corn, slightly below for corn after soybean, and were very good for alfalfa. Yield and N uptake by continuous corn were 17 and 28% higher than for corn after soybean. In addition, N concentration in corn after soybean was less than for continuous corn. These data suggest sufficient N may not have been present in the corn-soybean system. Yet, N deficiency symptoms were not noted (in fact, the corn after soybean looked more green than the continous corn in mid-September) and soil NO_3 in the top three feet at the end of the season was not different between the two systems. This unexpected difference between the two corn systems may be explained on the basis of grain moisture at harvest and plant maturity at the time of the first fall frost (September 28). Grain moisture on October 9 was 30.3% for continuous corn and 34.5% for corn after soybean. Perhaps the cooler growing season delayed maturity of corn after soybean greater than continuous corn, and the full yield potential was not reached by the time of the first fall frost. Nitrogen removal by alfalfa far exceeded that by corn. The CRP plots were essentially all grass at the end of 1992 after being dominated by alfalfa in 1989, showing a 50:50 split between grass and alfalfa in 1990, and a 90:10 ratio between grass and alfalfa in 1991. The wetter conditions in the last three years apparently led to the reestablishment of the grass species.

Fall Soil Nitrate and Ammonium

Soil NO_3 levels throughout the 10-foot profile were markedly lower for those cropping systems dominated by alfalfa and CRP compared to the corn and soybean systems (Table 5). Ranking from highest to lowest was: CC > C-Sb > Sb-C > A = CRP. Nitrate-N concentrations were often highest in the 0-1' profile, usually lowest between 1 and 3' and were somewhat higher again below 3'. Distribution below 3' was very uniform for the CC and C-Sb systems but declined below 5' with the Sb-C system. Nitrate-N concentrations between 4' and 8' were uniformly quite high for the CC system. The alfalfa and CRP systems exhibited very low NO_3-N concentrations down to 8 feet. From 8 to 10 feet, NO_3-N concentrations, although still low, more than doubled. Amounts of soil NO_3 in the top five feet in October ranged from 5% (continuous corn) to 34% (Sb-C) lower than in April. Absolute differences between the dates of sampling were 5 - 8, and -23 lb NO_3-N/A for the CC, C-Sb and Sb-C systems, respectively. Application of 155 and 120 lb N/A to the CC and C-Sb systems did not influence soil NO_3-N levels compared to the pre-application levels. Soil NH_4-N was not affected by cropping system (Table 6).

Soil Moisture

Soil moisture in the 0 to 5' profile in October was higher than in previous years and was affected by the cropping system (Table 7). Available soil water was lowest for the perennial crops (alfalfa and CRP), intermediate where corn was grown in 1992, and highest following soybean.

Tile Flow

Tile line discharge occurred from early March through mid-October (except September) for the corn and soybean systems and from early March through early May for CRP and alfalfa. Discharge averaged 5.6" for the systems containing corn and soybean; this was 2x higher than the 2.8" for the alfalfa and CRP systems (Table 8). Flow-weighted NO_3-N concentrations for the season were highest for the CC system and was approximately 16x higher than the alfalfa and CRP systems. Nitrate-N concentrations from the C-Sb and Sb-c systems averaged about 13 mg/L less than from the CC system. Temporal changes in NO_3-N concentration did not occur over the flow period. Losses of NO_3-N in the tile drainage for the 1992 season ranged from 20 and 32 times higher for the corn-soybean sequences and CC systems compared to the two perennial crop systems. Losses averaged 36 lb/A for the two corn-soybean sequences, 46 lb/A for the CC system and only 1.5 lb/A for the alfalfa and CRP systems. These data indicate that N removal (alfalfa) and N cycling (CRP) along with high ET demand of the perennial crops are resulting in minimal NO_3 loss. Thus, we can speculate that NO_3 loss from native prairies to ground water prior to the adoption of cropping and tillage practices in southern Minnesota would have been extremely small.

Water samples were collected periodically throughout the flow period from the corn and soybean systems and were submitted for pesticide analyses. Alachlor (Lasso) was found in 17 of the 69 samples collected. Alachlor concentration in the 17 samples averaged 0.46 ppb with a range from 0.09 to 1.88 ppb. Cyanazine (Bladex) was not found in the 51 samples collected from the CC and Sb-C systems that received cyanazine in 1991 or in the 18 samples collected after May 2 (date Bladex applied) from the C-Sb system that received cyanazine in 1992. Detection limits were 0.05 ppb for both herbicides. These data indicate little need for concern regarding the leaching of these herbicides to tile discharge water in these high organic matter, fine-textured soils in southern Minnesota.

Conclusions

The slightly wetter than normal conditions in 1992 resulted in good corn and alfalfa yields and average soybean yield in this fifth year of the study. Nitrogen removal by soybean and alfalfa was 1.2x and 2.2x as high, respectively, as with continuous corn. After three moist years, the grass species again dominated the CRP system. Over winter, "loss" of soil NO_3 was very low. Residual soil NO_3 in the fall, although not as high as in some previous years, was approximately 5x higher with the row crop systems compared to the perennial crop systems. Tile flow occurred over a 6-month period for the corn and soybean systems and a 2-month period for the perennial crops. Drainage averaged 5.6 acre-inches from the row crop systems and 2.8 acre-inches from the perennial crop systems. Nitrate-N concentrations also were 11 to 16x higher with the row-crop systems. Nitrate-N losses to the drainage water totaled 46 lb/A from the continuous corn system and 29 lb/A from the corn-

soybean rotation that received fertilizer N in 1992. Nitrate-N losses from the soybean-corn system were higher (43 lb/A) due primarily to higher tile flow. Less than 2 lb NO_3-N/A were lost in the drainage water from the alfalfa and CRP systems. Tile water samples analyzed for alachlor and cyanazine showed 25% of the samples to contain detectable levels of alachlor with an average concentration of 0.46 ppb in the 17 positive samples. No cyanazine was detected in any of the 69 samples.

Table 1. Experimental procedures used in 1992 for the nitrate-pesticide movement study at Lamberton.

Cropping System	Procedures
Cont. Corn and Corn-"Sb"	
Hybrid	Pioneer 3615
Planting rate and date	29000 ppA on 5/4
Insecticide	Furadan (1 lb/A)
Herbicides	Lasso (4 lb/A) + Bladex (3 lb/A)
Date	Both applied on 5/2 and incorporated 1X with field cultivator; previous field cultivation on 4/30
N rate (Cont. corn only)	155 lb N/A as urea
Date	6/5 and cultivated in the same day
Cultivation date(s)	6/5 and 6/22
Harvest date	10/9
Fall tillage (kind and date)	Moldboard plow 10/30
Corn - "Sb"	
N rate	120 lb N/A as urea on 6/5
Soybeans	
Secondary tillage	Field cultivated 2X (4/30 and 5/2)
Variety	Hardin
Planting rate and date	150,000 seeds/A on 5/5
Row width	30"
Herbicides	
Lasso: Rate and date	4.0 lb/A on 5/2, incorporated with a field cultivator
Pursuit: Rate and date	0.083 lb/A plus surfactant + UAN on 5/27
Cultivation date(s)	6/22
Harvest date	10/13
Fall Tillage	None
Alfalfa	
Harvest date(s)	6/4, 7/7 and 9/1
Harvest area	3' x 20'
CRP	
Harvest date	9/25

Table 2. Growing season monthly air temperature averages and precipitation amounts during 1992 and the long-term normals for Lamberton.

Month	Avg. Temperature 1992	Avg. Temperature Normal	Precipitation 1992	Precipitation Normal
	°F	°F	inches	inches
April	41	46	2.50	2.73
May	62	59	1.62	3.16
June	66	68	4.08	3.55
July	65	73	4.80	3.88
Aug.	64	70	5.13	2.73
Sept.	59	60	2.10	3.34
Oct.	46	49	3.41	2.17
7-mo avg.	58	61	-	
Total	-	-	23.64	21.56

Table 3. Residual NO_3-N in the 0 to 5' soil profile of the cropping systems in April, 1992.

Depth	Cropping System in 1992		
	Cont. Corn	Corn-Sb	Soybean-C
feet	lb NO_3-N/A		
0 - 1	8.1	15.7	9.1
1 - 2	17.6	14.5	15.9
2 - 3	22.6	12.4	17.3
3 - 4	28.4	11.9	14.0
4 - 5	23.6	12.4	10.5
Total (0-5')			
Apr.'92	100.3	66.9	66.8
Oct. '91	83.9	85.7	55.9
% Change over winter	+20	-22	+19

Table 4. Crop yields, N concentration, and N uptake at Lamberton in 1992.

Cropping System	Yield	N Concentration	N Uptake
		%	lb/A
Cont. Corn			
Grain (bu/A)	156.1	1.25	109.2
Stover (lb DM/A)	5798.	0.54	31.1
Total			140.3
Corn-Sb			
Grain (bu/A)	133.6	1.07	80.2
Stover (lb DM/A)	5562.	0.52	29.0
Total			109.2
Soybean-C			
Seed (bu/A)	36.2	6.39	139.0
Stover (lb DM/A)	2258.	1.21	27.9
Total			166.9
Alfalfa			
1st Cut Forage (lb DM/A)	4372	2.83	124.1
2nd Cut Forage (lb DM/A)	3452	3.00	103.6
3rd Cut Forage (lb DM/A)	2426	3.28	79.6
Total	5.12 T/A		307.3
CRP			
Grass (lb DM/A)	4686	1.00	46.5

Table 5. Soil profile NO_3-N concentrations and amounts in October, 1992 as influenced by cropping system at Lamberton.

Depth	Cont. Corn Avg.	Cont. Corn SE	Cont. Corn Avg.	Corn-Sb Avg.	Corn-Sb SE	Corn-Sb Avg.
feet	ppm		lb/A	ppm		lb/A
0 - 1	3.6	0.61	14.5	3.9	0.34	15.7
1 - 2	1.8	0.07	7.3	1.5	0.23	6.0
2 - 3	2.9	0.92	11.7	1.8	0.35	7.2
3 - 4	7.1	2.15	28.5	3.8	0.55	15.2
4 - 5	8.3	3.70	33.2	3.8	0.58	15.1
5 - 6	7.9	3.61	31.6	3.4	0.09	13.7
6 - 7	7.0	3.52	28.0	3.2	0.47	12.9
7 - 8	5.8	3.21	23.3	3.3	0.52	13.1
8 - 9	5.0	2.47	19.9	3.3	0.37	13.3
9 - 10	4.2	1.81	16.8	2.9	0.35	11.5
Totals						
0 - 5			95.3			59.2
5 - 8			82.9			39.7
8 - 10			36.7			24.8
0 - 10			214.9			123.7

Depth	Soybean-C Avg.	Soybean-C SE	Soybean-C Avg.	Alfalfa Avg.	Alfalfa SE	Alfalfa Avg.
feet	ppm		lb/A	ppm		lb/A
0 - 1	3.3	0.64	13.1	1.3	0.96	5.3
1 - 2	0.9	0.44	3.6	0.9	0.38	3.5
2 - 3	1.7	0.69	6.9	0.6	0.38	2.5
3 - 4	2.8	1.07	11.3	0.5	0.27	1.9
4 - 5	2.3	0.61	9.2	0.6	0.31	2.4
5 - 6	1.9	0.65	7.7	0.5	0.32	1.9
6 - 7	1.6	0.35	6.5	0.5	0.30	2.1
7 - 8	1.7	0.26	6.7	0.7	0.41	2.9
8 - 9	1.6	0.26	6.4	1.5	0.35	6.0
9 - 10	1.2	0.56	4.8	1.6	0.12	6.5
Totals						
0 - 5			44.1			15.6
5 - 8			20.9			6.9
8 - 10			11.2			12.5
0 - 10			76.3			35.1

Depth	CRP Avg.	CRP SE	CRP Avg.
feet	ppm		lb/A
0 - 1	1.0	0.43	4.1
1 - 2	0.3	0.19	1.3
2 - 3	0.4	0.18	1.5
3 - 4	0.4	0.21	1.6
4 - 5	0.3	0.12	1.2
5 - 6	0.3	0.15	1.2
6 - 7	0.4	0.18	1.5
7 - 8	0.7	0.33	3.1
8 - 9	1.4	0.47	5.6
9 - 10	1.7	0.48	6.7
Totals			
0 - 5			9.7
5 - 8			5.8
8 - 10			12.3
0 - 10			27.7

Table 6. Soil profile NH_4-N concentrations and amounts in October, 1992 as influenced by cropping system at Lamberton.

Depth	Cont. Corn Avg.	Cont. Corn SE	Cont. Corn Avg.	Corn-Sb Avg.	Corn-Sb SE	Corn-Sb Avg.
feet	------ ppm ------		lb/A	------ ppm ------		lb/A
0 - 1	8.8	0.26	35.2	8.1	0.15	32.4
1 - 2	3.4	0.17	13.6	3.5	0.03	13.9
2 - 3	2.5	0.17	10.1	2.9	0.19	11.7
3 - 4	3.0	0.20	12.1	3.2	0.09	12.7
4 - 5	3.7	0.22	14.9	4.0	0.32	15.9
5 - 6	4.0	0.19	15.9	4.4	0.46	17.5
6 - 7	4.3	0.21	17.2	4.7	0.44	18.7
7 - 8	4.9	0.21	19.6	4.9	0.36	19.6
8 - 9	5.0	0.15	19.9	5.0	0.51	20.0
9 - 10	5.3	0.25	21.2	5.2	0.33	20.7
Totals						
0 - 5			86.0			86.5
5 - 8			52.7			55.8
8 - 10			41.1			40.7
0 - 10			179.7			182.9

Depth	Soybean-C Avg.	Soybean-C SE	Soybean-C Avg.	Alfalfa Avg.	Alfalfa SE	Alfalfa Avg.
feet	------ ppm ------		lb/A	------ ppm ------		lb/A
0 - 1	6.6	1.13	26.5	5.4	0.90	21.7
1 - 2	4.1	0.33	16.5	3.5	0.29	14.0
2 - 3	3.8	0.41	15.1	3.2	0.29	12.9
3 - 4	4.2	0.20	16.9	3.3	0.20	13.3
4 - 5	4.9	0.45	19.6	3.8	0.35	15.3
5 - 6	5.5	0.57	22.1	4.6	0.31	18.4
6 - 7	5.4	0.50	21.5	5.0	0.23	20.0
7 - 8	5.4	0.50	21.7	5.3	0.35	21.2
8 - 9	5.3	0.53	21.2	5.2	0.37	20.9
9 - 10	5.3	0.58	21.2	5.4	0.52	21.5
Totals						
0 - 5			94.7			77.3
5 - 8			65.3			59.6
8 - 10			42.4			42.4
0 - 10			202.4			179.3

Depth	CRP Avg.	CRP SE	CRP Avg.
feet	---------- ppm ----------		lb/A
0 - 1	4.0	1.42	16.1
1 - 2	3.6	0.50	14.5
2 - 3	2.9	0.31	11.6
3 - 4	3.1	0.15	12.3
4 - 5	3.6	0.09	14.5
5 - 6	4.6	0.31	18.4
6 - 7	5.1	0.12	20.3
7 - 8	5.1	0.32	20.5
8 - 9	5.3	0.35	21.3
9 - 10	5.4	0.41	21.5
Totals			
0 - 5			69.1
5 - 8			59.2
8 - 10			42.8
0 - 10			171.1

Table 7. Gravimetric water content of the 0-10' profile and "available" water in the 0-5' profile as influenced by cropping system in October, 1992.

Profile depth	Cropping system				
	Cont. Corn	Corn-Sb	Soybean-C	Alfalfa	CRP
feet	Water Content (%)				
0 - 1	24.5	23.2	23.5	21.6	23.8
1 - 2	22.4	21.9	22.0	21.8	21.4
2 - 3	20.1	20.3	21.8	20.4	16.8
3 - 4	19.4	20.1	20.6	18.9	18.3
4 - 5	20.1	20.2	20.5	19.1	19.6
5 - 6	20.6	20.0	22.5	19.9	19.5
6 - 7	23.2	20.5	20.7	20.7	19.8
7 - 8	22.4	20.3	20.7	20.1	20.0
8 - 9	20.9	19.7	20.2	19.4	20.2
9 - 10	19.8	19.8	21.0	19.7	21.5
"Available" Water 0-5' (inches)	5.58	5.67	6.11	5.06	4.68

Table 8. Tile discharge, flow-weighted NO_3-N concentration, and NO_3-N loss via the tile lines as influenced by cropping system.

Month	Cont. Corn	Corn-Sb	Soybean-C	Alfalfa	CRP
	Tile Flow (acre-in)				
March	1.19	0.95	2.17	0.61	1.58
April	1.43	1.70	2.13	1.40	1.69
May	0.44	0.52	0.50	0.10	0.12
June	1.16	1.03	1.08	0.00	0.00
July	0.40	0.30	0.38	0.00	0.00
August	0.06	0.02	0.01	0.04	0.00
October	0.48	0.34	0.68	0.00	0.00
Total	5.16	4.86	6.95	2.15	3.39
	Flow-weighted NO_3-N Conc. (ppm)				
March	38.3	28.0	25.2	1.4	1.3
April	39.2	25.1	27.8	5.6	1.4
May	37.1	26.5	28.2	3.9	1.1
June	41.0	25.3	30.3	0.0	0.0
July	37.8	25.5	29.7	0.0	0.0
August	40.0	26.8	33.4	2.9	0.0
October	36.4	22.3	28.0	0.0	0.0
Season Avg.	39.8	26.1	27.1	3.8	1.3
	NO_3-N Loss (lb/A)				
March	10.4	6.1	12.0	0.18	0.47
April	12.9	9.7	13.2	1.59	0.53
May	3.8	3.2	3.3	0.08	0.03
June	11.1	6.0	7.3	0.00	0.00
July	3.6	1.7	2.6	0.00	0.00
August	0.5	0.1	0.1	0.02	0.00
October	4.2	2.0	4.2	0.00	0.00
Total	46.5	28.8	42.7	1.87	1.03

WEST CENTRAL EXPERIMENT STATION
WEATHER SUMMARY - 1992

		Precipitation			Temperature			Soil Temperature (10 cm depth)	
Month	Period	1992	100-yr. av.	Dev. from av.	1992	100-yr. av.	Dev. from av.	1992	10 yr. av.
January	1-31	0.56	0.68	-0.12	18.8	8.0	+10.8	28.2	20.7
February	1-28	0.29	0.67	-0.38	24.7	12.8	+11.9	29.6	23.9
March	1-31	1.66	1.13	+0.53	32.5	26.7	+ 5.8	36.5	29.2
April	1-10	0.67	0.57	+0.10	39.2	38.0	+ 1.2	40.8	
	11-20	0.70	0.64	+0.06	37.9	44.4	- 6.5	41.8	
	21-30	0.61	1.05	-0.44	41.9	48.3	- 6.4	44.6	
Total or av.		1.98	2.26	-0.28	39.7	43.6	- 3.9	42.4	41.4
May	1-10	0.01	0.77	-0.76	61.6	52.0	+ 9.6	62.0	
	11-20	0.95	0.95	0.00	61.0	55.8	+ 5.2	62.8	
	21-31	0.49	1.25	-0.76	57.4	60.0	- 2.6	62.9	
Total or av.		1.45	2.97	-1.52	59.9	56.1	+ 3.8	62.6	57.1
June	1-10	1.20	1.29	-0.09	61.8	63.0	- 1.2	66.4	
	11-20	3.35	1.30	+2.05	67.6	66.3	+ 1.3	71.3	
	21-30	0.17	1.37	-1.20	60.6	68.1	- 7.5	69.5	
Total or av.		4.72	3.96	+0.76	63.4	65.8	- 2.4	69.1	69.3
July	1-10	2.05	1.44	+0.61	61.8	70.1	- 8.3	68.4	
	11-20	3.28	1.06	+2.22	63.4	71.4	- 8.0	70.2	
	21-31	0.23	1.01	-0.78	63.8	71.4	- 7.6	73.4	
Total or av.		5.56	3.51	+2.05	63.1	70.9	- 7.8	70.8	76.7
August	1-10	0.16	1.04	-0.88	67.2	70.4	- 3.2	75.6	
	11-20	0.08	0.93	-0.85	61.8	69.0	- 7.2	72.4	
	21-31	1.22	1.04	+0.18	61.6	66.9	- 5.3	67.1	
Total or av.		1.46	3.01	-1.55	63.6	68.7	- 5.1	71.6	73.9
September	1-30	1.62	2.20	-0.58	56.9	59.0	- 2.1	61.9	61.5
October	1-31	0.19	1.74	-1.55	45.0	47.2	- 2.2	49.1	47.8
November	1-30	1.94	0.97	+0.97	27.0	29.7	- 2.7	34.5	33.6
December	1-31	0.62	0.61	-0.01	13.7	15.2	+ 1.5	31.5	23.4
April-Aug. Growing Season		15.17	15.71	-0.54	58.0	61.0	- 3.0	63.4	63.8
January-December Annual		22.05	23.78	-1.73	42.4	42.0	+ 0.4	49.0	46.7

CONTINUOUS CORN SILAGE[1]

MORRIS, 1992

S.D. Evans[2]

ABSTRACT: This long-term study addresses the effects of removal of continuous corn silage and corn grain on soil properties and yield. Results after 27 years show no yield differences due to the removal of silage versus grain. A significant difference in yield exists between the high and low fertilizer rates for the long-term (27 years) and in 1992.

OBJECTIVE

This is the 27th 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 1991 corn stalks were chopped and fall fertilizer was spread on October 17, 1991. The experimental area was moldboard plowed on October 21, 1991. The study was field cultivated on May 4, 1992 for seedbed preparation. The study was then seeded to Pioneer 3751 corn at 27,500 seeds per acre. 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 6. The study was cultivated on June 23 and date of tasseling and silking was recorded. Silage yields were chopped from 3-10 foot rows on September 28 and grain yields were calculated from 2-45 foot rows harvested with a plot combine on October 16, 1992. Yields were also taken, as in past years, on an adjacent unfertilized (check) area where only the grain is removed.

RESULTS AND DISCUSSION

Silage yields are given in Table 1. Silage yields for 1992 and the 27-year average are not significantly different for silage versus grain plots, but do show sifnificant differences between high and low fertility treatments. Grain yields, including the grain yield from the unfertilized check area adjacent to the treatment plots, are given in Table 2. Grain yields for 1992 and the 27-year average show a significant difference between the high and low fertility treatments.

This study will be continued in 1993.

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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	1992 Yield	1966-1992 Yield
	- - - - dry matter, tons/acre	- - - - - - - - -
Silage, low fertility	6.73	5.59
Silage, high fertility	7.75	6.12
Grain, low fertility	6.83	5.67
Grain, high fertility	8.16	6.04
Signif. Levels (%)		
Treatment	93	>99
Year	--	>99
Treatment x Year	--	>99
LSD, treatment (.05)	.78	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	118.8	90.0
Grain, high fertility	130.5	95.3
Signif. Levels (%)		
Treatment	98	>99
Year	--	>99
Treatment x Year	--	>99
LSD, Treatment (.05)	8.6	2.9
Grain, check (Bu/Ac)	37.8	48.3

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

D. Allan, S. Evans, G. Rehm, J. Johnson, L. Oldham, G. Nelson, A. Scobbie, and D. Schmitz[2/]

ABSTRACT: Early growth, K concentration and uptake, and grain moisture and yield were compared for two tillage treatments (fall chisel and ridge tillage planting systems), two hybrids (Pioneer 3732 and 3737), and three fertilizer treatments (control and 40 lb/A banded or broadcast K_2O). Early growth, K uptake, and grain yields were greater in the fall chisel system and for the Pioneer 3737 hybrid. Banded application of K also improved early growth and yield especially in the ridge tillage system. Potassium uptake was always highest from the banded K_2O application, with little difference between the broadcast and control treatments. Root measurements indicate that Hybrid 3732 has higher root length density than 3737, especially in the ridge-till planting system, despite its lower K uptake rate.

Introduction

Potassium (K) deficiency is a common problem in ridge-till corn production in Minnesota as well as Iowa and South Dakota, and can result in reduced corn yields. The deficiency occurs even on soils with high to very high soil test K values. Severity of the deficiency varies with hybrid. Band application of 40-50 lb K_2O/acre in the previous fall or as a starter fertilizer at planting can correct the problem.

Recent research at the West-Central Experiment Station at Morris has shown that the K deficiency problem is limited to ridge-till and no-till planting systems. The early growth and response to applied K_2O is the same for both tillage systems.

The purpose of this research is to identify the physiological basis for this problem by examining the development and morphology of root systems for a sensitive and tolerant hybrid in a ridge-tillage planting system.

Objectives

The research described in this study is designed to:

1. Determine more precisely the effect of potash placement on root growth and subsequent corn yield in a ridge-till planting system as contrasted to a fall chisel planting system.
2. Quantify root growth in both ridge-till and fall chisel planting systems as affected by corn hybrid.

Methods and Materials

This study was initiated in the fall of 1991 at the West-Central Experiment Station at Morris, Minnesota. Three factors (tillage system, hybrid, K_2O treatment) were combined in a complete factorial with 4 replications. A split-plot arrangement was used. Tillage system (fall chisel, ridge-till) was the main plot. The sub-plots were hybrids (Pioneer 3732, Pioneer 3737) and potash fertilizer treatment. The three potash fertilizer treatments were: 1) control, 2) 40 lb. K_2O/acre in a band, 3) 40 lb. K_2O/acre broadcast.

The potash was applied in late October, 1991. When applied in a band, the K_2O was placed at a depth of 3-4 inches below the soil surface directly beneath the existing row. The previous crop was soybeans. The banded and broadcast application of K_2O was made before the chisel plow operation. All treatments received 10-34-0 as a starter at planting and ample N as anhydrous ammonia in the fall of 1991. Corn was planted in early May and a recommended herbicide program was used for weed control.

One major objective of this study is to quantify root growth as affected by tillage system and corn hybrid. To do this, non-essential nutrients (strontium, rubidium, lithium) were hand injected to various depths at a distance of 4 inches perpendicular to the row. These non-essential nutrients were injected shortly after emergence.

[1/] Support for this project was provided by Pioneer Hi-breds International and the Minnesota Agricultural Experiment Station.

[2/] D. Allan, G. Rehm, J. Johnson, L. Oldham, A. Scobbie, and D. Schmitz are Assistant Professor, Professor, Scientist, Graduate Research Assistant and Technical Field Crew in the Soil Science Department of the University of Minnesota, St. Paul, MN 55108. S. Evans, and G. Nelson are Professor and Assistant Scientist at the West Central Experiment Station, Morris, MN.

Plant and soil samples were collected at approximately 30, 40, and 60 days after emergence. The plant samples were dried, weighed, ground and analyzed for potassium, strontium, rubidium, and lithium. The analysis for potassium provides a measure of potassium uptake. Analysis for strontium, rubidium, and lithium provides some measure of root growth and development.

Soil samples were also collected at approximately 30 and 40 days after emergence. Roots were separated from the soil and root length was measured. Root density was calculated from the root length and soil volume measurements. Soil samples for root measurement were collected from the control treatment for both hybrids in both tillage systems.

Grain yields were measured in late October. Moisture samples were collected and grain yields were corrected to 15.5% moisture.

Results and Discussion

Plant growth at all samplings was significantly affected by both tillage system and the application of potash (Table 1 and 2). When averaged over hybrid and potash treatment, plant growth was greater for the fall chisel planting system. Hybrid had a significant effect on growth for the samples collected at 60 days after emergence. For this sampling, there was better growth for Pioneer 3737. The hybrid used had no significant effect on early growth for the samples collected at 30 and 40 days after planting.

Table 1. Combined statistical analysis for plant growth at 30, 40, and 60 DAP, grain moisture content and grain yield at the West Central Experiment Station, Morris site, 1992.

Source of Variation	df	Early Plant Growth			Percent K		K Uptake		Grain Moisture	Grain Yield
		30 DAP	40 DAP	60 DAP	40 DAP	60 DAP	40 DAP	60 DAP		
Tillage	1	**	**	*	NS	NS	+	+	*	*
Hybrid	1	NS	NS	*	**	**	*	**	**	**
Till x Hyb	1	NS	NS	NS	NS	NS	NS	NS	NS	NS
K rate	2	**	**	**	**	NS	**	**	**	**
Till x K	2	*	NS	NS	NS	NS	NS	NS	**	**
Hyb x K	2	*	*	NS	NS	+	NS	NS	NS	NS
Till x Hyb x K	2	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV		24.4	24.8	18.7	23.8	23.4	39.3	33.4	9.1	12.8

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

Table 2. The effect of tillage system, hybrid and potash fertilizer treatment on the weight of young corn plants.

Tillage System	Hybrid	K_2O Treatment	Days After Planting 30	40	60
		lb./acre	gm/8 plants	gm/6 plants	gm/4 plants
Fall Chisel	3732	0	3.9	31.4	137.7
		40 (band)	5.4	49.5	194.6
		40 (bdcst)	2.8	28.3	128.3
Fall Chisel	3737	0	3.9	35.8	163.9
		40 (band)	4.5	45.1	220.9
		40 (bdcst)	4.3	38.7	159.3
Ridge Till	3732	0	1.7	17.9	73.6
		40 (band)	5.2	47.2	202.1
		40 (bdcst)	2.5	21.8	92.5
Ridge Till	3737	0	2.0	20.4	106.5
		40 (band)	4.3	37.4	161.8
		40 (bdcst)	3.0	29.4	117.0

There were no significant interactions between tillage system and hybrid for any sampling date (Table 1). However, there was a highly significant interaction between hybrid and potash treatment when the corn was sampled at both 30 and 40 days after planting. These results are consistent with grower reports that the potassium deficiency condition is more severe with Pioneer 3732 when compared with Pioneer 3737.

For plant samples collected at 40 and 60 days after planting, potassium concentrations are summarized in Table 3. As expected, K concentration decreases with time due to the increase in dry matter production. Treatment can influence the K concentration in plant tissue, with lower K concentrations in tall plants when compared to short plants because of plant dilution.

Table 3. Potassium concentration in whole corn plants as affected by tillage system, hybrid, and potash fertilizer treatment.

Tillage System	Hybrid	K_2O Treatment	Days After Planting 40	60
		lb./acre	- - - % K	- - -
Fall Chisel	3732	0	.401	.371
		40 (band)	.644	.517
		40 (bdcst)	.384	.460
Fall Chisel	3737	0	.507	.598
		40 (band)	.859	.590
		40 (bdcst)	.588	.506
Ridge-Till	3732	0	.312	.334
		40 (band)	.670	.431
		40 (bdcst)	.374	.447
Ridge-Till	3737	0	.417	.536
		40 (band)	.877	.557
		40 (bdcst)	.560	.459

Hybrid had a significant effect on K concentration when the corn was sampled at both 40 and 60 days after planting. The concentration was higher for Pioneer 3737. The higher plant weights and higher plant concentration of K indicate that this hybrid is better equipped to absorb K from the soil system.

Potash application affected K concentration when samples were collected 40 days after planting. Concentrations were higher when the potash was applied in a band for both tillage systems and both hybrids.

The K uptake at both 40 and 60 days after planting was significantly affected by tillage system, hybrid, and potash application (Tables 1 and 4). There were no significant interactions between any of the variables. When averaged over hybrid and potash treatment, K uptake was higher in the fall chisel system. Uptake by Pioneer 3737 was higher than uptake by Pioneer 3732 when averaged over tillage system and potash treatment. Potassium uptake was highest for both hybrids and both tillage systems when the potash fertilizer was applied in the band. Potassium uptake from broadcast applications was nearly equal to uptake from the controls receiving no potash fertilizer.

Because of the abnormally cool growing season, grain moisture at harvest was exceptionally high (Table 5). Moisture content was significantly affected by tillage system, hybrid, and potash treatment (Table 1). There was also a highly significant interaction between tillage system and K treatment.

Grain moisture was lower in the fall chisel planting system and Pioneer 3737 had a lower moisture content than Pioneer 3732. The banded application of potash also reduced the moisture content at harvest to a greater extent for ridge tillage than for the fall chisel treatment. The moisture content of the grain at harvest is a consequence of differences in early growth. Taller plants, early in the growing season, were more mature at frost. If more mature, the moisture content of the grain was reduced.

Grain yields were substantially below potential because of the extremely cool growing season. Yields were higher for the chisel plow planting system. Pioneer 3737 produced statistically higher yields than Pioneer 3732. These differences can be traced to differences in early growth (Table 2). Effect of potash treatment on yield varied with tillage system. Potash use increased yields of Pioneer 3732 in both tillage systems. However, larger increases were measured in the ridge-till planting system. Potash use increased the yield of Pioneer 3737 only in the ridge-till planting system. These conclusions are consistent with observations of growers who use the ridge-till planting system.

Table 4. Potassium uptake by corn plants as affected by tillage system, hybrid, and potash fertilizer treatment.

Tillage System	Hybrid	K_2O Treatment	Days After Planting 40	60
		lb./acre	- - - mg/plant	- - -
Fall Chisel	3732	0	22.1	128.4
		40 (band)	54.8	262.9
		40 (bdcst)	18.9	152.1
Fall Chisel	3737	0	30.3	253.0
		40 (band)	63.7	335.2
		40 (bdcst)	38.9	212.7
Ridge-Till	3732	0	9.1	64.4
		40 (band)	53.9	219.0
		40 (bdcst)	15.0	102.0
Ridge-Till	3737	0	15.6	147.9
		40 (band)	54.8	228.6
		40 (bdcst)	29.0	133.7

Table 5. Moisture content of grain at harvest and grain yield as affected by tillage system, hybrid, and potash fertilizer treatment.

Tillage System	Hybrid	K_2O Treatment	Grain Moisture	Yield
		lb./acre	%	bu./acre
Fall Chisel	3732	0	41.7	79.3
		40 (band)	35.4	102.0
		40 (bdcst)	37.1	97.5
Fall Chisel	3737	0	33.1	100.6
		40 (band)	29.5	111.2
		40 (bdcst)	33.6	101.2
Ridge-Till	3732	0	47.1	53.6
		40 (band)	37.3	93.3
		40 (bdcst)	47.0	57.8
Ridge-Till	3737	0	45.2	58.4
		40 (band)	29.3	101.6
		40 (bdcst)	43.8	68.7

These results demonstrate the positive effect of the banded application of potash. They support the recommendation that potash fertilizer should be banded instead of broadcast in a ridge-till planting system.

Analysis of plant samples for strontium, rubidium, and lithium is not yet completed. Root length density for the second sampling time is presented in Table 6. When averaged over all positions and depths, there was no difference between the ridge-till and fall chisel planting systems (.38 cm/cm^3). Hybrid 3732 had a higher mean root density (0.48 cm/cm^3) than 3737 (0.28 cm/cm^3), with the biggest differences between hybrids in the ridge-till planting system (3732 - 0.55 cm/cm^3, 3737 - 0.20 cm/cm^3). Hybrid differences were much less in the chisel system (3732-0.41 cm/cm^3, 3732 - 0.35 cm/cm^3). It appears that the roots of Hybrid 3732 are considerably less efficient at K uptake than 3737, since these plants have higher root densities and lower uptake rates. Physiological studies of K uptake rates by roots of both hybrids will be conducted to confirm this observation.

Table 6. Root length density at 40 days after emergence.

Position	Depth	Tillage		Hybrid		Ridge		Chisel	
		Ridge-Till	Fall Chisel	3732	3737	3732	3737	3732	3737
		cm/cm³							
in row	0-6"	0.52	0.81	0.65	0.68	0.68	0.37	0.62	0.99
	6-12"	0.29	0.36	0.48	0.17	0.54	0.04	0.42	0.31
	12-24"	0.28	0.29	0.32	0.25	0.46	0.09	0.17	0.41
3" from row	0-6"	0.60	0.40	0.72	0.28	0.95	0.24	0.49	0.31
	6-12"	0.29	0.45	0.58	0.17	0.53	0.06	0.62	0.28
	12-24"	0.36	0.23	0.44	0.19	0.55	0.17	0.27	0.21
6" from row	0-6"	1.00	0.42	0.97	0.45	0.14	0.60	0.55	0.22
	6-12"	0.29	0.67	0.51	0.45	0.30	0.28	0.73	0.62
	12-24"	0.24	0.22	0.14	0.33	0.07	0.42	0.21	0.24
12" from row	0-6"	0.06	0.43	0.33	0.16	0.04	0.07	0.62	0.24
	6-12"	0.36	0.20	0.42	0.13	0.66	0.05	0.18	0.21
	12-24"	0.25	0.10	0.25	0.10	0.46	0.02	0.03	0.18

INTERACTIONS OF HARD RED SPRING WHEAT (TRITICUM AESTIVUM L.) CULTIVARS WITH TILLAGE SYSTEMS, NITROGEN RATES, AND CHLORIDE APPLICATION.

Dennis D. Warnes, Robert H. Busch, Samuel D. Evans, George A. Nelson, and Roy D. Wilcoxson[1/]

Increased concern for soil conservation and further compliance with government programs, that have targeted reductions in soil erosion, will dictate further adoption of conservation tillage systems. In addition to reduction in soil erosion, conservation tillage systems can increase soil water retention which is a benefit in short drouth periods. However, the extra water retained in excessive soil water conditions can contribute to denitrification losses (Blevins 1983). As tillage practices are changed to leave more residue on the soil surface, other management practices must be re-evaluated to determine if different management strategies are required with conservation tillage. Generally, plant growth and grain yield responses to various seedbed preparation methods are the result of such factors as changes in soil moisture, soil temperature, and diseases and insects associated with increased crop residue left on the surface.

No-till seedbeds tend to have lower spring soil temperatures and higher soil moisture and may have more problems with insect and diseases that overwinter on residue on or near the soil surface (Wall & Stobbe, 1984; VanDoren, 1978; MacLean & Donovan, 1973). Crop residue associated with no-till seedbeds also has been shown to have an allelopathic effect on the newly seeded crop of certain species (Elliot, 1978). Cox et al. (1986) evaluated the effect of three tillages on the winter survival of two hard red winter wheat cultivars and found that percentage winter survival was greatest for no-till wheat planted into tall stubble for snow catch. Type of tillage was more important than cultivar selection in determining percentage winter survival. Wilhelm et al. (1982) reported that nitrogen fertilization did not significantly change rooting pattern of hard red winter wheat, however, root weight was greatest for the no-tillage and least for the subtillage. Ditsch et al. (1991), using two red winter wheat cultivars and two tillage systems, found that the incidence of powdery mildew was higher under no-till but septoria glume blotch was not affected by tillage.

Literature on the effects of various tillage systems on spring wheat cultivars is very limited. Ciha (1982) compared four spring wheat cultivars and three tillage systems. He found cultivar x tillage interactions for yield and test weight which indicates a need to evaluate individual spring wheat cultivars for specific tillage conditions. Hall and Cholick (1989) compared 18 spring wheat cultivars and two tillage systems and reported a significant cultivar x tillage interaction for grain yield. Cultivars ranged from a 9.8% increase to 11.6 decrease in grain yield depending on tillage.

Fixen et al. (1986) studied the influence of soil and applied chloride on hard red spring wheat. They found that chloride did not influence root rot but did suppress leaf rust and a complex of leafspot diseases at one location. However, the beneficial effect of chloride was more general than disease reduction and contributed to grain yield. Goos (1987) summarized the roles of chloride in plant nutrition and concluded that apart from its direct role as an essential nutrient, chloride fertilization also can restrict nitrate uptake by plants, lower leaf water potential, and inhibit nitrification by soil microorganisms. South Dakota chloride recommendations (Fixen, 1987) are calculated from the equation: Fertilizer chloride in kg/ha = 67.2 - soil chloride in a 0-.61 meter soil profile. Windels et a.l (1992) found that application of chloride tended to increase forage yield, decrease grain protein, and significantly increased test weight. However, soil supplemented with chloride was not effective in decreasing common root rot or in increasing hard red spring wheat grain yield in Northwest Minnesota. Breeding and selection programs for spring wheat are generally conducted on conventional seedbeds. Therefore, factors associated with non-conventional tillage are not considered until released cultivars are used with various tillage systems in farmers' fields.

The objective of this study was to determine: 1) the reaction of eight spring wheat cultivars reacted uniformly to nitrogen application in three tillage systems and, 2) the response of two cultivars to chloride application.

Materials and Methods

Field plot studies were conducted for four years (1987-1990) at the West Central Experiment Station at Morris, Minnesota. However, data from the severe drought year, 1988, were not included in the combined analysis. A split-split plot with four replications was employed with main plots as tillages, subplots as

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nitrogen rates, and sub-sub plots as cultivars. A companion study was used to evaluate the effect of chloride on yield and leaf diseases using the same experimental design. Each year the experiment was planted in a different location after a bulk planting of wheat the previous year, but each year was on a Barnes loam soil. Soil samples were taken to evaluate for nitrogen, phosphorous, potassium, and chloride. Phosphorous and potassium were applied each fall prior to fall tillages according to soil test recommendations.

Fall plow, fall chisel and no-till were the three primary tillages. Fall tillages were performed in the October. Each spring the fall plow and fall chisel treatments were field cultivated to prepare a seedbed. No tillage was performed on the no-till plots but glyphosate, (N-(phosphono-methyl) glycine, was applied prior to seeding wheat to kill emerged weeds. Immediately after seeding, ammonium nitrate (34-0-0) was applied broadcast over the soil surface at nitrogen rates of soil (0-0.61 m depth) plus applied nitrogen equal to 67.2, 134.4 and 201.6 kg/ha. Individual cultivar plots consisted of eight rows (1.42 m.) 17.8 cm apart and 9.12 m. long. The plots were seeded using an ALMACO plot drill with a fluted coulter in front of each planter unit in all seedbeds. The cultivars were seeded at 101 kg/ha on April 17, 1987, May 11, 1989, and April 25, 1990.

The origin and traits of hard red spring wheat cultivars used are as follows:

Cultivar	Release Origin	Release Year	Plant Height	Maturity
+ Marshall	Minnesota	1982	Semidwarf	Late
Wheaton	Minnesota	1983	Semidwarf	Medium
Len	North Dakota	1979	Semidwarf	Medium
+Guard	South Dakota	1983	Semidwarf	Early
2369	Pioneer	1983	Semidwarf	Medium
Nordic	AgriPro	1986	Semidwarf	Late
Butte 86	North Dakota	1986	Tall	Early
Stoa	North Dakota	1985	Tall	Medium

+ Cultivars used in chloride companion study

Just after wheat tillering, diclofop + COC was applied at 0.84 kg/ha to control grass weeds and three days later (bromoxynil (3,5- Dibromo-4-hydroxybenzonitrile) + MCPA [(4-chloro-2-methylphenoxy)acetic acid] was applied at 0.28 kg/ha to control broadleaf weeds. Grain yield was measured by harvesting 1.6 or 3.2 m^2 of each plot. Date of emergence was determined in 1987 and 1990 and converted to days after planting. Leaf spotting diseases in 1990 were tan spot and septoria and were visually rated from 1-5 with 1=1-5%, 2=6-10%, 3=11-30%, 4=31-70%, and 5=71-100% infection. Scab infection in 1990 was rated on the same rating scale. Analysis of variance was first calculated using individual years and then combined over years.

In the companion study, chloride treatments were applied as potassium chloride with the seed at the rate of 67.2 kg/ha minus the soil test in a 0 to 0.61 meter profile for chloride. Guard and Marshall were the only cultivars used in the chloride study. All other variables were the same as in the primary study.

Results and Discussion

The combined analysis of variance for 1987, 1989, and 1990, nitrogen rates, tillage systems, and cultivars are presented for yield, test weight, grain protein, and date of emergence in 1987 in Table 1. Growing conditions were favorable in 1987 even with minimal precipitation because of adequate moisture carryover from a very wet year in 1986. Severe dought was encountered in 1988 and the data are not included in the combined analysis. Favorable growing conditions occurred during 1989 and 1990 with adequate precipitation during the growing season.

Significant differences in emergence date after planting was observed for cultivars, tillages and the cultivar x tillage interaction. The range of cultivar emergence was from 12.1 to 14.1 days after planting in 1987 from 8.6 to 9.9 days after planting in 1990. Tillage had a similar range in days to emergence in 1987 with conventional at 12.4 and both Chisel and No-Till emerged 13.2 days after planting, but there was no difference in 1990 due to tillage (Table 2). The average soil temperature for 10 days after planting at 5 cm depth was 1.5 °C degree cooler in 1987 than 1990 (nearby weather station) and could explain the greater delay in emergence for reduced tillage treatments in 1987. This delay in emergence in 1987 resulted in a 1 to 2 day delay in heading date for the reduced tillage treatments, similar to Hall and Cholick (1989). Reduced tillage treatments have lower spring soil temperatures and higher soil moisture due to the increased residue (Wall and Stobbe,1984; Van Doren et al. 1978, and MacLean and Donovan,1973). Another possible cause of emergence delay could be due allelopathic effects from the previous crop residue (Elliot,1978), but cooler soil temperatures were probably most responsible for emergence delays in 1987 in this study.

Nitrogen rate and cultivar both differed significantly for grain yield and test weight. The nitrogen x cultivar and tillage x cultivar interactions for yield were significant for grain yield. The cultivar x tillage interaction agrees with Hall and Cholick (1989) who reported a cultivar x tillage interaction from work in South Dakota. A comparison of yield in the different tillages was computed by using the formula Tillage Yield Difference (TYD) = till - no-till (Table 3). Marshall and Guard favored no-till while 2369, Len, and Wheaton favored conventional tillage, very similar to the results of Hall and Cholick (1989).

The cultivar x nitrogen interaction was further investigated using trend analyses to determine the yield response to rate of nitrogen fertilization. Both the linear and quadratic effects of nitrogen rate were significant. Responses were classed as those cultivars that increased yield with each increasing rate of nitrogen, cultivars that increased yield with only the first increment of nitrogen and cultivars which increased yield at the first increment of nitrogen but decreased in yield at the second rate (Chart 1). Wheaton produced the largest increases in yield for each rate of nitrogen, while Stoa and Butte 86 had smaller yield increases for each rate of nitrogen. Guard and Len increased yield only with the first increment of nitrogen. Marshall, 2369, and Nordic produced slight increases of yield with the first nitrogen rate but decreased in yield with the second rate of nitrogen. Cultivars ranged in grain protein from 12.3 to 13.8 %. Increasing the rate of nitrogen increased average protein from 12.3 to 13.5 % (Table 2).

Effects from chloride application were evaluated combined over years. Cultivar and chloride applications differed for grain yield. Grain yield increased with application of chloride on the cultivar Marshall but Guard did not respond. Diseases were severe to rate only in 1990 with Guard move severely affected by leaf spotting diseases (tan spot and septoria) than Marshall. A significant variety x chloride interaction for control of head scab was detected. The application of chloride reduced head scab on Guard but had no benefit on Marshall.

A cultivar x tillage and cultivar x nitrogen interaction indicates cultivar development should include selection and evaluation under various tillage systems and under various nitrogen fertility levels. Tillage systems and nitrogen fertility levels can be viewed as altering the environment for growth and development. They add to the complexity of a genotype x environment interaction which are a major component of nearly all plant breeding programs.. This research was partially funded by grants from the Minnesota Wheat Research and Promotion Council. The assistance of Alfred J. Koehler, Plot Coordinator and Carlos Bright, Senior Research Plot Technician in this research is gratefully acknowledged.

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Table 1. A partial list of the sources of variation from analysis of variance of eight cultivars compared for three years with three nitrogen rates and three tillage systems for measured traits at Morris, MN.

Source	d.f.	Combined 1987,1989,1990 Yield	Test Weight	Protein	1987,1990 Emergence
		P>			
Year (Yr)	2	NS	0.01	-	0.01
Tillage (T)	2	NS	NS	NS	0.01
Nitrogen (N)	2	0.02	0.01	0.01	0.02
Cultivar (C)	7	0.01	0.01	0.01	0.01
Yr x T	4	NS	NS	-	0.01
YR x N	4	NS	0.01	-	NS
YR x C	14	0.01	0.01	-	0.01
T x N	4	NS	NS	NS	0.02
N x C	14	0.05	NS	NS	NS
T x C	14	0.06	0.01	NS	0.01

Table 2. Dates of emergence for eight spring wheat cultivars and three tillage systems at Morris, MN. 1987, 1990.

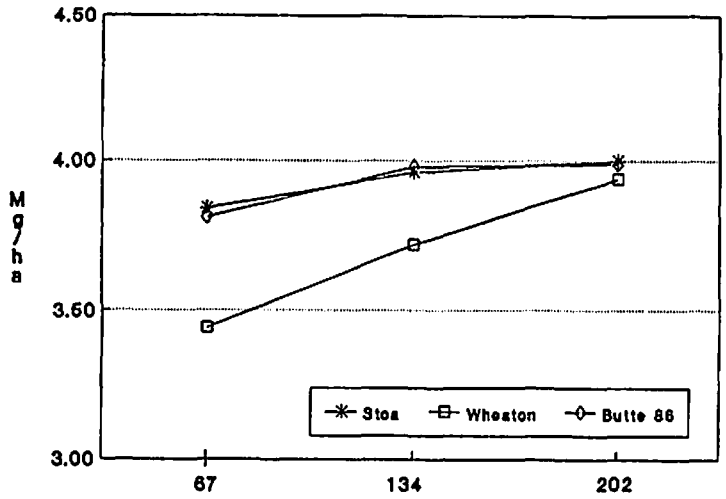
Cultivar	Tillage System: Moldboard 1987	Moldboard 1990	Fall Chisel 1987	Fall Chisel 1990	No-Till 1987	No-Till 1990	Average 1987	Average 1990	Average
	----days after planting----								
Butte 86	11.8	8.8	12.8	9.1	12.4	9.3	12.3 e	9.1 d	10.7 d
Guard	11.5	8.5	12.1	8.7	12.8	8.8	12.1 e	8.6 e	10.4 e
Marshall	12.2	9.6	12.6	9.5	12.5	9.3	12.4 de	9.5 b	11.0 c
Stoa	11.9	9.3	12.9	9.2	13.5	9.6	12.8 c	9.4 bc	11.1 c
Wheaton	12.5	9.0	12.8	9.2	12.8	9.2	12.7 cd	9.2 bcd	10.9 c
Len	13.1	9.1	13.7	9.5	13.4	9.1	13.4 b	9.2 cd	11.3 b
2369	13.6	9.1	14.4	9.5	14.2	9.2	14.1 a	9.3 bcd	11.7 a
Nordic	12.8	9.8	14.2	10.0	13.8	9.8	13.6 b	9.9 a	11.7 a
Average	12.4	9.1	13.2	9.3	13.2 a	9.3	12.9	9.3	

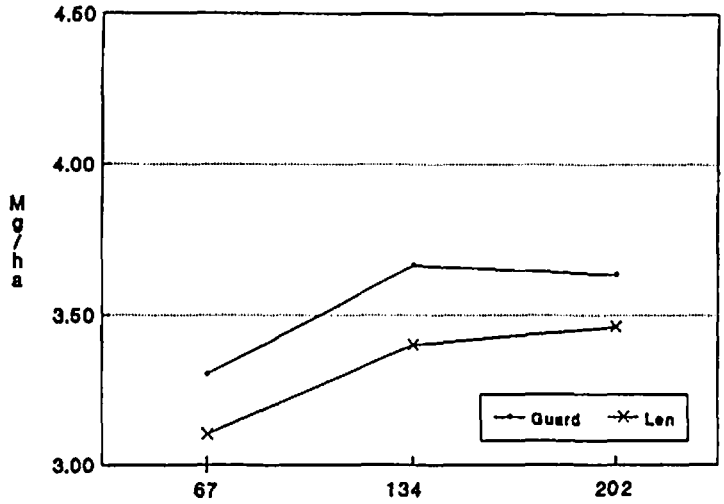
Table 3. Mean grain yields (mg/ha) and TYD (Tillage Yield Differences) for eight spring wheat cultivars using three tillage systems combined across 3 years.at Morris, Mn, 1987, 1989, 1990

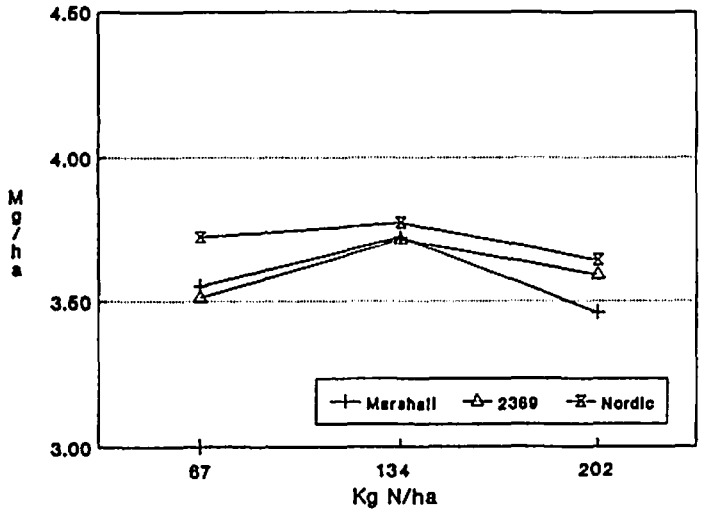
		Tillage		TYD (Tillage Yield Difference)		
Cultivar	No-Till	Fall Chisel	Moldboard	Fall Chisel - No-Till	Moldboard - No-Till	Tillage(SD)# - No-Till
Len	3.20	3.31	3.46	+0.11	+0.26	+0.05
2369	3.53	3.52	3.27	-0.01	+0.24	+0.16
Butte 86	3.87	3.94	3.98	+0.07	+0.11	
Wheaton	3.65	3.57	3.89	-0.08	+0.24	+0.03
Stoa	3.91	3.76	4.12	-0.15	+0.21	
Marshall	3.67	3.49	3.60	-0.18	-0.07	-0.10
Guard	3.61	3.40	3.60	-0.21	-0.01	-0.30
Nordic	3.75	3.80	3.59	+0.05	-0.16	

Chisel TYD = Chisel - No-Till
Moldboard TYD= Moldboard - No-Till
#Tillage (SD) TYD = Tillage - No-Till (Hall and Cholick, 1989)

Chart 1. Cultivar x Nitrogen Interaction







EFFECT OF RATE OF APPLIED N ON CORN RESPONSE AND SOIL WATER NITRATE CONCENTRATION ON A COARSE TEXTURED SOIL[1]

J.F. Moncrief, S.D. Evans, D. Ginting, G.N. Nelson, and B.J. Johnson[2]

This is the second year of a study designed to look at the effect of nitrogen rate on soil water nitrate concentration on a coarse textured soil under dry land conditions in west central Minnesota. Corn responded to the highest rate of applied N (150 lbs/acre). There was above average rainfall in June and July. At the beginning of the season there was very little difference in soil water nitrate concentration due to rate. As the season progressed, differences due to N rate were apparent.

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 1992 the area had no tillage done due to ridges. Urea fertilizer was broadcast with a airflow applicator at rates of 0, 50, 100, and 150 lbs-N/ac on May 5. Corn was planted on May 5 using Pioneer 3788 at 27500 seeds/ac. 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 to be 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 with a Hiniker 5000 during on 06/12/92 and ridged on 06/29/92. On 10/12/92 two 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. On 10/28/92, 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.

Results and Discussion

Corn responded to the highest rate of applied N (150 lbs/acre). There was above average rainfall in June and July. At the beginning of the season there was very little difference in soil water nitrate concentration due to rate. As the season progressed, differences due to N rate were apparent.

Table 1.Cultural practices at Morris, MN in 1992.

Tillage
No tillage
Cultivated on June 12
Ridged on June 29

Cropping Pattern
Corn - Soybean rotation from 1991

1991-92 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.

[1]Support for this project was provided by the Agricultural Utilization and Research Institute and the Minnesota Agricultural Experiment Station.

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Crop	Planting Date	Planter	Rate	Harvest date Grain	Silage
Corn	May 5, 1992	Row	27,500 seeds/ac	October 12	September 28

Weed control

3.0 qt/A (3.0 lb/A) Lasso + 2.2 qts (2.2 l/A) Bladex 90 DF applied preemergence on May 6. Lorsban 15G (10 lbs/A) with planter.

Table 2. Effect of nitrogen application rate on grain nitrogen percent and uptake of corn at Morris, MN, 1992

Nitrogen rate (lbs/A)	Grain N (%)	Grain N uptake (lbs/A)
0	1.16 a	33.9 a
50	1.16 a	48.3 b
100	1.31 a	69.3 b
150	1.29 a	73.2 b

The p value for nitrogen rate on grain nitrogen percent and uptake are 0.448 and < 0.001 respectively. The means within the same column with the same letters are not significantly different (α= 0.10).

Table 3. Monthly precipitation totals (inch) at site of study.

May	1.36
June	4.88
July	5.50
August	1.48
September	1.48
October	0.12

Table 4. Effect of nitrogen application rate on grain and total dry matter of corn at Morris, MN, 1992

Nitrogen rate (lbs/A)	Grain Yield (bu/A)	Total dry matter (tons/A)
0	61.9 a	3.35 a
50	88.2 b	5.38 b
100	112.1 c	6.05 c
150	120.3 c	6.58 d

The p value for nitrogen rate on grain yield and total dry matter are <0.001 and <0.001 respectively.

Table 5. Effect of N rates on plant density and grain moisture at Morris, Mn, 1992

Nitrogen rate (lbs/A)	Population (plts/A x 10^{-3})	Grain moisture (%)
0	25.8	26.1
50	25.6	24.3
100	25.0	23.6
150	25.4	25.1

The p value for nitrogen rate on population and grain moisture are 0.465 and 0.09 respectively.

Table 6. Distribution of total, nitrate and ammoniacal nitrogen concentration in soil water on different dates of sampling in Morris, MN, 1992.

Date	Total N (ppm)	Nitrate N (ppm)	Ammoniacal N (ppm)
06/18/92	63.98	63.89	0.08
07/07/92	63.04	63.00	0.04
07/15/92	49.37	49.23	0.09
08/27/92	42.43	42.41	0.02
09/03/92	45.26	45.13	0.13
10/04/92	59.95	59.88	0.07
10/16/92	56.75	56.54	0.21

1. Mean value averaged over N rates.

Table 7. Effect of nitrogen application rate on total, nitrate and ammoniacal N in soil water over different sampling dates in Morris, MN, 1992.

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	72.1	58.5	60.5	64.2	72.0	58.4	60.4	64.1	0.05	0.07	0.07	0.13
07/07	55.6	62.3	67.6	70.2	55.6	62.2	67.5	70.2	0.00	0.07	0.04	0.05
07/15	36.6	33.9	53.9	72.5	36.3	33.8	53.8	72.5	0.12	0.08	0.09	0.05
08/27	20.8	35.2	50.7	62.0	20.8	35.2	50.6	62.0	0.01	0.01	0.02	0.04
09/03	26.9	42.2	58.9	59.6	26.8	42.1	58.8	59.5	0.13	0.12	0.13	0.13
10/04	46.2	73.8	83.3	49.5	46.1	73.7	83.2	49.5	0.09	0.08	0.12	0.01
10/16	42.9	111.1	65.5	48.4	42.7	110.9	65.3	48.2	0.20	0.24	0.24	0.19

FIG. 1 SOIL WATER–N CONCENTRATION OVER TIME IN CORN AT MORRIS, MN. 1992

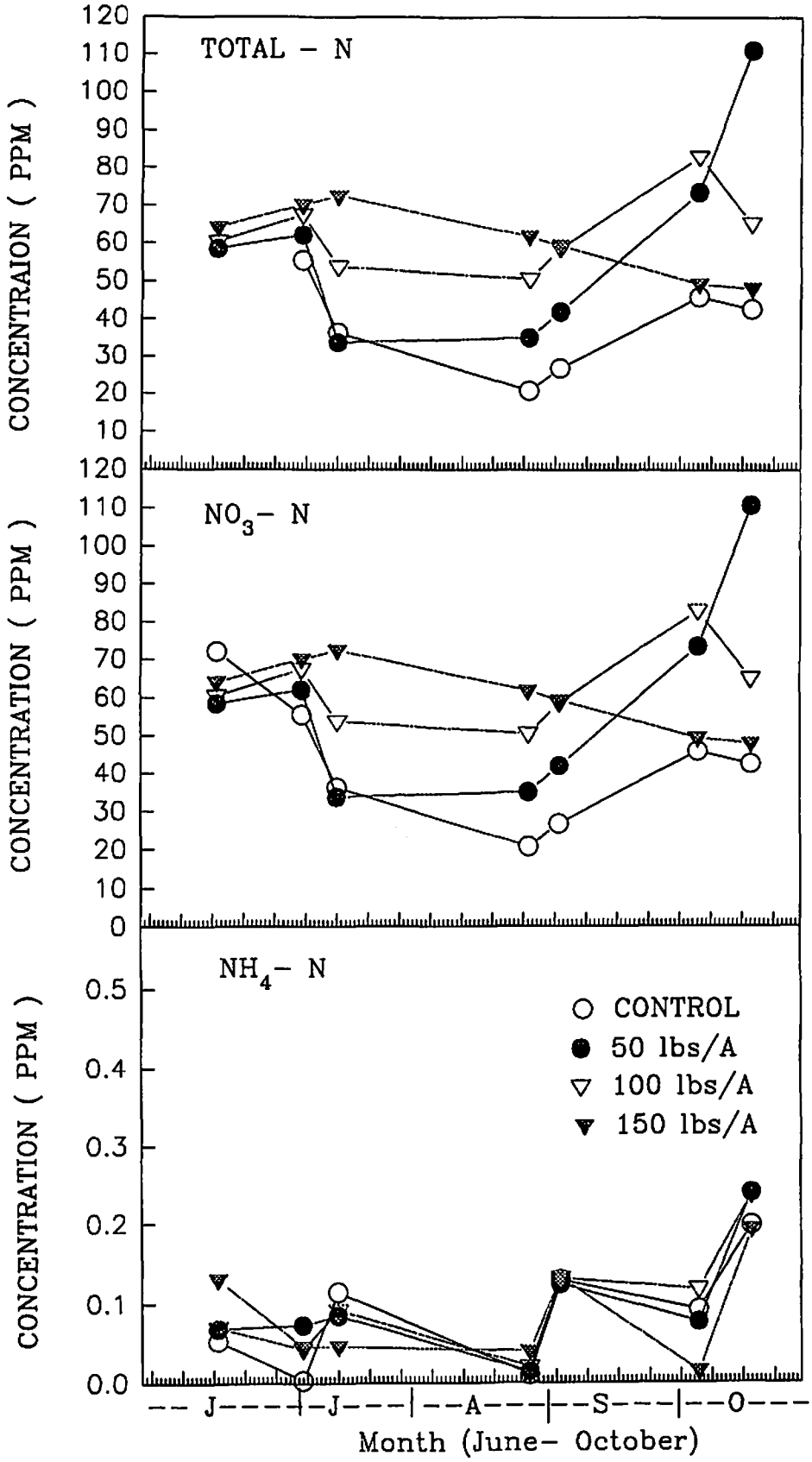
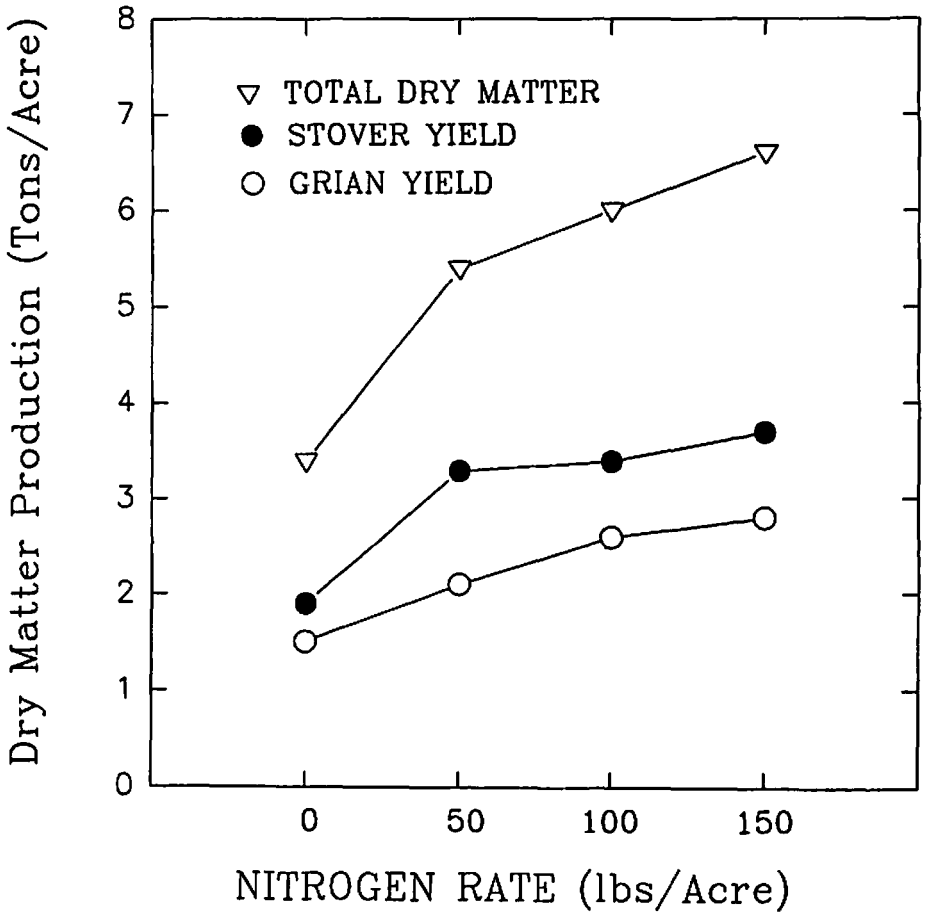


Figure 2.

GRAIN, STOVER AND TOTAL DRY MATTER OF CORN AT DIFFERENT N RATES. MORRIS, MN.



ASSESSMENT OF THE EFFECTS OF TILLAGE AND MANURE APPLICATION ON SEDIMENT AND P LOSS DUE TO RUNOFF[1]

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Abstract

Tillage and beef manure application effects on total-P, bioavailable-P and soluble-P were evaluated. Due to greater runoff volume and sediment produced from moldboard plowing, moldboard plowing resulted in significantly greater total-P, bioavailable-P and soluble-P compared to no-till system. Beef manure application resulted in significantly higher total-P. The application of manure in combination with moldboard plowing resulted in 167 % higher total-P compared to the non-manure application.

Introduction

One of the important questions in manure utilization on a steep land is what type of tillage is necessary such that manure is incorporated into the soil. At the same time, the tillage system will not cause excessive erosion. Sound utilization of manure from farming enterprises is imperative. Since beef and livestock operations are an important part of the economy in the West Central Minnesota and since there are several lakes in the area which are subject to contamination from surface runoff, an experiment was conducted at the West Central Agricultural Experiment Station, Morris, MN to evaluate the influence of tillage (Ridge till and moldboard) and beef manure application on surface water quality.

Materials and Methods

Tillage treatment included ridge tillage and moldboard plowing. Since ridging was not done until July 1992 the results reported here applied to no-till conditions. Moldboard plowing was done in the spring of 1992. Prior to plowing beef manure was spread over the plots assigned for manure treatments at a rate of 25 ton/a (May, 6/1992). The erosion plots were established after plowing (5/6/92) and planting (5/7/92). Corn was replanted two times because of plant damage caused by gophers (June 15). Cultural practices are presented in Table 1.

The plot area had 12 % slope and was previously cropped with alfalfa. The experimental design is a randomized complete block with three replications with tillage as main plot and manure treatment as the subplot. Twelve erosion plots, 76 feet by 10 feet (to accomodate four rows of corn) were marked and isolated from the border areas using corrugated steel plates. At the end of each plot the runoff was trapped with a pvc sheet (10 feet by 1 foot) and then channeled through a pvc pipe of 4 and 3 inch diameter to a series of collectors consisting of three barrels of 55 gal. each. Over the PVC trap, corrugated roofing was placed to avoid direct precipitation getting in to the trap. The collector was designed for runoff volume of 550 gallons (25 years return period of excess runoff after considering the curve number of Barnes loam). The first barrel mainly collected very coarse sediments. The overflow from the first barrel was channelled to the second barrel. At the second barrel, 8 adjacent holes of 1.5 inch diameter were drilled near the rim of the barrel. One of the holes was connected to a PVC pipe of 1.5 inch diameter which channelled the excess runoff to the third barrel. This setup allowed 1/8 of the overflow from the second barrel to be collected in the third barrel.

The collected runoff volume in each barrel was measured using calibrated dip stick. After volume measurement, the runoff suspension was thoroughly stirred and samples were taken for sediment amount and phosphorus (total-P, bioavailable-P and soluble-P) analysis. Sediment was measured by evaporating 200 ml suspension followed by drying at 105 C. For each treatment sediment measurement was done in duplicate.

Total phosphorus was analyzed using perchloric acid digestion as described in EPA procedure. Twenty mL of suspension was pipetted while magnetically stirred to obtain a well mixed sample. Bioavailable phosphorus was measured using extraction of the 20 ml of suspension with 180 ml of NaOH to make a final concentration

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of 0.1 N NaOH, a procedure in the literature that has been correlated with a procedure on algal growth to estimate algal available-P. Extraction was conducted by shaking for 18 hours on a reciprocating shaker. Soluble-P was measured after filtration of suspension through 0.45 micron filter paper, preceded by centrifugation. Phosphorus was then determined by measuring the intensity of blue molybdate as a coloring agent at wave length of 882 nm.

Table 1. Cultural practices at the West Central Agricultural Experimental Station, Morris, MN, 1992.

Tillage

No-till
Ridge till (July 21, 1992)
Spring moldboard (May 6, 1992)

Cropping History

1991-Alfalfa
1992-Corn Pioneer-3751
-Corn Pioneer-3617
-Corn Pioneer-3921

Planting and Harvest Dates

Corn - was planted with a Hiniker 4 row planter with 30 inch row spacing.
Corn was replanted due to plant damage from gophers, using an Almaco Planter

Crop	Planting/Replanting Date	Rate	Harvested
Corn	May 7,1992	32,000 seeds/A	Corn was chopped, and left on field (10/23/92)
	May 29, 1992	40,000 seeds/A	
	June 15, 1992	60,000 seeds/A	

1992 Manure Analysis

Manure source	Rate	Date Applied	NH4	NO3	Mineral	Organic	Total N	Total P	Total K	Solids Total	Solids Volatile	Solids fixed
			%									
Beef Manure	25t/a	May 6/92	.215	.005	.220	.64	.860	.289	.668	29.12	84	16

Rate of applied and available N, P_2O_5 and K_2O

Manure source	Rate	Date Applied	NH4	NO3	Mineral	Organic	available N	Total N	P205	K20
			lb/a							
Beef Manure	25 t/a	May 6/92	107.5	2.5	110.0	320.0	190.0	430.0	331.0	334.0

It is assumed that 25 % of organic N and all of mineral N is available in the year of application.

Soil

Barnes loam (fine-loamy mixed Udic Haploborolls, 12 % slope with southern aspect. Soil is high in organic matter, and pH is 8.0. Initial soil test on Olson-P, Bray-P and K are 17, 23 and 155 ppm respectively.

Weed Control

Lorsban 15G ,10 lbs/A (May 7, 1992)
Ranger 1 lb/A+2,4-D ester 0.5 lb/A+Banvel 0.25 lb/A+Lasso EC 4 lb/a+Bladex DF (90%) 2.2 lb/A (5/8/92)
Ranger 1 lb/A only on no till plot to kill grasses and alfalfa (5/22/92)

Results And Discussions

The results presented in this report are preliminary. There were three rainfall events in June 1992 that produced runoff. Mean values indicated that moldboard plowing resulted in significantly greater total-P, bioavailable-P and soluble-P in the runoff, compared to no-till (Table 2). This was mainly due to greater volume of runoff and sediment amount that resulted from moldboard plowing (Table 3). The concentration of total-P, bioavailable-P and soluble-P was always higher in no-till runoff compared to moldboard plowed plots. Since the runoff volume and sediment were much lower in no-till, total amount were also lower in no-till than moldboard system. The distribution of cumulative total-P, bioavailable-P and soluble-P in runoff water and precipitation overtime is presented in Fig. 1.

Manure application resulted in significantly higher total-P although the bioavailable and soluble-P are relatively similar compared to non-manure application. The application of manure combined with moldboard plowing resulted in 167 % higher total-P compared to non-manure application. This was mostly due to increased sediments produced in the non-manure plot. Sediment production in moldboard, non-manured plot was 141 % higher than the sediment produced from moldboard, manured plots (Table 3). The distribution of cumulative runoff volume and sediments over time during three events of runoff are presented in Fig. 2.

Table 2. Cumulative Total-P, bioavailable-P (bio-P) and soluble-P (sol-P) in runoff at Morris Agricultural experiment Station, MN (During June, 1992).

Tillage	Manure			No manure			Means		
	Total-P	Bio-P	Sol-P	Total-P	bio-P	Sol-P	Total-P	bio-P	Sol-P
	g/ha								
No till	6.6	5.4	2.9	7.0	3.1	2.0	**6.8**	**4.3**	**2.5**
Moldboard	365.4	38.1	15.6	218.6	28.1	14.9	**292.0**	**33.1**	**15.3**
Means	**166.0**	**21.8**	**9.3**	**112.8**	**15.6**	**8.5**			

Table 3. Cumulative Runoff volume and sediment at Morris Agricultural experiment Station, MN (During June, 1992).

Tillage	Manure		No manure		Means	
	runoff vol.	sediment	runoff vol.	sediment	runoff vol.	sediment
	----kL/ha--	--kg/ha---	-----kL/ha--	--kg/ha---	-----kL/ha--	-- kg/ha--
No till	1.0	2.2	2.0	5.7	**1.5**	**4.0**
Moldboard	36.0	354.6	39.4	500.6	**75.4**	**427.6**
Means	**18.5**	**178.4**	**20.7**	**253.2**		

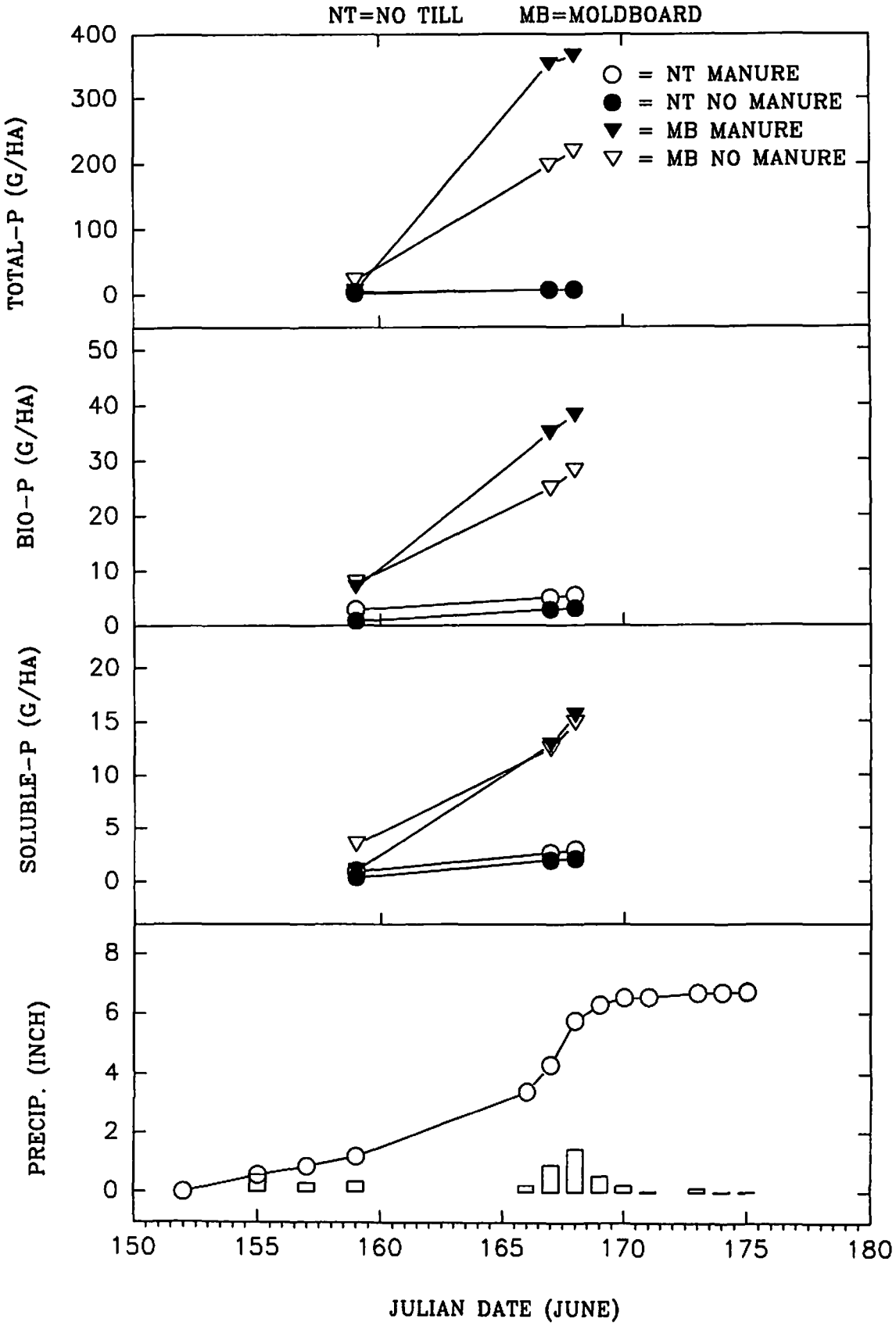

FIG. 1. CUMULATIVE TOTAL, BIOAVAILABLE, SOLUBLE PHOSPHORUS AND PRECIPITATION OVER TIME AT MORRIS EXPERIMENTAL STATION, MORRIS, MN (JUNE, 1992).