Table 4. Influence of nitrogen rates, tillage sytems and methods of 28% N application on grain yield and dry matter production on corn. Goodhue Co. MN - 1984

Treatments			Grain		Dry Matter Production		
N-Rate	Tillage System	Method Applied	Yields	DM	Grain	Stover	Total
#/A			Bu/A	%	----------T/A----------		
Control	No Till	--------	82.8	60.8	1.96	1.85	3.81
Control-Knife	No Till	---------	84.7	61.0	2.00	1.87	3.88
Control	Ridge Till	---------	70.8	65.0	1.67	1.59	3.26
Control-Knife	Ridge Till	---------	73.4	63.9	1.73	1.63	3.37
Control	Chisel	---------	91.3	66.1	2.16	1.61	3.77
Control-Knife	Chisel	---------	93.2	64.0	2.20	1.86	4.07
75	No Till	Broadcast	127.8	63.1	3.02	2.34	5.37
75	No Till	Injected	145.7	63.8	3.44	2.68	6.13
75	No Till	Dribble	140.9	63.2	3.33	2.65	5.98
75	Ridge Till	Broadcast	143.6	64.6	3.39	2.46	5.86
75	Ridge Till	Injected	152.4	63.6	3.60	2.78	6.39
75	Ridge Till	Dribble	145.9	65.1	3.45	2.65	6.11
75	Chisel	Broadcast	144.1	66.0	3.41	2.70	6.11
75	Chisel	Injected	148.9	65.9	3.52	2.80	6.33
75	Chisel	Dribble	140.8	65.8	3.33	2.69	6.02
150	No Till	Broadcast	148.2	63.1	3.50	2.93	6.43
150	No Till	Injected	154.4	62.9	3.65	3.03	6.68
150	No Till	Dribble	159.1	63.4	3.76	2.98	6.74
150	Ridge Till	Broadcast	154.6	64.8	3.65	2.63	6.29
150	Ridge Till	Injected	168.0	64.6	3.97	3.16	7.13
150	Ridge Till	Dribble	165.3	64.4	3.91	2.87	6.78
150	Chisel	Broadcast	164.0	64.8	3.88	2.96	6.84
150	Chisel	Injected	158.8	63.8	3.75	3.02	6.78
150	Chisel	Dribble	167.0	66.4	3.95	3.19	7.14
300	No Till	Broadcast	161.1	62.6	3.81	3.08	6.89
300	No Till	Injected	158.2	62.8	3.74	3.08	6.82
300	No Till	Dribble	151.1	62.9	3.57	3.08	6.66
300	Ridge Till	Broadcast	167.1	64.1	3.95	2.97	6.92
300	Ridge Till	Injected	158.8	64.1	3.75	2.97	6.73
300	Ridge Till	Dribble	169.0	66.7	3.99	2.88	6.88
300	Chisel	Broadcast	161.3	64.7	3.81	3.23	7.05
300	Chisel	Injected	165.7	64.6	3.92	2.98	6.90
300	Chisel	Dribble	165.1	65.9	3.90	2.89	6.80

Table 4. Continued

Treatments Tillage System	Grain Yields	Grain DM	Dry Matter Production Grain	Stover	Total
	Bu/A	%	----------T/A----------		
Factorial Arrangement (Excludes controls)					
Tillage					
No Till	149.7	63.1	3.54	2.87	6.41
Ridge Till	158.3	64.7	3.74	2.82	6.57
Chisel	157.3	65.3	3.72	2.94	6.66
P-Value (%)	99	98	99	56	89
BLSD (.05)	2.7	1.5	0.06		
N-Rate					
75	143.3	64.6	3.39	2.64	6.03
150	159.9	64.2	3.78	2.97	6.76
300	161.9	64.3	3.83	3.02	6.85
P-Value (%)	99	31	99	99	99
BLSD (.05)	6.6		0.16		0.23
Method					
Broadcast	152.4	64.2	3.60	2.81	6.42
Injected	156.8	64.0	3.71	2.94	6.65
Dribble	156.0	64.9	3.69	2.88	6.57
P-Value (%)	84	99	84	95	94
BLSD (.05)		0.6			
Tillage X N-Rate	1	39	1	58	10
Tillage X Method	11	58	11	80	46
N-Rate X Method	85	56	85	96	94
Tillage X N-Rate X Method	71	73	71	32	37

Table 5. continued

Treatments Tillage System	N-Concentration Leaf	Stover	Grain	N Removal Grain	Stover	Total
	----------%----------			----------#/A---------		
Factorial Arrangement (Excludes controls)						
Tillage						
No Till	2.96	0.72	1.39	99.1	42.1	141.2
Ridge Till	2.87	0.68	1.34	101.0	39.1	140.2
Chisel	2.78	0.65	1.39	104.2	38.8	143.1
P-Value (%)	96	62	96	98	39	22
BLSD (.05)			0.04	3.2		
N-Rate						
75	2.69	0.57	1.27	86.5	30.6	117.1
150	2.90	0.71	1.40	106.3	42.3	148.7
300	3.02	0.77	1.45	111.5	47.1	158.7
P-Value (%)	99	99	99	99	99	99
BLSD (.05)			0.04	5.5	4.1	8.3
Method						
Broadcast	2.87	0.69	1.35	98.5	39.6	138.1
Injected	2.95	0.70	1.41	104.8	41.9	146.8
Dribble	2.79	0.66	1.36	101.0	38.5	139.5
P-Value (%)	99	80	99	99	84	99
BLSD (.05)			0.04	3.8		6.3
Tillage X N-Rate	39	71	54	11	47	28
Tillage X Method	98	93	8	1	98	74
N-Rate X Method	99	78	82	87	83	71
Tillage X N-Rate X Method	15	98	40	65	84	60

Table 5. Influence of nitrogen rates, tillage systems and methods of 28% N application, on leaf N content, grain N content and nitrogen removal by corn. Goodhue Co. MN - 1984

Treatments			N-Concentration			N-Removal		
N-Rate	Tillage System	Method Applied	Leaf	Stover	Grain	Grain	Stover	Total
#/A			----------%----------			----------#/A----------		
Control	No Till	---------	1.91	0.52	1.12	43.9	19.3	63.2
Control-Knife	No Till	---------	1.93	0.44	1.11	44.8	16.6	61.4
Control	Ridge Till	---------	1.70	0.41	1.10	37.1	13.0	50.2
Control-Knife	Ridge Till	---------	1.79	0.40	1.06	36.8	13.3	50.2
Control	Chisel	---------	1.85	0.46	1.06	45.9	14.9	60.9
Control-Knife	Chisel	---------	1.90	0.47	1.05	46.3	17.6	64.0
75	No Till	Broadcast	2.67	0.69	1.24	75.5	33.4	109.0
75	No Till	Injected	2.93	0.67	1.29	89.3	36.2	125.5
75	No Till	Dribble	2.60	0.60	1.28	85.6	32.2	117.8
75	Ridge Till	Broadcast	2.53	0.61	1.15	78.0	30.8	108.8
75	Ridge Till	Injected	2.89	0.52	1.32	95.0	29.1	124.1
75	Ridge Till	Dribble	2.66	0.53	1.24	86.1	28.5	114.7
75	Chisel	Broadcast	2.69	0.54	1.26	86.6	30.2	116.9
75	Chisel	Injected	2.85	0.55	1.36	96.2	31.1	127.3
75	Chisel	Dribble	2.40	0.45	1.28	86.0	24.2	110.2
150	No Till	Broadcast	3.02	0.58	1.44	100.8	34.1	134.9
150	No Till	Injected	3.03	0.85	1.46	106.5	51.2	157.8
150	No Till	Dribble	3.01	0.82	1.40	105.1	48.5	153.7
150	Ridge Till	Broadcast	2.96	0.68	1.40	103.0	36.0	139.0
150	Ridge Till	Injected	2.98	0.77	1.37	109.5	48.7	158.3
150	Ridge Till	Dribble	2.84	0.56	1.27	99.7	32.6	132.4
150	Chisel	Broadcast	2.84	0.75	1.40	108.9	45.3	154.2
150	Chisel	Injected	2.83	0.67	1.46	109.8	40.7	150.6
150	Chisel	Dribble	2.61	0.68	1.43	113.6	43.8	157.4
300	No Till	Broadcast	3.10	0.79	1.46	111.8	49.0	160.8
300	No Till	Injected	3.17	0.76	1.51	113.1	47.3	160.4
300	No Till	Dribble	3.15	0.75	1.46	104.4	46.9	151.3
300	Ridge Till	Broadcast	2.98	0.77	1.42	112.2	46.0	158.3
300	Ridge Till	Injected	2.92	0.91	1.46	110.2	54.7	165.0
300	Ridge Till	Dribble	3.05	0.78	1.44	115.3	45.5	160.9
300	Chisel	Broadcast	3.08	0.80	1.43	109.5	51.9	161.4
300	Chisel	Injected	3.01	0.64	1.45	114.0	38.4	152.5
300	Chisel	Dribble	2.77	0.76	1.44	113.1	44.1	157.3

CORNTILLAGE RESIDUE MANAGEMENT, LANCASTER, 1984

J. B. Swan, A. E. Peterson, W. H. Paulson,R. Higgs, D. Linden,
G. Randall, C. Sheaffer

The driftless soils area has the greatest county average estimated soil losses from cropland in Minnesota, ranging from 4.0 to 6.6 t/ac/yr in the six counties involved. Typical soils of the region such a Fayette-Dubuque, Seaton, and associated soils, are highly erodible, form dense crusts if unprotected from raindrop impact, and consequently, have low final infiltration rates and high runoff from the intense storm events common to the region. New and improved tillage practices are increasingly being relied upon to meet environmental goals under more intense cropping systems. These systems modify the soil and water losses as well as the kind and concentration of materials in the runoff. A more complete understanding of these tillage systems will allow a more accurate prediction of their effect on the environment; will permit the maximization of the crop production benefits of the tillage systems; and will permit them to be more effectively incorporated into the overall farming systems of the region.

EXPERIMENTAL PROCEDURES

The experimental site is located on the Lancaster Experimental Farm. Four tillage treatments are replicated four times (table 1), the first replicate is located on Palsgrove silt loam; the other three replicates are located on Rozetta silt loam. Each treatment is split into normal and mulched subtreatments. On the no-till (slot plant) plots an additional subtreatment (bare) is established by removing all residue prior to planting; the residue is then placed on the adjacent mulched plots of the same tillage treatment. On mulched subtreatments of the moldboard, chisel and paraplow treatments, corn residue additions are made after tillage but before planting to obtain approximately 60 to 80 percent surface cover. Plots are approximately 90 to 100 feet in width and 80 feet in length. Row width was 36 inches in 1984. In 1984 corn (Pioneer 3747) was planted (at 29,000 seeds/acre) on May 15. The conventional (moldboard) treatment was plowed about May 1 and secondary tillage with a disk was done on May 14 on the conventional and chisel treatments. The fall chisel and paraplow treatments were carried out in early November of 1983. All plots were planted with a 4-row John Deere 7000 Max-Emerge planter equipped with fluted coulters on one side and "trash whippers" on the other side which effectively removed residue from an 8 to 9 inch area over the row.

Nitrogen (240 lbs/A as anhydrous ammonia) with N serve was injected on October 31, 1983 prior to fall tillage. The starter fertilizer at planting was 180 lbs. of 6-24-24. The insecticide was Counter at 10 lb/A. Chemical weed control used per acre was 2 qts. Dual, 2 qts. Bladex and 1/4 pt. Banvel applied preemerge. One pound Atrazine and 1 quart crop oil per acre were applied post-emergence.

Percent cover was determined from slides made soon after planting. Planting depth, rate of emergence, plant height, silking date, and leaf number measurements were made on designated portions of each plot.

Ten plot frames (45-3/4 x 45-3/4 inches) were emplaced on May 16 and covered to protect the surfaces. Infiltration measurements were made on the paraplow normal, no-till bare and mulch, and conventional normal and mulch treatments on June 4-8. Random roughness measurements were made before and after each run. Residue amounts were measured for the mulch treatments.

Neutron probe measurements were made weekly on each plot starting June 9 through August 9. Bulk density of the surface layer was measured periodically. Hourly spring soil temperatures were measured on chisel, paraplow and no-till treatments in Rep. 3 for both mulch added and bare treatments (chisel normal) at depths of 1, 5, 10, 15, 50, 100 cm. Yields were determined by hand harvesting 60 foot samples (two 30-ft. subsamples) from each plot in mid October, 1984.

RESULTS-CORN YIELDS:

In 1984,corn yields were reduced on all treatments by water stress due to drought during pollination and grain filling stages; only 1.52 inches of precipitation occurred during the 45 day

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

period from July 17 to August 31, 1985, while air temperatures were 2.8°F above normal in August (table 2). Corn yields of individual tillage, residue, and in-row residue management treatments were not significantly different; however, corn yields between replicates were highly significantly different. As in 1983 average corn yields were related to average depth of rooting measured as depth to residual clay layer (table 3 and figure 1). In 1984 rep average corn yields increased 13 bu/ac as depth increased from 29 to 62 inches. In 1983 under more severe drought conditions rep average corn yields differed by 40 bu/acre. In 1981 and 1982 when water stress was minimal there was no relationship between depth to clay and average yield per rep. Thus the effect of rooting depth and available water holding capacity in the root zone on yield depends greatly on the climatic conditions in the individual year as well as on the crop grown. Under the water stress conditions in 1983 and 1984 at Lancaster, yield consistently decreased as rooting depth decreased (fig.1).

SEEDBED CONDITIONS

Significant differences in planting depth were measured (table 1) following emergence. In general, treatments planted with trash whip attachment (TW) had a greater planting depth than those planted with a fluted coulter (C). The trash whip attachment was adjusted for no-till and paraplow conditions and consequently ran excessively deep in the looser soil conditions of the moldboard and chisel plow treatments. Rainfall following planting moved soil into the trench created by the trash whip units in the moldboard plow treatment and resulted in the significantly deeper planting depth measured on the moldboard plow treatment.

In-row residue cover was reduced by the trash whip attachments (TW) compared to the in-row cover resulting from the coulter units (C) (table 1). The trash whip units were more effective in removing residue from the row on the no-till treatments than on the paraplow treatments indicating the importance of adjustment to the effective functioning of the unit. For each level of residue on the no-till and paraplow treatments, rate of emergence was more rapid following use of the trash whip than with the coulter except for the normal residue paraplow treatment where residue averaged only 24 percent (tables 1 and 4). This is to be expected since the trash whip units consistently decreased the level of residue in the row compared to the coulter treatments resulting in higher soil temperatures in the seedbed zone for the trash whip treatments.

The situation was reversed for the chisel and moldboard plow treatments (table 4) because the trash whip units created a shallow trench which decreased soil temperature and slowed the rate of emergence compared to the coulter treatments. This illustrates the necessity of proper adjustment of the trash whip units to the individual soil conditions created by the tillage treatment; such an adjustment between plots was not practical with the plot layout used in this study. As in-row residue levels increased with mulch level, the rate of emergence decreased and number of days to 75% emergence increased. The regression equation

$$\text{Days to 75\% emergence} = 10.3 + 0.0635\ (\text{\% in-row cover})$$

explained 75% of the variation in days to 75% emergence. When the corn yields from individual replicates of the paraplow and no-till treatments were analyzed as a 2 x 5 factorial design, the effect of coulter vs. trash whip is significant at the 5 percent level. Thus the use of trash whip attachments on the no-till and paraplow residue combinations significantly increased yields in 1984 compared to the coulter attachment.

Average population at harvest ranged between 23,400 to 27,200 plants/acre. The 14-tillage and residue treatments differed significantly with respect to population at harvest. With the exception of the paraplow mulch treatment, the tillage treatments with low residue and the tillage and residue treatments with trash whip had the highest populations. This indicates removal of residue from the row permitted the establishment of better seedbed conditions including presumably better seed soil contact. The equation

$$\text{population} = 26{,}622\ \text{PPA} - 33.3\ \text{PPA}\ (\text{\% in-row cover})$$

explained 66% of the variation in population at harvest.

The effect of in-row surface residue cover and tillage on soil temperature and on corn growth was evaluated at Lancaster in 1983 and 1984. Hourly soil temperatures were recorded for 1, 5, 10, 15, 50 and 100-cm depths under the row on the chisel normal and mulch, no-till bare and mulch, and the

paraplow normal and mulch treatments in 1984. Soil temperatures on both trash whip and coulter treatments were measured on paraplow and no-till mulch treatments. Soil temperatures were measured using 4-couples in parallel for 15 cm and shallower depths. Leaf stage observations were taken periodically. Cumulative 5-cm soil and air temperature growing degree days (GDD) from planting to 6-leaf stage (Hanway) were linearily related for each treatment. The number of soil temperature GDD per unit of air temperature GDD was a linear function of in-row surface residue cover. The cumulative air temperature GDD from planting to 6-leaf stage was also a linear function of cover. These results are in agreement with those from similar residue management-tillage studies at Waseca and Rosemount Experiment Stations done by Edward Schneider and the St. Paul, USDA-ARS, staff respectively. The combined results were summarized and presented in the paper "Tillage and Surface Residue Effect on Soil Temperature and Corn Growth" by J. B. Swan, E. C. Schneider, J. F. Moncrief and W. H. Paulson at the 1984 ASA-SSSA Annual Meetings in Las Vegas, Nevada.

Large differences in final (55) minute infiltration rates were measured between treatments (tables 5 and 6). When residue was present on tilled treatments (moldboard plow mulch and normal paraplow treatments) infiltration rates were consistently greater than where residue was absent (moldboard plow normal and no till bare). The final infiltration rates for no-till mulch were very low averaging only 0.5 inches per hour. This was due in part to the sealed soil surface and higher water content due to the mulch cover. The surface of the no-till treatment was disturbed by fall injection of anhydrous ammonia; however, by the planting date of May 15 the soil surface had resealed and final infiltration rates in 1984 were less than those measured on the conventional bare treatment, as was the case in 1982. In 1983, two passes with the anhydrous injector knives in late April, produced 9-10 inch deep slots about 18 inches apart. When protected by mulch these deep injection marks and their fracture planes were highly effective in increasing the infiltration rate. In contrast, in 1981, 1982 and 1984 the dense no-till surface was broken only in the narrow planter slot and the infiltration rate averaged about the same as or less than the bare conventional treatments' infiltration rate. Thus when the no-till surface is sealed, mulch cover is of little benefit in increasing the infiltration rate compared to conventional tillage, however, when the no-till surface has channels through which water can move readily, the heavy mulch cover is very effective in maintaining a high infiltration rate. These results illustrate the dual requirement of 1) a porous surface with high saturated hydraulic conductivity and, 2) a protective mulch cover, which are both necessary in order to have rapid sustained infiltration. Residue cover by itself is not sufficient to produce a high infiltration rate.

SUMMARY

Five and six year results with continuous corn at Lancaster show nearly equal average yields from conventional, chisel, and ridge plant treatment with no-till (slot plant) slightly lower in some years (table 7).

To evaluate tillage-residue management practices, a simple tillage-management model was developed which quantifies the effects of the major physical factors of planting date, final plant population, net growing degree days (GDD), and estimated water stress. GDD are included only when below a threshold value required to mature the crop. The net GDD are calculated as the cumulative air temperature GDD from planting to frost minus any residue management caused delay in growth up to the 6-leaf stage. Lancaster data from 1972 through 1983 was used to develop the model, which has an R^2 of 82 percent and a standard error of approximately 12 bu/acre. For the years of 1981-83 the model accounted for 89 percent of the variation with a standard error of 10 bu/ac. The major effect of tillage on yield was through the effect of tillage on seedbed conditions and water management. Seedbed conditions were affected by seed-soil contact and depth and accuracy of seed placement which affect final plant population as well as in-row residue cover which strongly affects the rate of phenological development of corn up to the 6-leaf stage. The between row surface residue cover and soil conditions strongly affect water infiltration and runoff from the soil surface.

Thus farmers in the driftless soil area can choose between a variety of tillage options which have yields comparable with conventional tillage, but which are superior in soil and water conservation and also offer savings in time, labor, and fuel compared to conventional moldboard plow tillage methods.

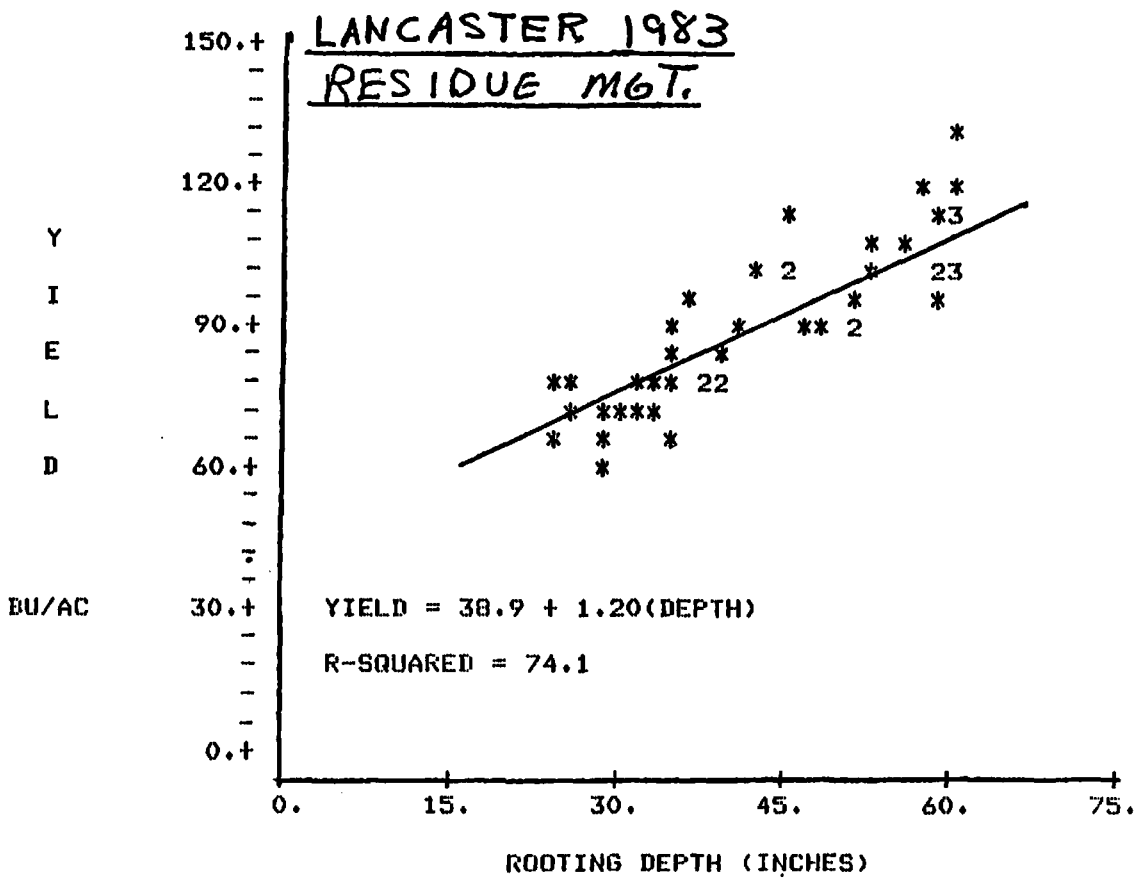

Fig 1. Relationship of 1983 corn yield to rooting depth (Depth to clay residuum).

Table 1. Effect of tillage and mulch treatments on percent cover, planting depth, corn emergence, silking date, population and yield.

Treatments			Percent Cover						
Tillage	Residue	In Row Residue Mgt.	Row	Entire Area	Avg Planting Depth mm	Days Post Plant To 75% Emergence	Date 50% Plants Silked July	Avg Population At Harvest Plants/Ac	Avg Yield Bu/Ac
Paraplow	Normal (N)	C	24		22 de	11	24.5	25,700 abcd	105.5
		TW	12		26 cde	12	24.5	26,700 ab	116.1
	Mulch (1X+N)	C	78		21 e	15.7	25	24,000 de	112.6
		TW	39		32 bc	13.3	25.3	24,600 cde	109.1
No Till	Bare (0)	C	6		26 cde	13	23.8	26,600 ab	116.5
		TW	2		27 cde	10	23.8	26,100 abc	121.7
	Normal (1X)	C	41		24 cde	12	23.8	25,200 bcde	107.7
		TW	11		30 bcd	11.5	23.8	26,500 ab	118.7
	Mulch (2X)	C	72		24 cde	14.8	25.5	24,600 cde	109.0
		TW	23		31 bcd	12.8	25.5	27,000 ab	118.3
Fall Chisel	Normal (N)	C	3		26 cde	9	23.3	27,200 a	114.5
	Mulch (1X+N)	C	67		29 cde	14	25.3	25,000 bcde	107.3
Conventional	Normal (0)	C	1		31 bcd	9	23.5	25,300 abcd	121.2
(Sp. Plow)	Mulch (1X)	C	66		31 bcd	14.5	25	23,400 e	116.4
Significance Level					0.01			0.01	0.10

Table 2. 1984 WEATHER SUMMARY, LANCASTER EXPERIMENT STATION

Month	Precipitation Inches Total	Precipitation Inches Departure	Growing Degree Days °f 1984	Growing Degree Days °f Departure	Temperature Avg May	Temperature Avg Min	Temperature Average	Temperature Departure
					°f			
April	3.98	0.78	--	--	56.6	35.9	46.2	-0.3
May	3.92	0.45	201	-95	64.1	43.0	53.6	-4.0
June	7.77	3.08	547	31	78.6	57.9	68.2	1.2
July	2.57*	-1.64	599	-58	81.3	57.7	69.5	-1.8
August	1.37*	-3.10	649	51	84.3	59.3	71.8	2.8
September	2.36	-1.04	355	-88	72.1	48.1	60.1	-0.8
October	7.31	4.91	--	--	61.9	42.1	52.0	1.4
	29.28	3.44	2351	-159				

First fall low temperatures: Sept 26 (29°F); Oct 23 (27°F)

* 1.52 inches of precipitation between July 17 and Aug 31.

Table 3. Average yields by repilcate and precipitation for 1981 - 1984 and depth to residual clay layer, Lancaster, Wisconsin

Year	Number 1	Number 2	Number 3	Number 4	Monthly Precipitation May	June	July	August
	Bu/Ac				Inches			
1981	146.8	146.7	142.1	147.1	0.85	4.28	2.91	11.35
1982	150.0	143.4	142.8	147.3	5.46	3.45	5.29	4.06
1983	72.8	85.2	96.4	111.2	5.18	3.28	3.34**	3.12*
1984	107.3	110.4	118.0	120.1	3.92	7.77	2.57**	1.37**
Avg depth to clay residuum in inches	29	41	46	62				

*1983 - 1.13 inches precipitation from July 3 to Aug 25 (53 days).

**1984 - 1.52 inches precipitation from July 17 to Aug 31 (45 days).

1981- Subplots with population < 17,000 omitted.
1983- Subplots with population < 18,000 omitted Rep II, III, IV.
1982- Missing values estimated for 8 plots out of a total of 48 plots.

Table 4. Influence of tillage method and in row residue management on rate of emergence.

Treatment			DAYS POST PLANT				
		In Row Residue	-----Percent of final emergence-----				
Tillage	Residue	Mgt	7	10	13	16	22
Paraplow	Normal (N)	C	2	71	83	92	100
		TW	0	58	82	95	100
	Mulch (1X+N)	C	0	11	51	78	100
		TW	0	27	73	98	100
No Till	Bare (0)	C	5	66	76	90	100
		TW	2	77	94	100	100
	Normal (1X)	C	1	61	84	95	100
		TW	0	61	89	98	100
	Mulch (2X)	C	0	22	60	87	100
		TW	0	28	79	94	100
Chisel	Normal (N)	C	21	86	90	97	100
		TW	1	53	82	98	100
	Mulch (1X+N)	C	0	51	72	84	100
		TW	0	32	63	95	100
Conventional Moldboard	Normal (0)	C	28	90	94	99	100
		TW	0	39	82	98	100
	Mulch (1X)	C	0	39	61	89	100
		TW	0	21	50	81	100

Table 5. 1984 Lancaster Infiltration rate measurments.

Tillage	Residue		Application Rate In 1 Hour	Water Applied Before Runoff Inches	Infiltration rate X minutes after runoff commences - In/Hour 2.5	7.5	12.5	17.5	25	35	45	55
No Till	Bare	E	4.72	0.39	4.36	3.16	2.56	2.08	1.96	1.84	1.72	1.72
		W	4.40	0.29	3.68	2.96	2.00	2.00	1.88	1.46	1.34	1.64
	Mulch	E	4.64	0.70	3.92	2.84	1.16	1.04	0.80	0.32	0.56	0.56
		W	5.20	0.69	4.00	1.12	0.88	0.88	0.88	0.76	0.76	0.64
Conventional	Normal	E	4.96	1.65	4.00	3.16	2.08	2.44	2.05	1.60	1.24	1.36
(Moldboard Plow)		W	5.28	2.11	4.20	3.48	2.88	2.64	2.28	1.92	1.92	2.04
	Mulch	E	5.28	10.56*								
		W	4.64	2.86	3.92	3.20	3.08	2.96	2.90	2.78	2.84	2.90
Paraplow	Normal	E	4.72	0.39	4.08	4.08	4.08	4.08	3.96	3.90	3.84	4.32
		W	4.64	0.31	4.04	3.80	3.56	3.20	2.84	3.14	2.72	3.02

*No runoff due to presence of large vertical drainage channel below plow layer.

Table 6. Infiltration rate* 55 minutes after runoff begins.

Treatment		1981	1982	1983	1984	Avg.
Tillage	Residue	Inches/Hour				
No Till	Mulch	1.46	1.10	3.53*	0.60	
	(No Till Mulch) / (Conv. Bare)	(1.51)	(0.72)	(6.53)	(0.35)	
Conventional	Bare	0.97	1.52	0.54	1.70	1.18
	Mulch	2.72	2.34	1.49	2.90	2.36
	(Bare/Mulch)	(0.36)	(0.65)	(0.36)	(0.58)	(0.50)

*Soil disturbed prior to planting by anhydrous ammonia injection in spring prior to planting.

Table 7. Continuous corn tillage yield results at Lancaster, Wisconsin 1979-1983.

Tillage	1979	1980	1981	1982	1983	1984	Average 1979-83	Average 1979-84
	Bu/Ac							
Ridge plant*	162	157	157	147	100	-	145	-
Slot plant	163	146	151	141	85	108	137	132
Chisel	160	150	167	154	95	115	145	140
Conventional	169	159	168	151	89	121	147	143
Paraplow	-	-	-	-	-	106	-	-

*Planted flat in 1979 and 1981 - corn not cultivated to form ridges in 1980 and 1983.

The Effect of Tillage and Potassium Placement on the Availability of Potassium to Corn

P. Burford, J. Moncrief, J. Swan, and B. Schreiber

Cooperator: Dale Flueger

With the trend towards increased use of conservation tillage taking place, present recommendations for fertilizer application need to be looked at critically. Farmers interested in adopting conservation tillage are looking for ways to conserve soil and reduce input costs without experiencing yield reductions. Potassium is a relatively immobile nutrient and remains concentrated near the soil surface if not incorporated. With conservation tillage this could lead to positional availability problems if the roots become inactive in this region.

The objectives of this study are:

1. To determine the effects of tillage on K availability to corn.

2. To determine the effects of row applied K and tillage on K availability and growth of corn over a range of soil K levels resulting from broadcast K treatments.

3. And to characterize the effect of tillage on the distribution of soil K and determine how this relates to soil test interpretation.

METHODS AND MATERIALS

The experimental plots are located on approximately three and one third acres land in Sec. 15 of Haycreek Township of Goodhue County, Minnesota on a deep loess soil over limestone. The soil is a Typic Eutrochrept (Timula silt loam) with initial soil test values of 20.7 ± 5.3 ppm phosphorus (Bray-1), and 83.0 ± 18.1 ppm potassium (ammonium acetate extraction). Initial pH was 6.5 ± 0.5 with about 2.5 percent organic matter. Three T/ac of limestone were applied in 1980. Oats and alfalfa were grown at the site in 1978, followed by two years of alfalfa. Corn as silage was grown in 1981 and corn as grain from 1982 to 1984. A 95 day single cross hybrid (Pioneer 3906) was planted at a rate of 28,000 plants/ac at a row spacing of 38 inches on 20 May 1984.

Terbufos (Counter) was used for control of root worms at a rate of 1.3 lb/ac a.i. Atrazine/Alachlor (Atrazine/Lasso) mixture was applied at the 4-5 leaf stage for general weed control at a rate of 2.5 lb/ac a.i. of both herbicides.

Equipment used consisted of: a chisel plow (Glencoe Soil Saver) with chisels 3.5 inches wide and spaced 13.3 inches apart with twisted shovels, a field cultivator (Bushog), and a planter (Hinicker) equipped with 2 inch fluted coulters.

This study was designed as a randomized complete block with six replications. Tillage treatments used were, spring chisel plowing (7-9 inches deep) followed by a field cultivator (4-5 inches deep) and no-till. Broadcast K applications were made in the spring prior to tillage (0, 200 or 400 lb/ac K_2O). Because of preexisting variability in soil K, regression was used to characterize treatment differences. Potassium was applied in the row at planting (0-0-5) to every other row. Nitrogen and phosphorus were also applied (7-21-.1) to all rows. Potassium present in the N-P row application was due to contamination. The actual application rate of K_2O with these two row applied fertilizers is in table 1. Nitrogen as ammonium nitrate was applied to the entire plot area (15 May 1984) at a rate of 300 lb/ac to eliminate its effects.

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

Table 1. K Applied as Row Fertilizer.

0-0-5 K	7-21-.1 K
---(lb/ac)---	
5.1	.2

Table 2. Fertilizer treatment application schedule.

Fertilizer Type	Date Applied	Method	Rate Applied
Potassium Chloride (KCl)	15 April 1984	Broadcast	0, 200 and 400 lb/ac K_2O
Ammonium polyphosphate+ urea (7-21-0)	20 May 1984	Row	20 gal/ac
Ammonium polyphosphate+ urea (7-21-0)+ Potassium Chloride (0-0-7)	20 May 1984	Row Row	20 gal/ac 10 gal/ac

In 1983 and 1984 ten samples per plot were taken, composited for the 0-6, and 6-12 inch depths. Ten soil samples per plot were also taken and composited for the 0-2, 2-4, and 4-6, inch depths. Soil samples were taken on two dates in 1983 and 1984, 26 April 1983, 16 June 1983, 10 April 1984, and 2 July 1984 before fertilizer application and chisel plowing and after fertilizer application and chisel plowing, respectively for each year. The samples were dried at 97° F, and ground to pass a

Samples for bulk density and soil moisture were taken 7 Sept. 1984 for the 1-4 inch depth increment. Sampling was done between the row, in and out of wheel traffic. Samples were dried at 105°F.

Whole plant samples were taken at approximately the 6-10 leaf stage of development on 22 June 1984. Plants were cut at ground level (10 plants/plot). Grain and stover samples were taken at harvest. All samples were dried at 140°F and ground to pass a 1 mm sieve.

Residue was measured by the line intersect method (Laflen et al., 1981). The K levels in the soil tested were determined using ammonium acetate extraction (Recommended Chemical Soil Test Procedures, 1980).

RESULTS AND DISCUSSION

Table 3 shows the effects of tillage on soil cover both in and between the row. There was approximately three times the level of cover without tillage than with chisel plowing regardless of position relative to the row. Within tillage treatments, the cover in the row was approximately two thirds of that between the

row. The cover with no-till was more variable due to poor distribution by the combine. Although, there was some effect of cover and tillage on date of emergence there was no effect on final stand (see table 4).

Table 3. The effect of tillage on soil cover in and between the row (6/7/84).*

Tillage	In Row	Between Row
	----------%----------	
No-till	42.2 (25.3)	74.0 (13.9)
Chisel	16.5 (12.3)	24.0 (14.6)

* Numbers in parenthesis represent the standard deviations, n=12. In and between the row are defined as the 8 inch area centered over the row and the remainder, respectively.

Table 4. The effect of tillage on corn emergence and final stand.*

Tillage	5/30	Emergence 6/1	6/3	6/4	6/5	Final stand 6/14/84
	----------% of final stand----------					plants/ac x 10^3
No-till	0	29.8 (16.9)	77.4 (15.1)	90.3 (8.3)	96.7 (4.5)	26.5 (1.4)
Chisel	0	50.0 (27.2)	84.7 (16.8)	95.4 (5.8)	98.7 (2.1)	25.7 (1.7)

* Numbers in parenthesis represent the standard deviations, N=12.

Table 5 shows the moisture content of incremented samples taken 2 July 1984 as affected by tillage. There was greater moisture in the 0-2, and 2-4 inch depths with no-till than with chisel plowing at the time of sampling.

Table 6 shows that significant differences between no-till and chisel plow treatments existed for bulk density and soil moisture when no traffic was over the area (no-till having greater moisture and bulk density). No-till and chisel plowing responded differently to traffic. Bulk density and soil moisture both increased in the chisel treatment with traffic, while with no-till no differences were seen in bulk density or soil moisture with or without traffic. There were no significant differences between tillage treatments when traffic was present for bulk density or soil moisture.

Table 5. The effect of tillage on soil moisture content on 7/2/84.*

Depth	Tillage No-till	Chisel
inches	--------% by wt.-------	
0-2	16.2 (2.2)	11.8 (1.7)
2-4	18.4 (1.4)	17.5 (1.3)
4-6	18.9 (1.1)	18.2 (1.3)
0-6	18.2 (1.6)	16.2 (1.7)
6-12	19.2 (1.2)	18.8 (1.6)

*Numbers in parenthesis represent the standard deviations, n=12.

Table 6. The effect of tillage and traffic on the bulk density, and soil moisture in the surface 1-4 inches 7 Sept. 1984.*

Sample Position	Tillage	Bulk Density	Soil Moisture
Between Rows		(g/cm^3)	(% by Vol.)
No-traffic	No-till	1.4 (.07)	30.0 (2.87)
	Chisel	1.2 (.09)	26.4 (1.67)
With-traffic	No-till	1.5 (.08)	29.3 (2.09)
	Chisel	1.4 (.05)	28.3 (3.00)

*Values in parenthesis represent the standard deviations, N=6.

The vertical distribution of soil K to a depth of 6 inches is shown in figure 1 for no-till and chisel treatments. The effect of the 1983 tillage is still present at the first sampling date in 1984 (figure 1a and b for no-till and chisel, repectively), however, soil buffering and fixation brought the soil test K down at all depths in both tillage systems from levels of the previous season. There were no significant differences in soil K between tillage treatments at any depth or rate of broadcast K on 4/10/84. Broadcast K applications caused a steep gradient of K in no-till to the 6 inch depth (figure 1c). There was also a gradient of K with the chisel treatment, but not as dramatic as with no-till (figure 1d). No-till plots had significantly higher concentrations of K in the surface 2 inches compared to the chisel treatment with the 200 and 400 lb/ac rate of broadcast K_2O. Chisel plowing had greater soil K than no-till in the 4-6 inch depth increment with the 200, and 400

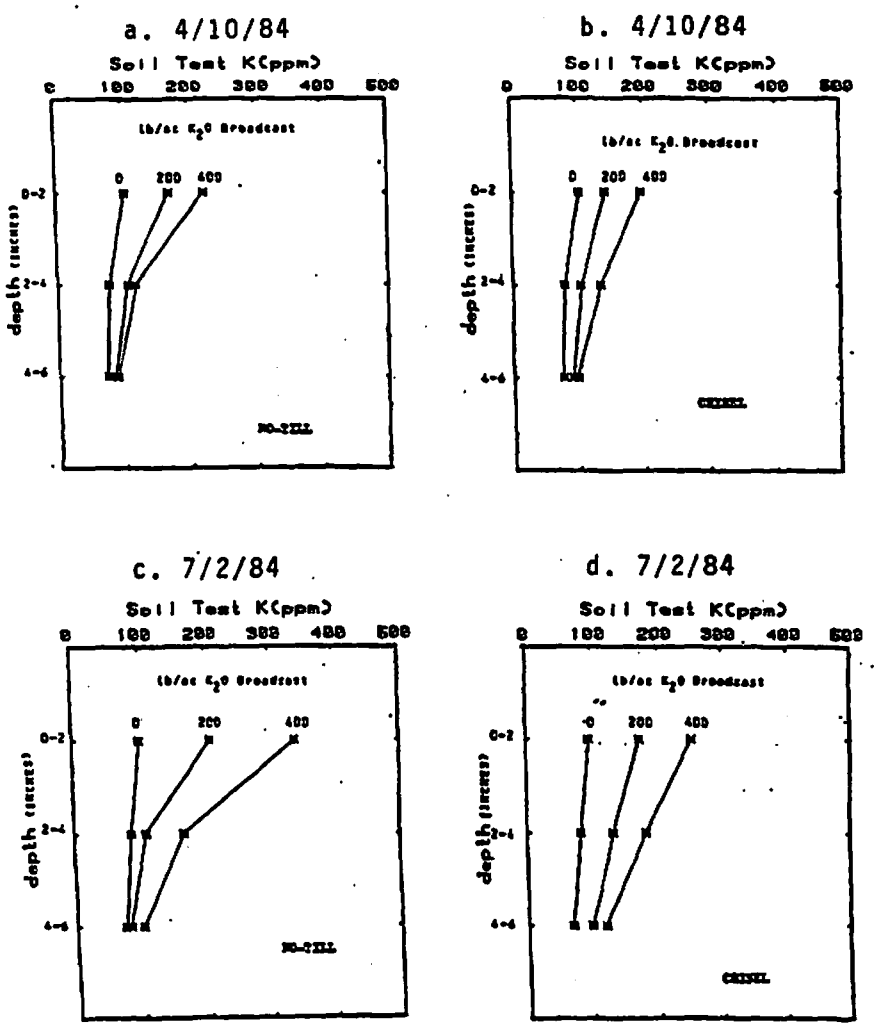

Figure 1. The effect of tillage and annual K application on soil test K distribution before and after tillage in 1984.

lb/ac rate of broadcast K_2O. Six inch cores had the same increase in soil test K with a given application rate of broadcast K with both tillage treatments (see table 7). This differed from 1983 responses to a given K application. No-till had greater increases in soil K with a given K application in 1983. This difference may be, in part, due to differences in weather conditions (see figure 8), and the longer period of time between fertilizer application and soil sampling in 1984 compared to 1983 (83 and 54 days in 1984 and 1983, respectively) which allowed more time for soil fixation of K to occur. No significant differences between tillage treatments were seen at the 6-12 inch depth.

Table 7. The effect of tillage and annual broadcast K applications on soil test K for the 0-6 and 6-12 inch depths for 1983 to 1984 sampling dates.*

Rate of K O Applied Annually	Depth	26 April '83	16 June '83	10 April '84	2 July '84
(lb/ac)	(inches)	----------Soil test K (ppm)----------			
			NO-TILL		
0	0-6	70.5 (12.7)	65.2 (13.8)	81.2 (11.1)	81.8 (13.0)
	6-12	54.0 (19.6)	54.7 (22.5)	70.2 (14.5)	76.8 (13.8)
200	0-6	84.5 (16.4)	124.5 (29.1)	112.7 (21.8)	127.8 (13.6)
	6-12	60.9 (23.1)	62.6 (22.8)	72.8 (26.1)	81.0 (17.3)
400	0-6	101.7 (11.0)	175.5 (30.0)	140.2 (30.9)	173.7 (40.4)
	6-12	55.8 (17.6)	58.2 (6.2)	74.2 (8.1)	82.7 (15.4)
			CHISEL		
0	0-6	68.5 (15.3)	72.0 (18.0)	83.7 (12.4)	79.8 (10.0)
	6-12	55.8 (10.0)	54.8 (12.4)	72.5 (12.1)	80.3 (14.9)
200	0-6	75.8 (18.8)	111.5 (30.9)	102.2 (25.3)	131.7 (18.6)
	6-12	53.5 (16.0)	55.3 (15.2)	78.0 (10.0)	87.0 (18.4)
400	0-6	111.8 (29.8)	152.7 (36.3)	138.0 (28.7)	174.5 (36.3)
	6-12	59.5 (22.2)	59.5 (24.8)	72.7 (22.9)	82.3 (19.7)

*Values in parenthesis represent the standard deviations, n=9.

Early growth of corn is shown in figure 2. Early growth was similar for both tillage treatments within row application treatments, and was independent of soil test K. Row applied K significantly increased early growth in both the no-till and chisel treatments. At the 400 lb/ac rate of broadcast K, the increase due to row applied K was greatest with both tillage treatments.

Early uptake of K is shown in figures 3. Row applied K significantly increased uptake in both tillage treatments. With or without row applied K the uptake of K by early growth with the chisel treatment leveled off after the broadcast rate of 200 lb/ac of K_2O, while with no-till uptake continued to increase.

Figures 4 and 5 show the effects of soil test K (0-6 inch 7/2/84 sample), and row applied K on grain and stover yields, respectively. Regression equations corresponding to the figures are in table 8. Non-significant regressions are accompanied by NS, and represent the least squares fit of the data.

Responses of grain yields were significantly related to soil test K levels with

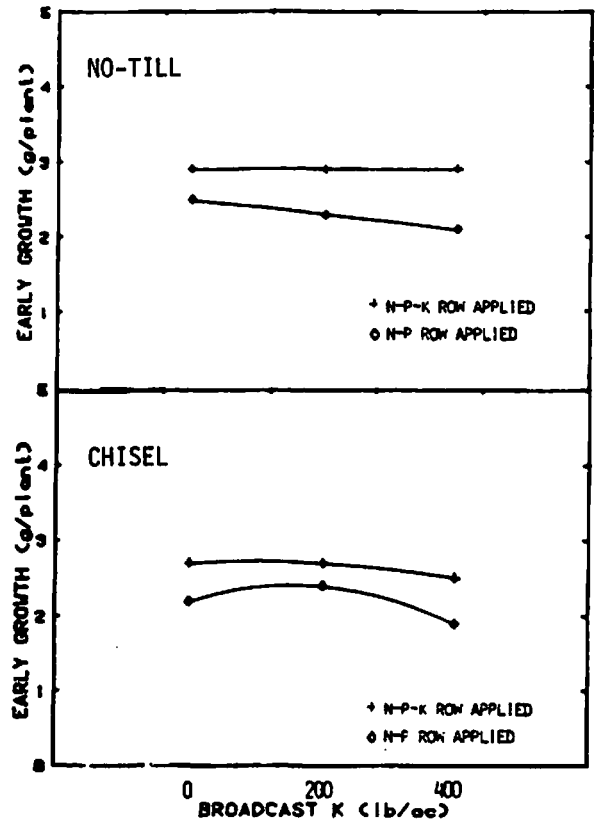

Figure 2. The effects of broadcast K, and row applied K on early growth with no-till and chisel plow treatments.

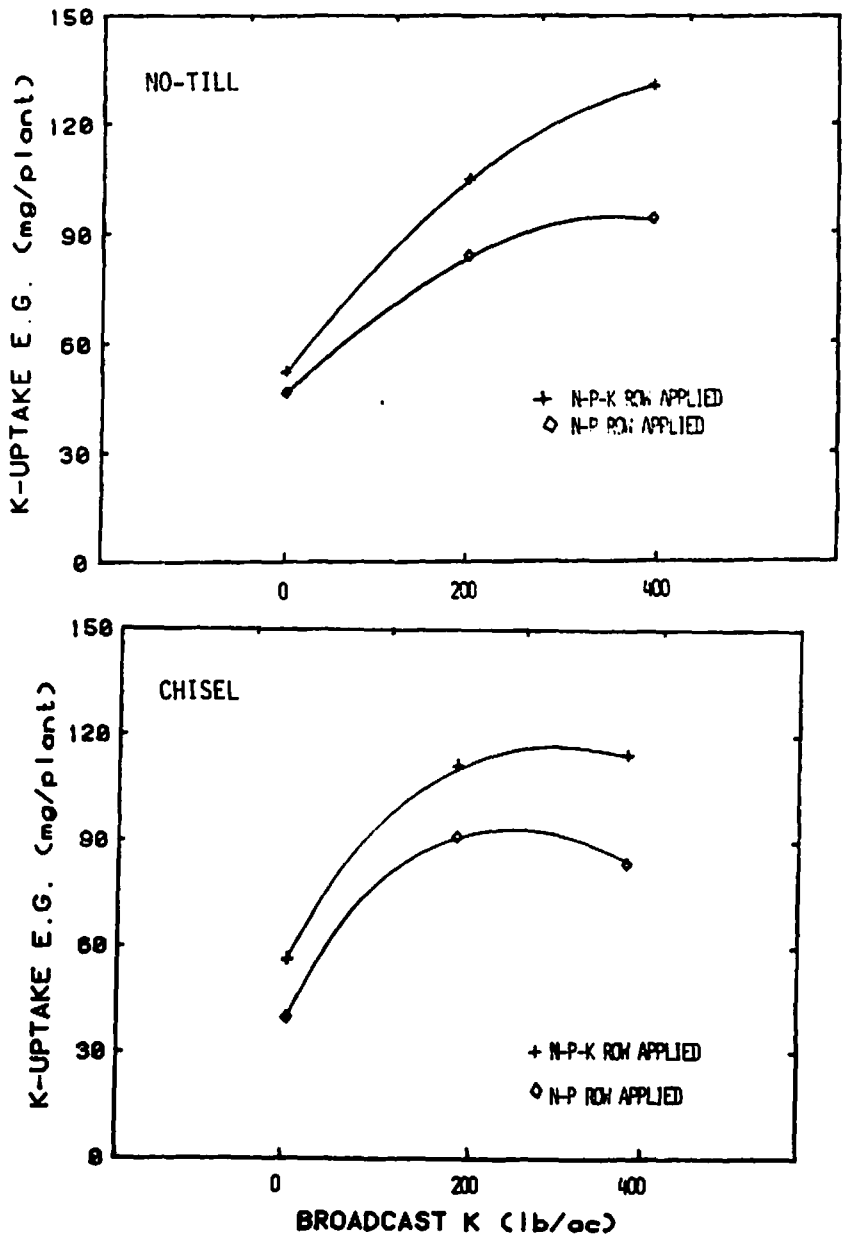

Figure 3. The effects of broadcast K, and row applied K on early K uptake with no-till and chisel treatments.

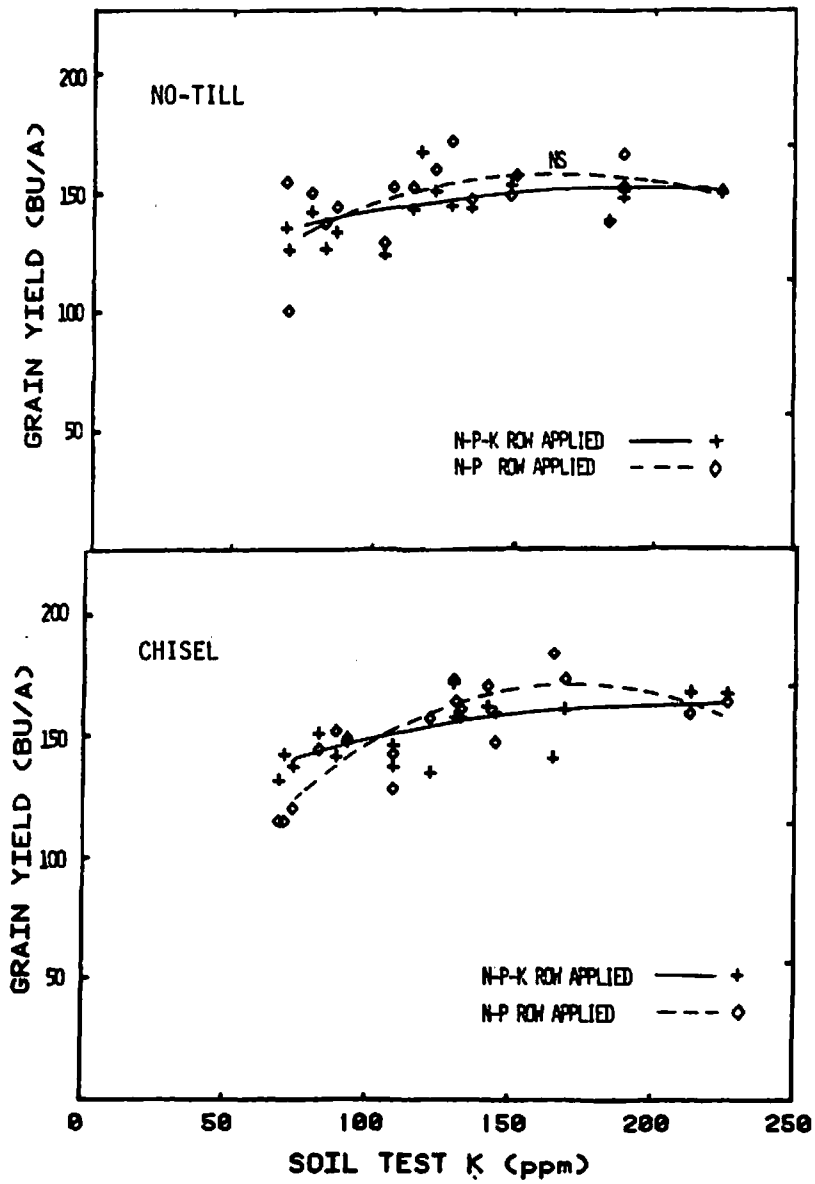

Figure 4. The effects of broadcast K, and row applied K on grain yields with no-till and chisel plow treatments.

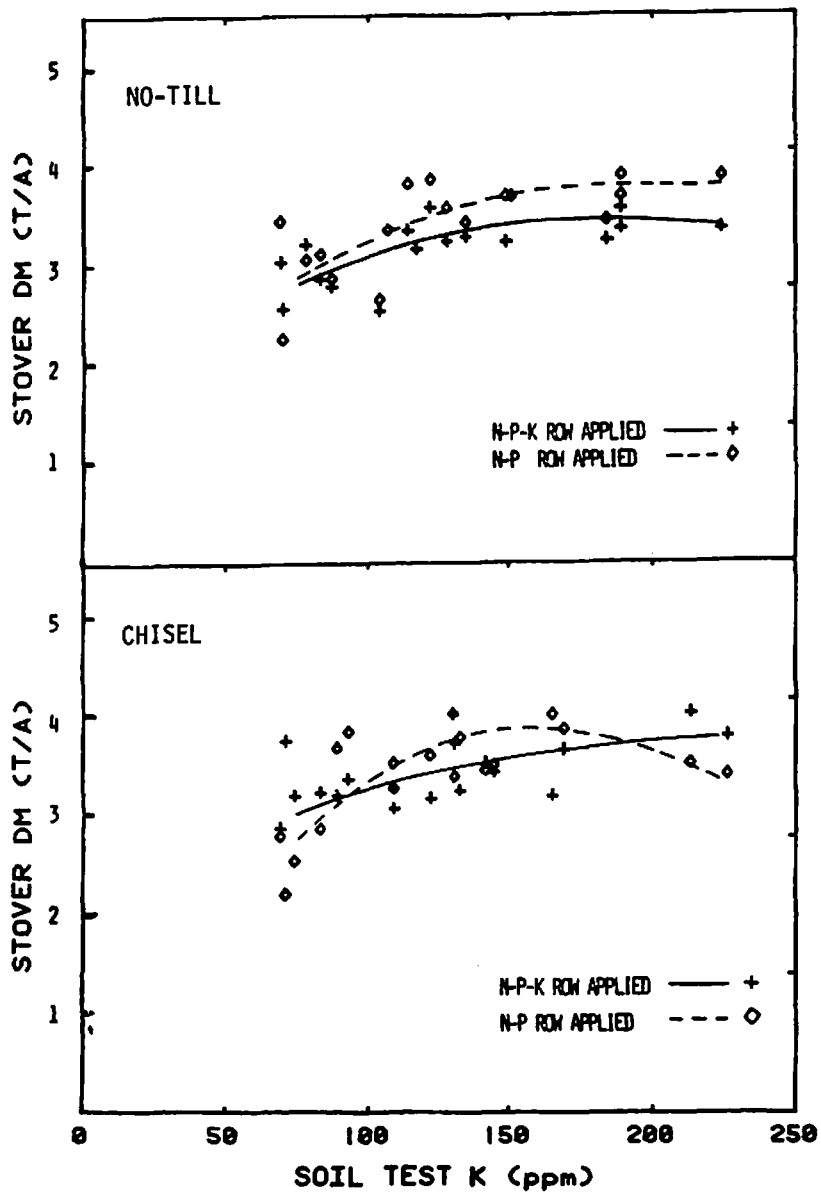

Figure 5. The effects of broadcast K, and row applied K on stover yields with no-till and chisel plow treatments.

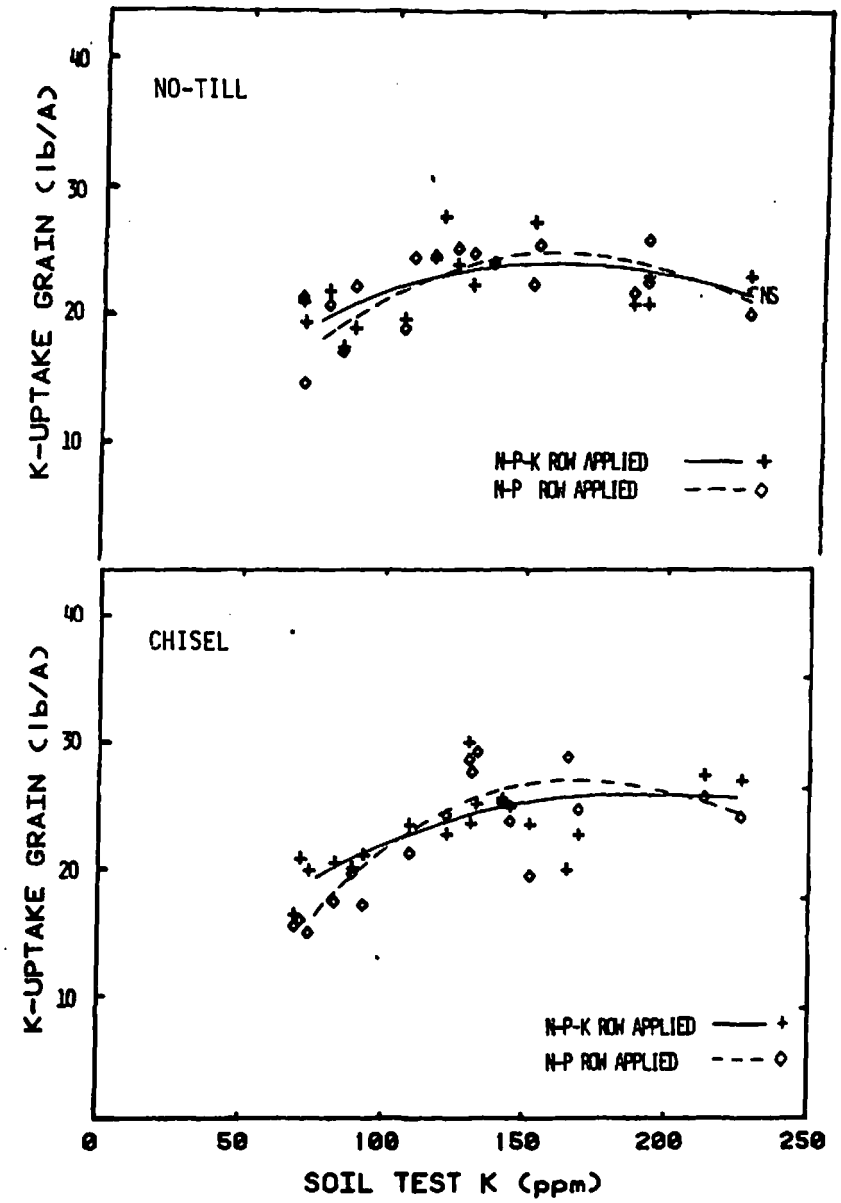

Figure 6. The effects of broadcast K, and row applied K on the K uptake by grain with no-till and chisel plow treatments.

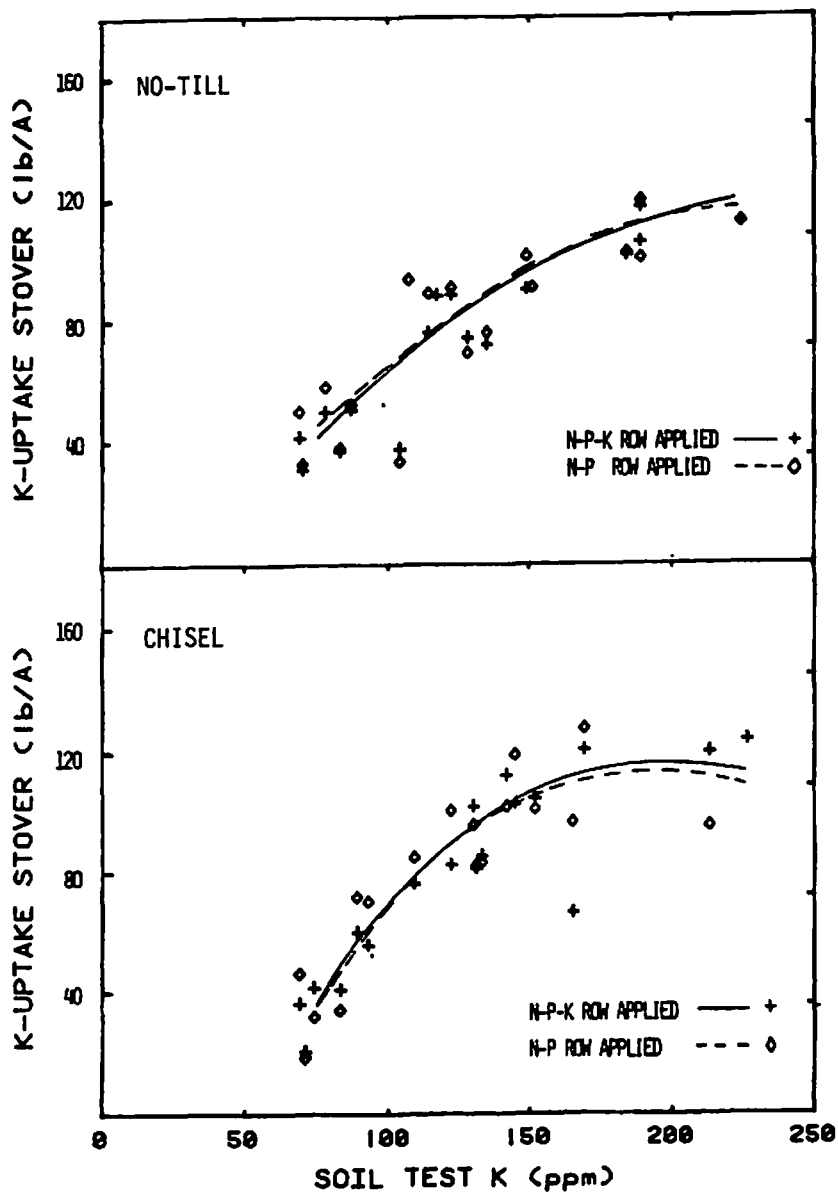

Figure 7. The effects of broadcast K, and row applied K on the K uptake by stover with no-till and chisel plow treatments.

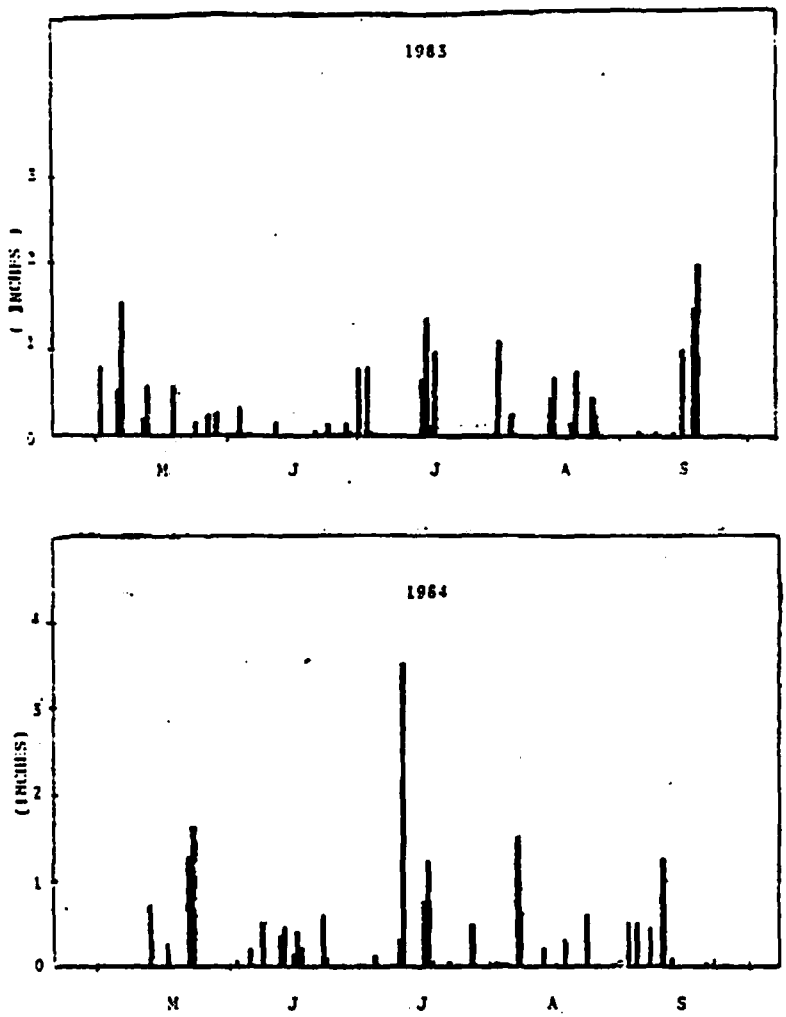

Figure 8. Precipitaion at the study site during the 1983, and 1984 growing seasons.

both tillage treatments when row applied K was used. Chiseled corn also responded in grain yields to soil K without the use of row applied K. Row applied K did not affect grain yields with the no-till treatment. At low levels of soil K row applied K increased grain and stover yields with the chisel treatment. Grain yields were similar for both tillage treatments. Stover yields responded to soil test K significantly in all cases. Row applied K increased the harvest index with the no-till treatment at medium to high soil K levels. Stover yields were similar for both tillage treatments.

Uptake of K as affected by soil test K, and row applied K is shown in figures 6 and 7 for grain and stover, respectively. Corresponding regression equations are given in table 9. Uptake of K by grain did not respond significantly to soil K with the use of row applied K with the no-till treatment, however, grain and stover uptake of K did respond in all other cases. Row applied K did not affect total uptake of K with the no-till treatment. Chisel plowing had greater K uptake by grain at low soil K levels due to row applied K, but stover uptake was not influenced by the row application.

Table 8. Regression equations used to describe yields.

Equation: $y=e^{a} K^{b}$.

y = Yields (Mg/ha)
K = 0-6 inch soil test K (ppm)

Row Fertilizer	Tillage	Equation Exponents a	Equation Exponents b	R^2	p-value
Grain Yields					
N-P-K	No-till	1.3793	.13333	.335	.05
	Chisel	1.1886	(.22504 - .00841 ln K)	.399	.05
N-P	No-till	-5.0793	(2.8382 - .28021 ln K)	.279	.23
	Chisel	-8.7585	(4.2640 - .41612 ln K)	.648	.00
Stover Yields					
N-P-K	No-till	-.95672	(1.0170 - .08663 ln K)	.424	.08
	Chisel	1.0185	.20136	.488	.00
N-P	No-till	-3.4629	(1.9949 - .17799 ln K)	.487	.05
	Chisel	-14.511	(6.6408 - .66389 lnK)	.667	.00

Table 9. Regression equations used to describe K-uptake by corn.*

Equation: $y=e^{a} K^{b}$.
y = K-Uptake (kg/ha)
K = 0-6 inch soil test K value (ppm)

Row Fertilizer	Tillage	Equation Exponents a	Equation Exponents b	R^2	p-value
Grain K-Uptake					
N-P-K	No-till	-6.7935	(4.0485 -.40666 lnK)	.322	.17
	Chisel	-3.4911	(2.5410 - .23516 ln K)	.555	.01
N-P	No-till	-12.473	(6.3647 -.64179 lnK)	.490	.05
	Chisel	-15.487	(7.3494 -.71553 lnK)	.775	.00
Stover K-Uptake					
N-P-K	No-till	-10.106	(4.9287 -.39819 lnK)	.833	.00
	Chisel	-26.188	(11.604 -1.0848 lnK)	.859	.00
N-P	No-till	-7.4253	(3.9562 - .31005 ln K)	.682	.00
	Chisel	-31.042	(13.646 - .23516 ln K)	.788	.00

SUMMARY

1. Under no-till conditions corn emergence was delayed about one day over that grown with chisel plowing.

2. Final stand was not affected by tillage.

3. Bulk density was greater with no-till than with the chisel plow treatment in the 1-4 inch depth when there was no traffic over the area.

4. Soil moisture was higher under no-till conditions compared to chisel plowing. This difference was associated with the top 4 inches.

5. The no-till treatment resulted in three times the soil cover of chisel plowing.

6. Soil cover in the row was two thirds of that between the row with both tillage treatments.

7. The spring distribution of soil K was not significantly different between tillage treatments.

8. Soil K distribution 83 days after application of K was greatly influenced by tillage.

9. With broadcast K applications, soil K in the surface 2 inches was higher with no-

till than with the chisel plow treatment.

10. With broadcast K applications, soil K in the 4-6 inch depth increment was higher with chisel plowing than with the no-till.

11. Changes in soil K with a given K application were similar for six inch cores with both tillage treatments in 1984.

12. Early growth was increased with row applied K and independent of soil test K.

13. Early growth was similar with both tillage treatments within row application treatments.

14. The increase in early K uptake due to row application of K was greater at higher soil test K levels with both tillage treatments.

15. Chisel plow treatments leveled off in early uptake after a broadcast rate of 200 lb/ac of K O, while no-till continued to increase.

16. Grain yields were not influenced by row application of K with the no-till treatment.

17. Chiseled corn had increased grain and stover yields at low levels of soil test K due to row applications of K.

18. Grain yields were similar for both tillage treatments.

19. Row K increased the harvest index at medium to high levels of soil K with the no-till treatment.

20. Uptake of K by grain was increased by row applied K at low levels of soil test K with the chisel treatment.

21. Total K uptake was similar for both tillage treatments.

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THE EFFECT OF TILLAGE, N RATE, AND NITRIFICATION INHIBITOR ON CORN RESPONSE ON AN IRRIGATED LOAMY SAND SOIL AND DRYLAND SILT LOAM SOIL

J.F. MONCRIEF, G.L. MALZER, G.W. REHM, AND J. CHAPLIN

Proper N management with conservation tillage is of paramount importance. Success or failure when growing continuous corn with very little tillage depends primarily on: 1) managing the crop residue to minimize reduced soil temperature affects, 2) adequate weed control, and 3) proper fertilizer management. Nitrogen management is important to minimize potential losses from increasd leaching and denitrification due to higher soil moisture levels.

The experimental sites are located at the Sand Plains Experiment Station, Becker, MN and on a cooperator's farm near Goodhue, MN. The Becker, MN site is located in East Central (EC) Minnesota on a soil formed in glacial outwash. The soil at this site is classified as a Udorthentic Haploboroll (Hubbard, loamy sand). These soils are capable of high production levels when irrigated. Nitrogen management is always of paramount importance on these soils. Growers are interested in conservation tillage on these soils to minimize wind and water erosion (water erosion from natural rainfall and also water application with low pressure irrigation systems). They are also motivated by the potential of reducing production inputs with conservation tillage. The other experimental site is located in South Eastern (SE) Minnesota on a soil formed in a deep-loess cap over limestone. This area of Minnesota has the highest potential for soil erosion.

Methods: At the EC site a Buffalo planter equipped with clearing discs was used to plant the ridge till treatment. A White planter with 2" fluted coulters was used for all other tillage treatments at this site. At the SE site a Hiniker Series 1 Econo Till planter was used for all tillage treatments. The cleaning discs were raised for the no till and chisel treatments. Cultural practices utilized in this study are summarized in Table 1. A continuous corn rotation was used at both sites.

Anhydrous ammonia was used as the nitrogen source. A sidedressed treatment was used at the SE site in addition to the Spring treatment at both sites. Nitrogen was applied at three rates with and without a nitrification inhibitor (N Serve) at both sites. The experimental design is a complete factorial arrangement with four replications as shown in Table 2.

RESULTS AND DISCUSSION

Tillage characterization: The resulting soil cover as a result of tillage is shown in Table 3. Soil cover slows soil moisture evaporation. This coupled with the increased soil density associated with the absence of tillage can result in denitrification (most likely the SE site) or increased leaching (the EC site). With moldboard tillage there is little residue and no difference relative to the row. The ridge till treatment resulted in about one-third the cover in the row as between rows at the SE site and about one-half as much at the EC site. The chisel treatment at the EC site resulted in less residue in the row but about the same at the SE site. No tillage resulted in 60-70% cover at both sites.

The effect of tillage on stands is shown on Table 4. There is no effect of tillage on stand. The ridge till treatment at the EC site had much less variability, however.

The effect of tillage on soil density and moisture is shown in Table 5. At the EC site there was traffic on all rows due to the necessary passes to apply N treatments and herbicides. With traffic all tilage effects have been masked out. There is a significant effect of tillage on soil moisture, however. These samples were taken the day following .58 inches of rain. The moldboard appears to be drying down the fastest. It is difficult to explain the higher soil moisture associated with chisel plowing.

Yield and N uptake: Tillage has been shown to affect the rate of several soil N transformations. In some cases there has been less N available with extremes in tillage reduction. One question this experiment was designed to address is "Is there a difference in N availability resulting from the tillage associated with anhydrous ammonia application"? The data collected in this reguard is shown in Table 6. There is no apparent effect of the tillage associated with anhydrous application (no N was applied).

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

Treatment means for yields and N uptake for the EC site are shown in Table 7. There was a significant effect of all treatments on grain yields and uptake at this site. It is interesting to look at the tillage in x N-rate X inhibitor interaction. This is shown in figure 1 and 2 for grain yields and grain N uptake respectively. At the first rate of N there was a greater inhibitor yield response with the no till treatment. The curves for the moldboald and ridge till treatment are similar in shape. There was considerable precipitation at this site in June (figure 3). The yields are similar without inhibitor at the 75 lbs/A rate for all four tillage treatment. There is more of an increase with the no till treatment with inhibitor at this rate. This suggests that the nitrification progressed more slowly under no till conditions. This is probably due to cooler temperature under this treatment which slowed the degredation of the inhibitor and N was present as NH_4^+ during the June rainfall. It is difficult to offer an explanation for the apparent response at the high rate of N with chisel plowing.

Treatment effects on yield and N uptake at the SE site are shown in Table 8. Generally the ridge till and chisel treatments resulted in similar yields which were higher than the no till treatments. Spring N application was consistantly better than sidedress. This is probably a result of the rainfall distribution (figure 4). June was fairly dry and with the exception of one 3 inch rain in July, it was also. Sidedress was especially a poor option with the chisel treatment.

There was no consistant effect of the nitrification inhibitor at this site. Again, it was dry and one would not expect an advantage with an inhibitor.

SUMMARY

Tillage affected soil moisture at both sights. Higher soil cover resulted in more soil moisture. There was no effect of the tillage associated with anhydrous application an corn yields (no N applied). Traffic masked the effects of tillage on soil density. There was a differencial inhibitor response (due to tillage) at the EC site. This is probably due to the temperature effect on the persistance of the NH_4^+ form of N. There was no consistant response of inhibitor at the SE site. This is the result of the difference in rainfall between sites. The Spring N application was better than sidedressed N.

Table 1: Cultural practices utilized.

Management Practice	East Central Minnesota	Date	South East Minnesota	Date
Tillage	Moldboard Plow	4/24		5/8
	Chisel Plow	4/25		6/29
	Ridge Till-Cultiviation	6/25		
Planting Date		5/3		5/9
Corn Hybrid	Pioneer 3906		Pioneer 3906	
Planting rate	29,600 plants/A		28,000 plants/A	
Row spacing	30 inches		38 inches	
Fertilizer Applications				
Row applied at planting	150/lbs/ 8-10-30	5/2-5/3	14 gal/A 7-21-7	5/9
Anhydrous Ammonia	All other spring N treatment	5/4	All Spring N treatment	5/10
	300 lb/A + N Serve	5/8	Sidedress N	6/25
Broadcast	300 lb/A 0-0-22 (Sulpomag)			
Insecticide				
At Planing	Lorsban 15G 7 lbs/A	5/3	Counter 15G 6 lbs/A	5/9
Through irrigation system	Lorsban 4e 7 lbs/A	7/11		
	Lorsban 4e 7 lbs/A	8/20		

Table 1: (cont.)

Herbicide				
Preemergence	Atrazine & Dual 2 lbs/A 1 lbs/A	5/3	Lasso + Bladex 2.5 lbs/A 1.5 lbs/A	5/9
Post Emergence	Atrayine & Oil 2 lbs/A 1 qt/A	5/29	Atrazine & Oil 2 lbs/A 1 qt/A	6/11
			Banvel 1/8 16/A	6/13

Table 2: Summary of Treatment

	Location	
	EC	SE
Tillage		
Moldboard	X	
Chisel	X	X
Ridge Till	X	X
No Till	X	X
Time of Application		
Spring	X	X
Sidedress		X
N Rate		
0	X	X
75	X	X
150	X	X
300	X	X
Nitrification Inhibitor		
with	X	X
without	X	X

Table 3: The affect of tillage and percent soil cover.*

Location	Tillage	In Row	Between Row
East Central Minnesota 6/8	Moldboard	3.5 (4.6)	2.5 (3.5)
	Chisel	25.0 (13.7)	41.3 (17.4)
	Ridge Till	16.7 (12.4)	32.0 (14.5)
	No Till	64.0 (18.0)	73.0 (14.6)
South East Spring N 6/19	No Till	70.0 (20.8)	51.0 (15.4)
	Ridge Till	13.8 (10.9)	31.8 (9.9)
	Chisel	27.8 (14.5)	26.0 (13.5)
Sidedress N 6/19	No Till	69.8 (17.8)	64.3 (14.4)
	Ridge Till	6.5 (3.5)	22.3 (12.3)
	Chisel	18.5 (10.3)	23.8 (11.2)

*Numbers in parenthesis are standard deviation N = 16. Measurements were made on the 300 lbs/A N rate only. In row is defined as the 8" area centered on the row.

Table 4: The effect of tillage on stand.*

Tillage	Location: EC Spring N	SE Spring N	SE Sidedress N
	plants/A x 10^3		
Moldboard	28.7 (3.1)	———	———
Chisel	29.2 (1.7)	26.7 (2.3)	27.9 (1.6)
Ridge Till	29.5 (0.8)	26.2 (1.8)	25.5 (2.5)
No Till	28.5 (2.5)	25.9 (3.2)	27.2 (2.4)

* The numbers in parenthesis are standard deviation, n = 16. Stand counts are for the high N rate only.

Table 5: The effect of tillage and traffic on soil density and moisture in the 1-4" soil depth (3" cores).

Location	Tillage	Bulk Density	Percent Moisture by Vol. *
East Central 9/4 (between the row with traffic)	Moldboard	1.57 (.04)	17.3 (1.5)
	Chisel	1.58 (.05)	22.9 (2.3)
	Ridge Till	1.57 (.07)	18.3 (2.2)
	No Till	1.59 (.07)	19.4 (3.1)

		Bulk Density		Percent Moisture by Vol.	
		No Traffic*	Traffic	No Traffic*	Traffic*
South East 9/4 (Between the row)	Chisel	1.19 (.07)	1.40 (.10)	26.9 (3.4)	29.8 (1.4)
	Ridge Till	1.27 (.06)	1.44 (.04)	28.7 (1.9)	33.2 (2.1)
	No Till	1.26 (.09)	1.40 (.08)	28.9 (3.5)	31.6 (2.9)

* Tillage is significant at a $\alpha = .10$. At the SE location traffic is significant a $\alpha = .10$ for both bulk density and soil moisture, there is no interaction.

Table 6: The effect of the tillage associated with anhydrous application on yields and N uptake (No N applied).

Location	Yields: Grain Bu/A		Stover T/A		N uptake: Grain		Stover	
East Central	Knife	No Knife	Knife	No Knife	Knife	No Knife	Knife	No Knife
Moldboard	56	56	1.3	1.3	32	30	11.7	9.2
Chisel	51	60*	1.2	1.4	31	31	12.7	10.2
Ridge Till	53	52	1.3	1.2	28	32	8.0	9.0
No Till	43	45*	1.0	1.0	23	23	8.9	9.3
South East								
Spring								
Chisel	93	91	1.7	1.5	46	46	16	14
Ridge Till	74	71	1.3	1.4	38	37	11	11
No Till	85	83	1.6	1.6	45	44	14	16
Sidedress								
Chisel	81	91	2.0	2.2	46	46	13	13
Ridge Till	83	71	2.0	1.7	47	37	12	10
No Till	83	83	1.9	2.0	45	44	16	17

*Significant as the result of a paired t test at $\alpha = .10$, n = 4.

Table 7: The effect of tillage, N rate, and nitrification inhibitor on corn yield and N uptake at Becker, MN, 1984.

Tillage	N Rate lbs/A	Inhibitor	Yield Grain Bu/A	Yield Stover T/A	N uptake lbs/A Grain	N uptake lbs/A Stover
No Till	75	-	93	2.11	57	20
"	"	+	144	2.75	90	31
"	150	-	125	2.36	77	28
"	"	+	158	2.85	110	39
"	300	-	164	3.03	121	48
"	"	+	169	3.12	115	50
Ridge Till	75	-	115	2.12	65	20
"	"	+	135	2.17	85	25
"	150	-	164	2.72	107	31
"	"	+	156	2.42	119	32
"	300	-	184	3.37	138	50
"	"	+	185	3.02	137	41
Chisel	75	-	101	2.48	58	24
"	"	+	118	2.34	72	22
"	150	-	141	2.59	90	29
"	"	+	167	3.02	113	32
"	300	-	168	3.01	118	43
"	"	+	187	3.39	148	45
Moldboard	75	-	72	].63	42	15
"	"	+	122	2.29	69	22
"	150	-	152	2.77	103	28
"	"	+	141	2.97	88	38
"	300	-	183	3.10	133	40
"	"	+	175	3.13	127	41

Main Effects

	Yield Grain Bu/A	Yield Stover T/A	N uptake lbs/A Grain	N uptake lbs/A Stover
Tillage				
No Till	143	2.70	95	36
Ridge Till	156	2.64	108	33
Chisel	147	2.81	100	33
Moldboard	141	2.65	94	31
P value	99	46	97	77
N rate lbs/A				
75	113	2.24	67	22
150	150	2.7]	101	32
300	177	3.14	130	45
P value	99	99	99	99
Inhibitor				
-	139	2.61	92	32
+	155	2.79	106	35
P value	99	97	99	97
Interactions				
Till X Rate	93	68	88	2]
Till X Inhibitor	90	95	94	89
Rate X Inhibitor	99	62	96	92
Till X Rate X Inhibitor	93	67	97	28

Table 8: The effect of tillage, N rate, time of application, and nitrification inhibitor on corn yield and N uptake at Goodhue Co., MN, 1984.

Tillage	N Rate lbs/A	Time of Application	Inhibitor	Yield Grain Bu/A	Yield Stover T/A	N uptake lbs/A Grain	N uptake lbs/A Stover
No Till	75	Spring	-	147	2.71	104	42
"	"	"	+	138	2.66	101	40
"	"	SD	-	149	2.67	99	40
"	"	"	+	147	2.44	104	38
"	150	Spring	-	150	2.92	110	60
"	"	"	+	155	2.90	107	46
"	"	SD	-	149	2.56	100	42
"	"	"	+	155	2.90	117	49
"	300	Spring	-	155	2.86	106	49
"	"	"	+	155	3.05	114	55
"	"	SD	-	149	2.71	100	46
"	"	"	+	146	2.69	102	45
Ridge Till	75	Spring	-	154	2.45	99	37
"	"	"	+	157	2.82	107	41
"	"	SD	-	160	2.71	112	41
"	"	"	+	157	2.59	104	39
"	150	Spring	-	166	2.96	113	51
"	"	"	+	168	2.93	127	50
"	"	SD	-	155	2.75	107	43
"	"	"	+	164	2.92	121	47
"	300	Spring	-	158	2.83	110	48
"	"	"	+	162	3.03	111	54
"	"	SD	-	164	2.91	117	49
"	"	"	+	161	3.03	116	50
Chisel	75	Spring	-	162	3.00	116	45
"	"	"	+	162	2.91	113	42
"	"	SD	-	155	2.77	103	39
"	"	"	+	147	2.62	88	33
"	150	Spring	-	171	3.14	118	52
"	"	"	+	161	2.99	115	48
"	"	SD	-	153	2.76	101	51
"	"	"	+	160	2.76	118	40
"	300	Spring	-	157	3.21	111	52
"	"	"	+	159	2.86	121	50
"	"	SD	-	157	2.93	116	41
"	"	"	+	155	2.82	114	49

Main Effects

	Yield Grain Bu/A	Yield Stover T/A	N uptake lbs/A Grain	N uptake lbs/A Stover
Tillage				
No Till	150	2.76	105	46
Ridge Till	161	2.83	112	46
Chisel	159	2.90	111	45
P value	99	40	99	02
N Rate				
75	153	2.69	104	40
150	159	2.88	113	48
300	157	2.91	112	49
P value	98	99	99	99
Time of Application				
Spring	158	2.90	111	48
Sidedress	155	2.75	108	44
P value	98	99	97	99

Table 8: (cont.)

Inhibitor				
-	156	2.83	108	46
+	156	2.83	108	45
P value	06	06	96	29
Interactions				
Till X Rate	16	36	84	27
Till X Time	96	96	98	58
Till X Inhibitor	51	99	55	71
Rate X Time	69	35	40	48
Rate X Inhibitor	84	46	99	87
Time X Inhibitor	19	07	06	20
Till X Rate X Time	97	23	99	19
Till X Rate X Inhibitor	13	64	49	16
Till X Time X Inhibitor	16	60	81	49
Rate X Time X Inhibitor	91	97	99	64
Till X Rate X Time X Inhibitor	58	46	60	93

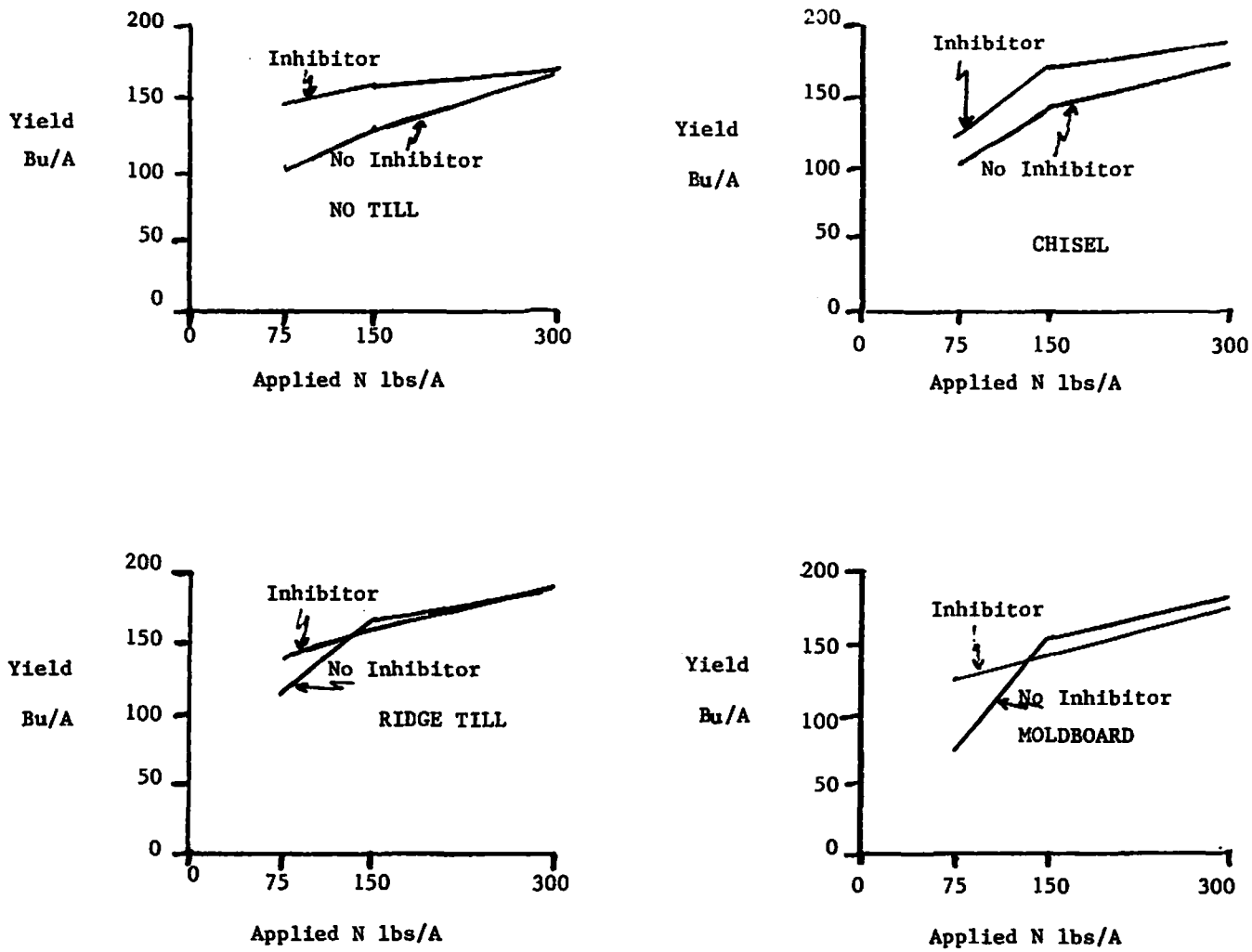


Figure 1: The effect of tillage, N rate, and nitrification inhibitor on grain yields, Becker, MN, 1984.

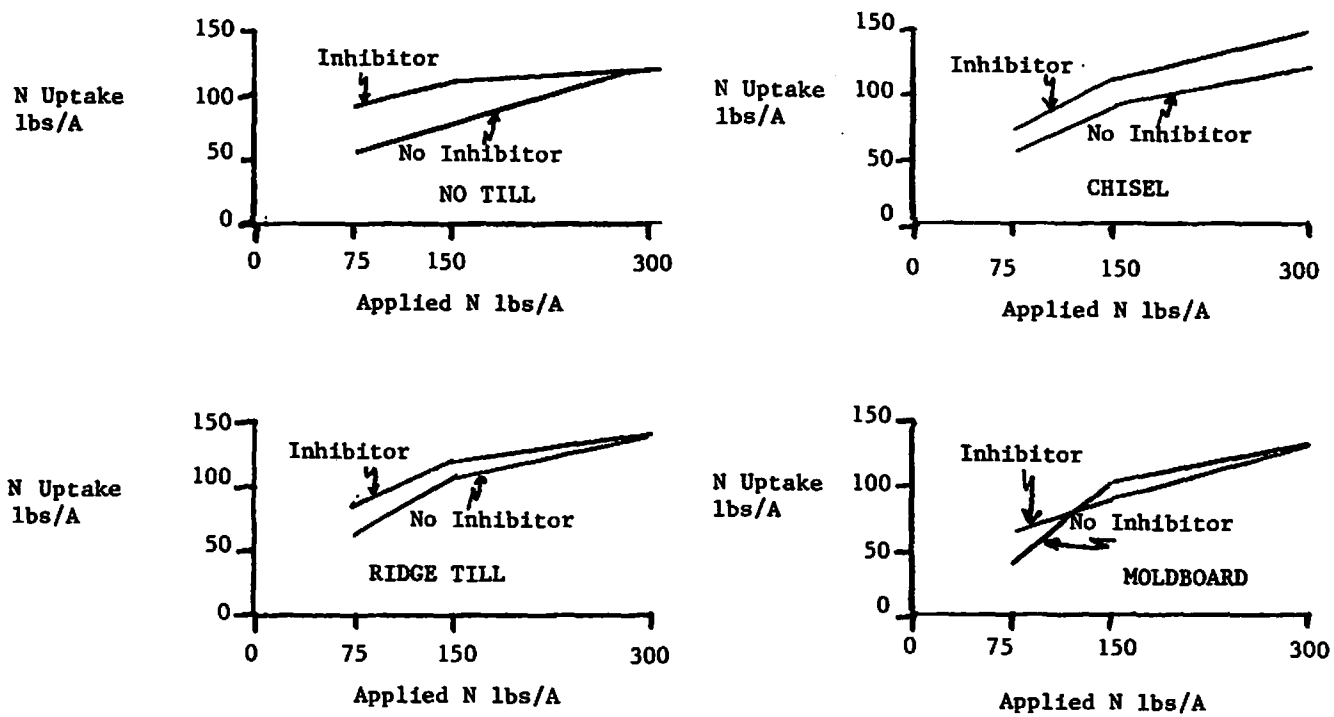


Figure 2: The effect of tillage, N rate, and nitrification inhibitor on grain N uptakes, Becker, MN, 1984.

Figure 3: Precipitation and irrigation at the EC site.

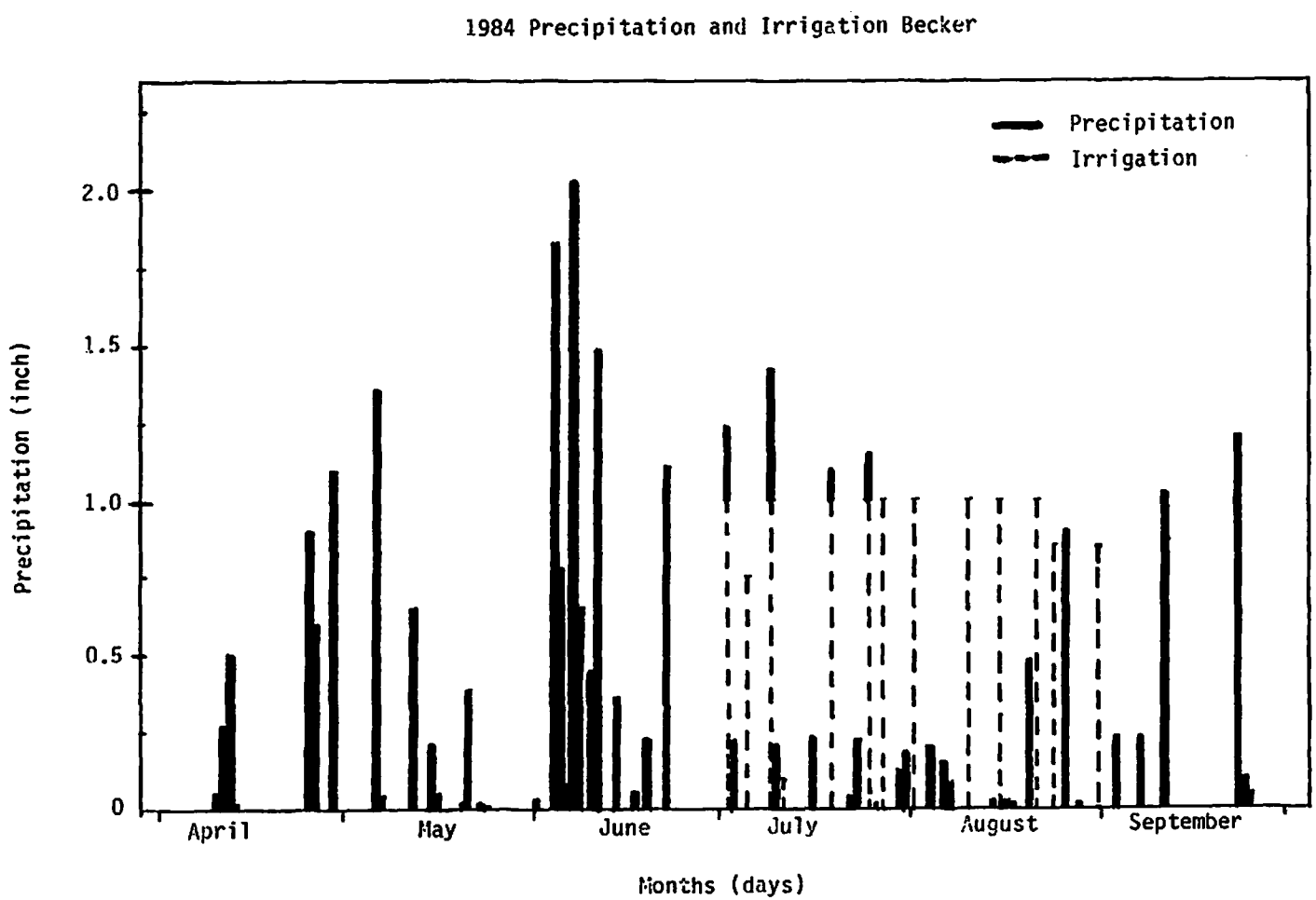
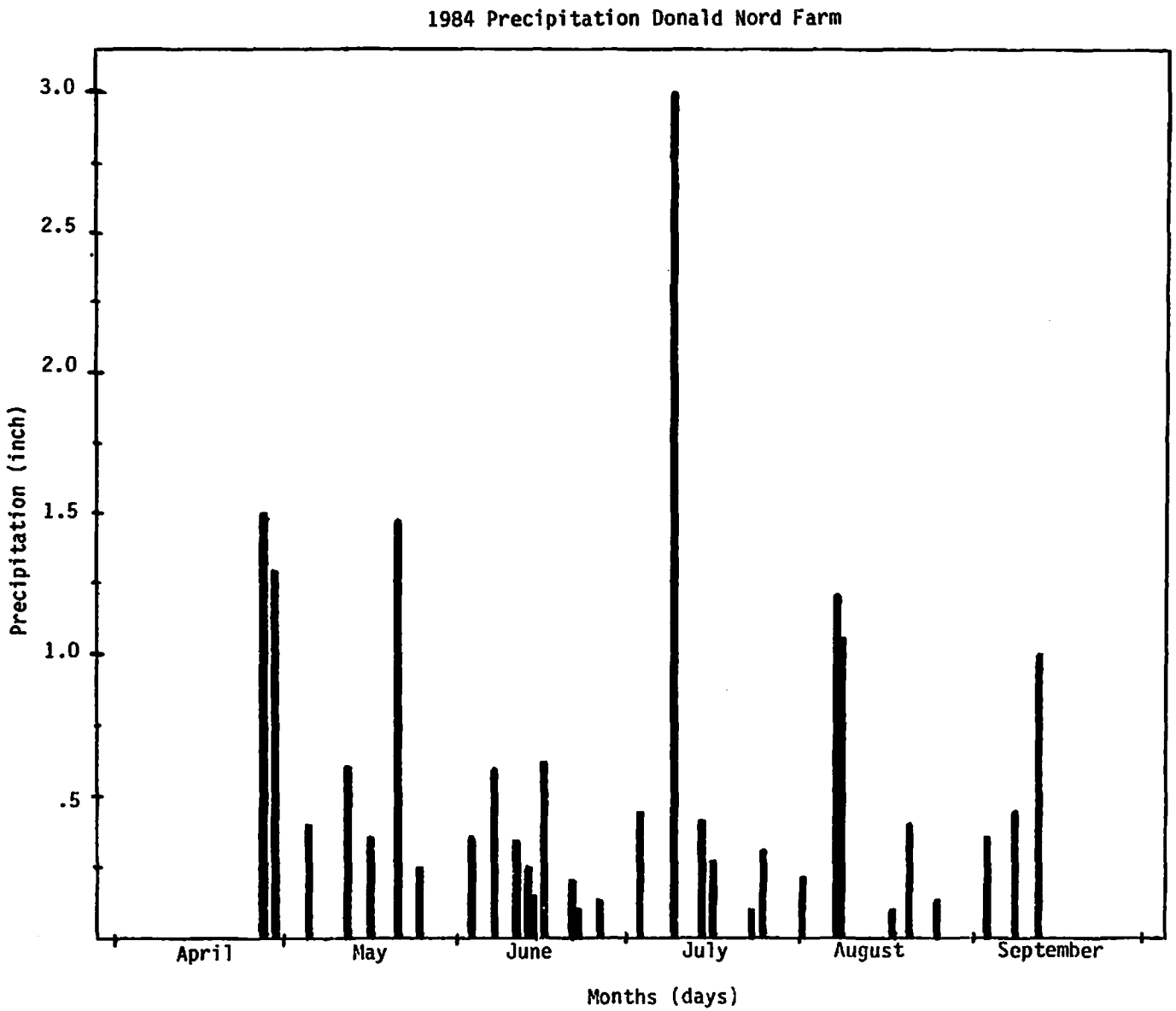


Figure 4: Precipitation at the SE site.



The Effect of Tillage on Corn and Soybean Production on a Typic Hapludalf Soil

J. F. Moncrief, J. Chaplin, D. Breitbach, C. Eberlein
T. L. Wagar, R. W. Hoff, M. P. Metz, and L. J. Svien

Demonstration plots were established on a Typic Hapludalf soil (Fayette, silt loam) in Wabasha County, Minnesota in the spring of 1984. The plot area has a slope of 2 to 6 percent. The farmer - cooperator (Francis Kottschade) idled the land in 1983 (PIK program) and planted it to sweet clover.

Soil Test and Fertilizer

The pH values range from 6.3 to 6.8. Soil P is generally in the high range (greater than 40). Soil K is in the medium to high range (200 - 300 lbs/A). The study area is remarkably uniform.

A row application of 12.5 gal/A of 7-21-7 was made at planting on all corn. This should have eliminated any limitation due to P and K at the soil levels of this site. Nitrogen was injected at 75 lbs/A as 28% urea-ammonium nitrate solution on the no-till, paraplow, and ridge till plots. No N was applied on chisel plowed plots. Research has shown that there will be less N released under no-till conditions after a legume. There should be adequate N released with the chisel plow treatment. The sweet clover stand was excellent.

Weed Control

Herbicide applications are summarized in table 1. The entire demonstration area received an application of Glyphosate (Round up). This was necessary to control a moderate stand of Quack and Bromegrass. Excellent weed control in the corn was obtained with a burndown application of 2,4-D ester plus dicamba (Banvel) followed by a preemergence application of alachor (Lasso) plus cyanazine (Bladex).

Soybean plots were split to evaluate a preemergence vs. post emergence weed control strategy. This comparison presented the following problems:

1. The glyphosate burndown on the preemergence plots (treatment A) did not adequately kill the sweet clover.

2. The soybeans had to be replanted due to crusting rains and resulted in disturbance of the preemergence treatment.

3. An accurate weed map was not available and several unanticipated weeds were present at moderate levels. This comparison will be made in 1985.

All tillage treatments received similar herbicide applications for both corn and soybeans.

Soil Cover

The soil cover with crop residue after planting corn is shown in table 2. The no-till and ridge till treatments are similar. At this point in time during the establishment year they are identical. There is about 25% less cover in the row than between with all tillage treatments except chisel plowing. "In" is defined as an 8 in. area centered on the row and "between" the remainder. The paraplow treatment resulted in about 10 to 15% less cover than no-till. The chisel plowing left much less residue and there was no difference in and between the row. Measurements were also made perpendicular to the rows and gave values similar to the weighted average of the in and between row measurements (data not shown).

The cover after planting soybeans is shown in table 3. Due to the late planting date and the narrow row drill (8 in. rows) with a 2 inch fluted coulter (Tye no till drill) the residue levels are generally lower than the corn plots. The same planter was used on both corn and soybean ridge till plots (Buffalo till in the no-till configuration). The measurements made perpendicular to the row is similar to the weighted average of the "in" and "between" values.

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Stands

The effect on tillage of plant populations is shown in table 4. Corn populations were similar for the no-till, paraplow, and ridge till treatments. The lower population associated with the chisel treatment is probably the result of a crusting rain which followed planting.

Due to the soil crusting at this site the soybeans were replanted in the no-till, paraplow and chisel treatments (narrow rows). These treatments had extremely low populations prior to replanting. The ridge till treatment was not replanted because the expected yield loss due to late planting was similar to the expected loss due to low population (about 10-15%). The other three treatments had similar stands after replanting. With the exception of the ridge till treatment in the soybean study plant populations would not be expected to limit yields.

Yields

Grain yields were measured by harvesting the center 8 rows of each corn plot and a 14 foot swath from the center of each soybean plot. Plot length measurements were made to be used in the yield calculation for each plot (~ 233 feet). A weigh wagon (± 1 lb) was used to determine plot grain weights.

Corn grain yields and moisture are shown in table 5. There is no significant difference in grain yields or moisture due to tillage. The chisel treatment had a severe infestation of leaf minor between the 8 and 12 leaf stage of growth in one plot which may be responsible for this lower trend in yields with this treatment.

Earleaf concentrations of N, P and K are shown in table 6. It is interesting to note that the chisel plow treatment resulted in higher N concentrations even though there was none applied. This is likely the result of slower mineralization and subsequent N release from sweet clover residue with the other tillage treatments. Lower K concentrations with extremes in tillage reduction are typical on these types of soils. Potassium or nitrogen would not be expected to be yield limiting in this study.

Soybean yields and moisture are shown in table 7. The soybeans grown with ridge tillage are pioneer 1677. All others are Dawson (see stand section). For this reason the ridge till treatment is excluded from the statistics analysis. Of the remaining treatments only the preemergence - no till treatment had a significantly lower yield. This was due to a poor control of the existing sweet clover sod with the burndown treatment (glyphosate). The tillage associated with the other treatments in conjunction with the glyphosate burndown eliminated any effect of the sweet clover on soybean yields. The pre vs. post-emergence comparison is of limited value for other reasons (see weeds). On July 4th all soybeans received an application of Bentazon (Basagran), poast, and crop oil (see table 1). Weed control was excellent under all treatments.

Summary

In spite of unforseen difficulties encountered this year there is still a valid comparison of most tillage treatments. After some difficulty excellent weed control was obtained in all plots. The lesson to be learned here is to get an accurate weed map the year prior to establishing a demonstration. Relying on farmer observations may be misleading. The crusting problem is something that must be accepted as a possibility on these silt loam soils. Crop residue appeared to lessen the severity of stand reduction.

Corn yields were similar regardless of tillage. When weeds were controlled soybean yields were also independent of tillage. This is an establishment year. It is not recommended to plant soybeans following a legume for obvious reasons.

In 1984 all tillage treatments and logistics of carrying out this demonstration have been established. This will enable the ultimate test of bottom line comparisons of four tillage strategies in southeastern Minnesota for corn and soybeans in 1985.

Information and Education Activities

This tillage demonstration plot generated a lot of interest in conservation tillage in Wabasha and surrounding counties. Despite the fact that this was an establishment year a number of activities were carried out.

Two field tours were conducted. One tour was held for cooperating agency field staff. This included SCS, Extension, SWCD and ASCS personnel with approximately 40 people attending. A second tour was conducted for the general public with approximately 60 area farmers attending.

A large sign was placed at the site to identify the project and the cooperating agencies. Local SCS and Extension Field staff prepared a number of news articles. This local publicity resulted in numerous individual farmer visits to observe crop growth and weed control. These are estimated at approximately 50 plot visits. Results from the plots will be utilized at farmer meetings being planned for early 1985.

Interest and enthusiasm remain at a high level for continuing this project in 1985. One anticipated benefit from this project was that it would generate interest in establishing demonstration plots in other surrounding counties. This is being done in an adjoining Major Land Resource Area and will serve as a demonstration site for a new cluster for counties.

Table 1. Management practices at the Wabasha County, Minnesota site in 1984.

Management Practice	Remarks	Date
Soil samples	10 core composites 0-6 in.	April 9
Burndown Corn	Sweet Clover 8 in. tall 2, 4-D ester .5 lbs/A Dicamba .25 lbs/A Glyphosate 2 lbs/A	May 10
Soybeans	A. Glyphosate 21 lbs/A or B. Poast .19 lbs/A + Petroleum oil 1 qt./A + 2, 4-D ester .5 lbs/A	
Inject N	28% Urea Ammonium Nitrate Solution 75 lbs/A All tillage treatments except chisel plowing	May 14
Corn Planted (Pioneer 3906)	25,500 plants/A Buffalo till planter in no-till configuration (38 inch rows)	May 16
	All tillage treatments except chisel plowing chisel plots planted	May 16 May 18
Row fertilizer	All corn plots received 12.5 gal/A of 7-21-7	
Soybeans planted (Pioneer 1677)	225,000 plants/A Tye no till drill 10 inch rows (38 inch rows Ridge till)	May 18
Preemergence Herbicide on corn	Cyanazine (Bladex) 1.5 lbs/A + Alachlor (Lasso) 2 lbs/A	May 22
Preemergence Herbicide on soybeans (treatment A)	A. Alachlor 2 lbs/A (Lasso) + Metribuzin .25 lbs/A (Sencor) + Chloramben 2.4 lbs/A (Ambiben) Glyphosate 2 lbs/A (Roundup) (all soybean plots)	May 23
Rotary hoe over all plots		May 30
Soybeans replanted Dawson	10 inch rows - no-till Paraplow, and Chisel	June 11

Post emergence Herbicide on soybeans (treatment B)	B. Bentazon 1 lb/A (Basagran) + crop oil 1 qt./A	June 19
Cultivate	Ridge corn (38 inch rows) Cultivate soybeans (38 inch rows)	July 2
Post emergence Herbicide on all soybeans	Bentazon 1 lb/A (Basogran) + Poast .5 lb/A + Crop oil 1 qt/A	July 4
Cultivate	Ridge soybeans (38 inch rows)	July 20
Harvest	All plots (4 row combine)	Oct. 24
Tillage	Chisel Plow Paraplow	Nov. 8 Nov. 14

Table 2. The effect of tillage on percent soil cover on June 7, 1984 after planting to corn.[1]

	Position Relative to Row		
	In	Between	Perpendicular
	percent		
No-till	59.0 (15.1)	84.5 (8.4)	80.3 (8.7)
Paraplow	43.3 (14.4)	71.0 (11.3)	69.5 (14.2)
Ridge Till	56.0 (17.3)	83.3 (15.3)	84.3 (9.3)
Chisel	16.8 (7.6)	16.3 (8.5)	19.0 (8.9)

[1]Numbers in parenthesis represent the standard deviation, n=16

Table 3. The effect of tillage on percent soil cover on June 27, 1984 after planting to soybeans.[1]

	Position Relative to Row		
	In	Between	Perpendicular
	percent		
No-till	59.5 (16.7)	55.5 (8.5)	61.5 (10.4)
Paraplow	48.3 (17.8)	50.0 (15.3)	46.0 (10.6)
Ridge Till	70.0 (11.8)	80.5 (8.1)	77.0 (7.1)
Chisel	9.0 (5.0)	9.0 (4.3)	7.3 (4.2)

[1]Numbers in parenthesis represent the standard deviation, n=16.

Table 4. The effect of tillage on corn and soybean stands on June 7 and 27th respectively.[1]

	Corn	Soybeans[2]
	Plants $A^{-1} \times 10^3$	Plants $A^{-1} \times 10^3$
No-Till	24.9 (4.2)	184 (23)
Paraplow	26.8 (3.2)	172 (41)
Ridge Till	26.3 (3.9)	55 (12)
Chisel	21.6 (3.1)	191 (35)

[1]Numbers in parenthesis represent standard deviation, n=16 and 8 for corn and soybeans respectively.

[2]Because of poor stand soybeans were replanted on June 11 with the exception of the ridge till treatment.

Table 5. The effect of tillage on corn yields following sweet clover (Wabasha Co., MN 1984).

Tillage	Yield Bu/A^{-1} @ 15.5%	Harvest Moisture (%)
No-till	154	24.7
Ridge Till	148	24.9
Paraplow	154	24.6
Chisel Plow	146	25.0

Table 6. The effect of tillage on corn ear leaf concentrations of N, P, and K (Wabasha Co., MN 1984).

Tillage	N	P	K
	----------	%	----------
No-Till	2.07	.29	1.80
Ridge Till	3.08	.29	1.57
Paraplow	2.97	.28	1.63
Chisel Plow	3.22*	.29	2.07*

*α= .10, n = 4

Table 7. The effect of tillage and weed control strategy on soybean yields (Wabasha Co., MN 1984).

	Pre	Post	Moisture %	
Tillage	Bu A^{-1}	Bu A^{-1}	Pre	Post
No-Till	40.3*	43.4	15.6	15.9
Ridge Till[1]	35.0	34.2	17.2	17.5
Paraplow	46.7	45.1	15.6	15.5
Chisel	43.7	44.0	15.6	15.5

[1]All treatments but ridge till were replanted, making an analysis including this treatment invalid.

*$\alpha = .10$, $n = 4$.

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

J.F. MONCRIEF, S.D. EVANS, AND A.E. OLNESS

Recently there has been much interest in the interaction between corn hybrid and N response. Tsai et al. evaluated 16 corn hybrid responses to N fertilizer (spring applied as anhydrous ammonia). They grouped hybrids into three N reponse types: 1. low fertility types, moderate fertility types, and high fertility types. Low fertility types didn't respond beyond 60 lbs N/A. High fertility types responded over the entire range of applied N (400 lbs N/A). They hypothesize three possible responsible mechanisms for differences: 1. ability to absorb late season N, 2. rate of grain N assimilation, and 3. duration of grain filling. The economic implications and obvious.

There is also local data from Minnesota suggesting differences in N response between hybrid. Geadelmann tested 45 hybrids on a loamy sand soil over a range in applied N (0-300 lbs N/A) under irrigation and found similar results. A study under dryland conditions comparing two hybrids also resulted in differences (Randall and Walters, 1984).

There have also been numerous studies showing reduced N availability under extremes in tillage reduction with a continuous corn sequence. (Moncrief, et al., 1984; Malzer et al., 1984). One suspected mechanism for reduced N availability is immobilization of applied N which would result in N becoming available later is the season when some hybrids would be unable to utilize it. Other suspected mechanisms are reduced mineralization and increased denitrification.

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

Methods: The experimental site is located in west central Minnesota on a Pachic Udic Haploboroll (Tara, silt loam) soil. The experimental design is a split plot with tillage main plots, N rate subplots, and corn hybrid sub-subplots. There are four replications. Treatments are summarized in Table 1. Weed control was obtained with Alochlor (Lasso) 3 lbs/A + Cyanizine (Bladex) 2.2 lbs/A applied preemergence. There was excellent weed control. Row fertilizer was applied at planting (9.4 gal of 7.4-25-0).

RESULTS AND DISCUSSION

Yields: The relationship between tillage and soil cover, stand and harvest index are shown in Table 2 and 3. Moldboard plowing resulted in a considerable amount of cover. The ridge till and chisel had similar cover although most was between the row with the ridge till treatment. It is interesting to note the interaction between tillage and stand. There is a significant reduction under no till conditions with the Dekalb hybrid. This may be the result of susceptability of this hybrid to residue borne disease. This will be investigated more thoroughly in 1985.

Grain yields are shown on Table 4. Due to above average rainfall in June (figure 1) corn generally responded over the entire range in applied N. At a given level of applied N grain yields were higher with the Pioneer hybrid. Although the tillage X N rate interaction is not significant (R value = 81), the no till treatment tended to reach a plateu at the intermediate rate of applied N. The other tillage treatments continued to respond beyond this rate.

The pioneer hybrid had a more favorable harvest index (HI). Both hybrids had about the same stover yield. The ridge till treatment resulted in the highest HI. This has been shown in other Minnesota research (Moncrief et al., 1984). There was also an interaction between N rate and hybrid (fig. 2). At the higher N rates both hybrids had similar harvest indexes. This may be related to time of N uptake. Studies which had a time of application variable show late N to increase HI.

Moisture Stress: Tillage changes levels of soil moisture, soil hydraulic conductivity, and root distribution. One way of estimating the integrated effects of many interacting changes is to measure the moisture stress in the plants themselves. The potential energy of the moisture in the plants

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under high evaporative demand are shown in Table 5. With the exception of the early morning reading (0545) on July 18, which was beyond the sensitivity of the instrument, P 3906 showed less stress than the DXL8 hybrid. There also was an absence of any interaction with tillage. Generally the ridge till treatment shows the highest stress, again independent of hybrid. Stress levels below -8 bars are considered moderate and as anticipated the differences in stress due to tillage did not show up in grain yields. Interestingly, the moldboard and no till treatment appear to have similar stress. The chisel treatment changes in rank from low to high with time.

These measurements were made at tassel and silk emergence. Other research has shown this to be related to yields if stress in excess of -10 bars is encountered at this time (Moncrief, 1981). Soil moisture levels are shown in Table 6. These data support the stress measurements.

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Table 1: Treatment summary at Morris, MN 1984

Treatment	
Tillage:	Fall Moldboard plow Fall Chisel plow Ridge till No till
N Rate:	0, 40, 80, 120, 160 lbs N/A applied Oct. 27, 1983 prior to tillage as anhydrous ammonia
Hybrid:	Pioneer 3906 Dekalb XL8

Table 2: Probability levels of treatment effects on measured variables.

Source	% Cover	Yield Grain	Yield Total	Harvest Index*
Tillage	99	95	97	67
Nitrogen	98	99	99	99
Till X N	86	81	32	25
Hybrid	51	99	99	99
Till X Hybrid	63	61	53	90
N X Hybrid	43	62	87	99
Till X N X Hybrid	82	42	93	60

*Harvest index is defined as the ratio of ear dry matter over total.

Table 3: The effect of tillage and hybrid on stand and harvest index.

Tillage	Percent Cover	Stand P 3906	Stand D XL8	Harvest Index* P 3906	Harvest Index* DXL8
	%	---plants/A X 10^3--			
Moldboard	16.4	26.6	20.8	58.2	54.6
Chisel	54.7	27.7	28.0	57.4	54.6
Ridge till	54.3	27.0	28.1	60.1	57.1
No till	86.2	28.2	29.1	58.7	52.5

* Harvest index is defined as the ratio of ear yield to total.

Table 4: The effect of tillage and corn hybrid on grain yields (Morris, MN, 1984).

N Rate (lbs/A)	Tillage	Pioneer 3906	Dekalb XL8
		---Bu/A---	
	No Till	116	106
N = 160	Ridge Till	137	125
	Chisel	128	120
	Moldboard	135	126
	No Till	117	97
N = 120	Ridge Till	128	103
	Chisel	120	98
	Moldboard	129	121
	No Till	117	82
N = 80	Ridge Till	120	99
	Chisel	120	95
	Moldboard	118	111
	No Till	95	78
N = 40	Ridge Till	93	75
	Chisel	99	88
	Moldboard	102	87
	No Till	63	48
N = 0	Ridge Till	72	61
	Chisel	86	56
	Moldboard	82	61

Table 5: The effect of tillage and hybrid on leaf water potential at Morris, MN, 1984.

Date	Time	Hybrid	Tillage[1] No Till	Ridge Till	Chisel	Moldboard	Significance[2] Till	Hybrid	Till X Hyb.
			(- bars)						
7/18	1345	P 3906	8.4 (1.1)	8.6 (.33)	7.0 (1.1)	7.3 (1.1)	*	*	
		DXL8	8.9 (7.2)	10.1 (.37)	8.6 (.51)	9.6 (.28)			
	0545	P 3906	.65 (.10)	.63 (.13)	.68 (.10)	.58 (.05)			
		DXL8	.68 (.15)	.68 (.10)	.83 (.05)	.65 (.10)			
7/19	0950	P 3906	3.5 (.76)	3.4 (.17)	2.8 (.44)	3.3 (.21)	*	*	
		DXL8	4.2 (1.1)	4.8 (.66)	3.7 (.89)	4.0 (.40)			
	1305	P 3906	4.9 (.93)	5.4 (1.1)	5.3 (.52)	4.4 (1.1)	*	*	
		DXL8	5.5 (.46)	7.0 (1.4)	6.7 (.94)	5.5 (.97)			
7/26	1955	P 3906	2.0 (.30)	2.2 (.33)	2.0 (.31)	2.3 (.44)		*	
		DXL8	2.5 (.63)	3.1 (.78)	2.6 (.49)	2.8 (.40)			
7/21	0920	P 3906	1.5 (.49)	1.9 (.56)	1.7 (.17)	1.6 (.46)		*	
		DXL8	1.8 (.77)	2.4 (.90)	2.2 (.52)	2.1 (.35)			
	1340	P 3906	4.4 (.95)	6.1 (1.4)	5.3 (.98)	4.8 (1.5)	*	*	
		DXL8	6.4 (1.3)	7.7 (.84)	6.7 (.53)	5.9 (1.6)			

[1]Numbers in parentheses represent the standard deviation.
[2]Treatments with asterisk are significant at a probability level of 90.

Table 6: The effect of tillage on soil moisture distribution on July 27, 1984, Morris, MN

	Depth 0-6	6-12	12-18	Avg.
	% by wt.			
No Till	23.3	25.6	22.4	23.7
Ridge Till	21.5	23.2	19.8	21.5
Chisel	21.0	22.8	20.9	21.6
Moldboard	22.8	27.4	23.7	24.6

Figure 1: Precipitation, Morris 1984.

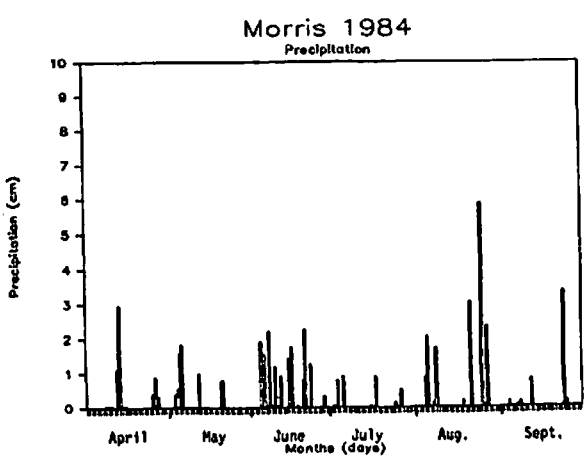
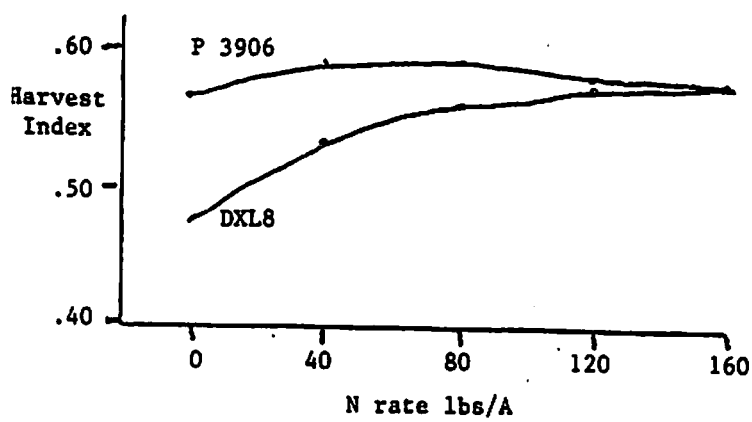


Figure 2: The effect of N rate and hybrid on harvest index.



EFFECT OF TILLAGE AND FREQUENCY OF MANURE APPLICATION ON N-UPTAKE AND CORN YIELD - 1983-1984 SUMMARY

J. Swan, J. Moncrief, P. Burford, and B. Schreiber

Cooperator: Dale Flueger

The purpose of this study is to determine the effect of tillage and of frequency of manure application on corn yield and on N uptake. A second purpose is to determine the amount of nitrogen take up from manure applications applied one and two years prior to the current cropping year.

Procedure: Liquid dairy manure is injected either annually, biennially or triennially on chisel plowed treatments and annually or biennially on no-till treatments. Yields are compared with check treatments which receive broadcast potassium and starter phosphorus but no nitrogen fertilizer and with "fertilized check" treatments receiving high rates of N, P and K. The tillage treatments, site, cropping history and herbicide applications are identical with those described in "The Effect of Tillage and Potassium Placement on the Availability of Potassium to Corn" in the 1983 and 1984 bluebook. Nitrogen and potassium uptake are measured and reference nitrogen measurements are made annually on selected plots.

In summary, the greater amount of nitrogen mineralized following tillage with the chisel plow appears the most likely explanation for the greater yields measured on the checks and carryover application treatments following chiseling compared to no-till planting. The yield of the biennial carryover treatment on no-till was significantly lower than current applications in both 1983 and 1984. Yields from the biennial carryover treatments were not significantly different than yields from current applications for chisel plowing in either 1983 or 1984. The check treatments were significantly lower in yield than all other chisel or no-till treatments.

Average concentrations of N, P and K in the liquid manure are quite consistent (table 2). On the average, slightly more than one-half the nitrogen was in the ammonium form.

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Table 1. Corn Yield - Bu/Acre

Manure Application	1984		1983	
	No Till	Chisel	No Till	Chisel
None	66.4 c	85.7 c	82 c	95 c
Annual	144.9 a	163.4 a	129 a	133 a
Biennial				
Current yr	155.3 a	157.4 ab	123 a	117 b
Carryover from previous year	101.1 b	133.4 ab	107 b	122 ab
Triennial				
current yr	----	149.1 ab	----	----
Carryover from previous year	----	125.1 b	----	----
Carryover from 2 years previous	----	128.1 ab	----	----
Significance level	5%	5%	5%	5%

All yields are the average of 3 reps.
All years and tillage systems are analyzed separately.

Table 2. Nutrient analysis of liquid dairy manure from Dale Flueger farm for 1982, and 1983.

	Concentration of Liquid Manure		
	1982 Spring	1983 Spring	1983 Fall
NH_3-N	0.185%	0.1735%	0.177%
Total N	0.365%	0.3060%	0.348%
% Solids	7.21%	6.99%	7.35%
Phosphorus	624 ppm	(10260 ppm) (solids)	672 ppm
Potassium	1895 ppm	(34940 ppm) (solids)	2443 ppm

	Amount of N, P_2O_5 and K_2O in 9000 Gal. of Liquid Dairy Manure			
	1982 Spring	1983 Spring	1983 Fall	Avg.
	lbs/acre			
NH_3-N	139	130	133	134
Total N	274	230	261	255
P_2O_5	106	128	114	116
K_2O	171	221	221	204

THE EFFECT OF TILLAGE ON SOYBEAN PRODUCTION IN MINNESOTA

J.F. Moncrief, W.E. Lueschen, S.D. Evans, J.H. Ford, W.W. Nelson
G.W. Randall, D.D. Warnes, W.C. Stienstra, and D.R. Hicks

Conservation tillage has gained recent impetus due to a higher level of public awareness of the importance of soil erosion control and the potential for reducing production inputs to ease the economic squeeze present day farmers are experiencing. Soybeans are a major crop in Minnesota. In 1982 a study designed to assess the effect of tillage on soybean production was established at three locations (the Morris, Lamberton, and Waseca Ag. Exp. Sta.).

Methods: The experimental sites represent diverse climatic and soil conditions. Generally the Morris and Lamberton sites have lower rainfall than the Waseca site. The Morris site has a shorter growing season than the other two. The Lamberton and Waseca sites are on soils with aquic suborders although both are well tiled. The Morris site has better natural internal drainage. Soybeans followed corn at all sites. At Morris they were also preceeded by spring wheat. The various management practices utilized at each site is shown in Table 1. There was a very agressive weed control program at each site and in some instances several post emergence applications were made to control weeds. Excellent weed control was obtained at all sites.

RESULTS AND DISCUSSION

Cover: Soybeans were planted in both 10 and 30 inch rows. The till plant treatment was managed with and without a ridge. A Buffalo planter was used at Lamberton and Waseca and a Hiniker at Morris for the till plant treatment (all equipped with clearing discs). An Almaco no till drill was used for all other tillage treatments (both 10 and 30 inch rows).

Stalks were chopped for the fall chisel plow (fall), till plant (fall for ridged and spring for non ridged). Ridges were built during the corn year. Soybeans were not cultivated.

The soil surface covered with residue is shown on Table 2. At the Morris and Waseca locations cover with fall moldboard plowing ranged from 5 to 20 percent. At Lamberton there was a wider range in cover following this treatment. Chisel plowing in the fall resulted in similar cover to the spring disc (tandem finishing disc) treatment at Waseca but varied by crop and year at the other two sites. No till wheat resulted in higher cover than corn at Morris. No till after corn at the other two locations resulted in more cover than Morris.

The till plant treatment was quite variable in the amount of cover. When ridges are built in the fall after spring wheat, straw is moved into the ridge. During the planting operation, this straw is exposed. The result is a fairly high amount of cover in the row. The cover in the row ranged from 22 to 70 percent with this treatment. The cover in the row after a corn crop ranged from 2 to 53 percent. This variability is the result of moisture content of stover at planting, setting of tillage depth on the planter, and speed. This illustrates the wide variation that can be obtained with this tillage approach. Generally there is more cover in the row after corn with the non-ridged treatment and the converse following wheat. This is the result of concentrating the straw in the ridge during ridge formation and in the case of corn residue, reduced depth of tillage during planting with the non-ridged treatment. With the range in soil cover established by tillage in this study there would also be extremes in soil temperature, moisture, and aeration due to tillage.

Grain Yields: The levels of signficance for treatment effects are shown in Table 3. Morris is analyzed separately due to fewer replications (4 vs. 6 at other two locations) and a better drained soil. There are two analyses for each site grouping. The first includes row spacing treatment (10" vs. 30") but excludes the till plant treatments. The other is for 30" row spacing only and includes the till plant treatments. Treatments which had significant effects on soybean yields but are not discussed are: row spacing (10" 30"), and planting date (early late, only early is presented).

At the Morris location there is a significant interaction between preceeding crop, year, and tillage, on soybean yields. This is illustrated in figure 1. In 1982, no till soybeans grown after wheat resulted in a lower yield but not after corn. Several no till (after wheat) plots were located in a lower spot in the field and suffered frost damage in 1982 and this be responsible for the lower

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yields with this treatment (both row spacings). In 1983 the no till soybeans outyielded the other tillage treatments in 10" rows. Yields were similar in 1984. Yields after wheat were higher each year presumably due to earlier recharge after wheat and higher soil moisture levels going into the season.

It appears that there may be an advantage to less soil cover in the row with the till plant treatment. The "till plant-flat" treatment generally has less cover in the row after wheat than the ridged treatment. The opposite is the case after corn. The soybean yields are also ranked in the same direction. This may illustrate an advantage of a clean row area with 30" soybeans. The narrow row soybeans grown under no till conditions generally yielded as well as a cleaner treatment, however.

At the Waseca and Lamberton sites there was a significant interaction between year, location, and tillage. Yields are shown in figure 2. At Waseca, the no till, chisel, and spring disc are similar (10" rows) and the moldboard treatment tended to fluctuate with year.

This may be due to differences in precipitation. Growing season precipitation is shown in figure 3 a, b, and c for Morris, Waseca, and Lamberton respectively. In 1983 there was an extremely dry July and first half of August at Waseca. At the Lamberton site the chisel treatment appears to be quite variable. This is most likely due to the soil moisture level at the time of fall tillage. In wet falls chiseling was detrimental.

At both the Waseca and Lamberton sites, the till plant-ridged treatment appeared to show an advantage in 1982 and 1983. In 1984, there was little or no advantage to the ridged treatment over the flat.

SUMMARY

The effects of tillage on soybean yields at three locations and years in Minnesota varied by both location and year. At the west-central site over the three years and two crops, tillage main effects were non-significant. Performance of a ridged vs flat treatment appeared to be related to cover in the row. At the Lamberton and Waseca sites, the tillage treatments appeared to be the most variable in their relative ranking.

Within the range in soil types and climate of this study it appears that there is no consistant effect of tillage on soybean yields.

Table 1A: Management variables of tillage-soybean study for 1982, 1983, and 1984 at Morris.

		Morris		
		1982	1983	1984
Soil Type		Pachic Udic Haploboroll (Aastad, clay loam)	Udic Haploboroll (Barnes, clay loam)	Pachic Udic (Aastad, clay loam)
Soil test	pH			6.9 - 7.5
lbs/A	P	59		26 - 56
	K	32		384 - 600+
Fertilizer Applied	N	96		
lbs/A	P_2O_5	396		
	K_2O	204		
Date applied (Broadcast)		1/2 Oct 1980 1/2 April 1982		
Soybean variety		Evans	Evans	Evans
Planting Date		May 6	May 2-3	May 2-3
Herbicide Program	Preemergence	Lasso 3	Lasso 3	Lasso 3
		Amiben 2.5	Amiben 2.5	Amiben 2.5
lbs/A		May 6	May 4	May 4

Table 1A: (cont.)

Postemergence soil is applied at 1 qt/A as concentration at 1 qt/A as concentrate	Poast .29 + Oil June 8 (spot spray)	Basagran 1 + Oil June 23	Basagran 1 + Poast Oil June 20
	Poast .29 + Oil June 16	Roundup + 1% solution Hand wick June 17 (for perennials)	
	Poast .19 + Oil July 16	Poast .38 + Oil July 22	

Table 1B: Management variables of tillage-soybean study for 1982, 1983, and 1984 at Lamberton.

		Lamberton		
		1982	1983	1984
Soil Type		Cumulic Haplaquoll Typic Haplaquoll (Ves - Webster clay loam)	Typic Haplaquoll Typic Haplustoll (Webster Delft clay loam)	Cumubic Haplaquoll Typic Haplaquoll (Ves - Webster clay loam)
Soil test	pH			
lbs/A	P	56		
	K	176		
Fertilizer applied	N			
lbs/A	P_2O_5	100	100	
	K_2O	100	100	
Date applied		Fall	Fall	
Soybean variety		Corsoy 79	Corsoy 79	Corsoy 79
Planting Date		May 1	May 12	May 18
Herbicide Preemergence Program lbs/A		Lasso 3 + Amiben 2.5 May 1	Lasso 3 + Amiben 2.5 May 16	Lasso 3 + Amiben 2.5 + Roundup .75 May 19
Postemergence oil is applied at 1 qt/A as concentrate			Basagran 1 + Poast .2 June 8	Basagran 1 + Oil June 29
				Poast .2 + Oil July 2

Table 1C: Management variables of tillage-soybean study for 1982, 1893, and 1984 at Waseca.

		Waseca		
		1982	1983	1984
		Typic Haplaquoll (Webster, clay loam)	Typic Haplaquoll (Webster, clay loam)	Typic Haplaquoll (Webster, clay loam)
Soil test	pH			7.5
lbs/A	P	55	70	75
	K	475	475	520
Soybean variety		Corsoy 79	Corsoy 79	Corsoy 79
Planting Date		April 28	April 30	May 11
Herbicide Preemergence		Lasso 3	Lasso 3	Lasso 3
		+	+	+
Program		Amiben 2.5	Amiben 2.5	Amiben 2.5
lbs/A		April 28	May 10	May 11
Postemergence		Basagran 1.5	Basagran .75	Poast .2
oil is applied		+	+	
at 1 qt/A is concentrate		Poast .2	Poast .2	July 2
		+	+	
		Oil	Oil	
		July 1	June 25	

Table 2: The effect of tillage and previous crop on percent soil covered by crop residue after planting.

Location:	Morris											
Year:	1982				1983				1984			
Previous Crop:	Wheat		Corn		Wheat		Corn		Wheat		Corn	
Row Spacing:	10"	30"	10"	30"	10"	30"	10"	30"	10"	30"	10"	30"
Tillage:												
Moldboard	12	10	12	15	5	5	8	10	8	10	11	15
Chisel	36	34	43	35	20	17	21	34	16	19	30	33
Spring Disc	47	53	47	46	18	19	38	36	27	27	50	50
No Till	97	96	79	76	79	83	54	58	85	89	71	74
Till Plant												
In Row		58		32		22		8		29		17
Flat Between Row		66		63		68		58		85		60
Ridged In Row		70		24		29		11		49		12
Between Row		81		77		62		52		60		52

Location:	Lamberton					
Year:	1982		1983		1984	
Previous Crop:	Corn					
Row Spacing:	10"	30"	10"	30"	10"	30"
Tillage:						
Moldboard	34	23	6	7	11	18
Chisel	55	57	45	49	50	50
Spring Disc	58	54	49	56	56	51
No Till	82	71	74	84	89	90
Till Plant						
In Row		45		32		53
Flat Between Row		60		76		76
Ridge In Row		54		24		40
Between Row		75		43		69

Location:	Waseca					
Year:	1982		1983		1984	
Previous Crop:	Corn					
Row Spacing:	10"	30"	10"	30"	10"	30"
Tillage:						
Moldboard	20	18	11	11	10	15
Chisel	49	51	36	31	37	37
Spring Disc	49	49	35	32	28	28
No Till	86	91	84	83	80	77
Till Plant						
In Row		41		37		22
Flat Between Row		46		65		77
Ridge In Row		25		12		2
Between Row		28		32		26

Table 3A: Levels of signficance of treatment effects on soybean yields at Morris, MN for 1982, 1983, and 1984. Morris is analyzed separately due different soil type, and replication (4 vs. 6 at other two locations). The are two analysis of varience for each site grouping. One includes row spacing treatments (10" vs. 30") but excludes the till plant treatments. The other is for the 30" row spacing only and includes the ridge till treatments.

Morris

Source	
yr[1]	100
cp[2]	99
Yr x cp	99
Blocks (yr x cp)	--
Till[3]	30
Yr x Till	80
Cp x Till	97
Yr x Cp x Till	97
Blocks (Yr x Cp x Till)	--
PD[5]	100
Yr x PD	100
Cp x PD	71
Yr x Cp x PD	86
Till x PD	47
Cp x Till x PD	29
Yr x Till x PD	62
Yr x PD x Till x Cp	4
Blocks x PD(YR x PD x Till)	—
RS[5]	100
Yr x Rs	100
Ca x Rs	94
Till x Rs	14
PD x Rs	56
Cp x Yr x Rs	75
Yr x PD x Rs	94
Cp x Till x Rs	55
Yr x Till x Rs	59
Till x PD x Rs	60
Cp x PD x Rs	99
Cp x Yr x Till x Rs	24
Cp x Till x PD x Rs	41
Cp x Yr x PD x Rs	93
Yr x Till x Pd x Rs	99
Cp x Yr x Till x PD x Rs	68
Blocks x Rs (Yr x Cp x Till x PD)	—

Source	
yr[1]	100
cp[2]	100
Yr x cp	100
Block (yr x cp)	—
Till[4]	14
Yr x Till	73
Cp x Till	100
Yr x Cp x Till	99
Blocks x Till (Yr x Cp)	--
PD[5]	100
Yr x PD	99
Cp x PD	26
Yr x Cp x PD	97
Till x PD	84
Cp x Till x PD	65
Yr x Till x PD	52
Yr x Cp x Till x PD	55
Blocks x PD (Yr x Cp x Till)	—

1. Years: 1982, 1983, 1984
2. Previous Crops: Wheat and Corn
3. Tillage: moldboard plow, chisel plow, spring dics & no till
4. Tillage: moldboard plow, chisel plow, spring dics, till plant-ridge, and till plant no ridge
5. Planting Date: early (4/28-5/18) and late (5/20-6/2)

Table 3A: Levels of signficance of treatment effects on soybean yields at Waseca and Lamberton, MN for 1982, 1983, and 1984.

Waseca and Lamberton			
Source		Source	
Yr[1]	100	Yr[1]	100
Loc[2]	99	Loc[2]	98
Yr x Loc	100	Yr x Loc	100
Blocks (Yr x Loc)	--	Blocks (Yr x Loc)	--
Till[3]	95	Till[3]	99
Yr x Till	92	Yr x Till	100
Loc x Loc	53	Loc x Till	84
Yr x Loc x Till	95	Yr x Loc x Till	90
Blocks x Till (Yr x Loc)	--	Blocks x Till (Yr x Loc)	--
PD[4]	100	PD[4]	100
Yr x PD	90	Yr x PD	70
Loc x PD	100	Loc x PD	100
Yr x Loc x PD	100	Yr x Loc x PD	100
Till x PD	43	Till x PD	51
Loc x Till x PD	67	Loc x Till x PD	82
Yr x Till x PD	66	Yr x Till x PD	44
Yr x Loc x Till x PD	83	Yr x Loc x Till x PD	8
Blocks x PD (Yr x Loc x Till)	--	Blocks x PD (Yr x Loc x Till)	--
Rs[5]	100		
Yr x Rs	83		
Loc x Rs	15		
Till x Rs	7		
PD x Rs	39		
Yr x Loc x Rs	7		
Yr x PD x Rs	5		
Loc x Till x Rs	25		
Yr x Till x Rs	43		
Till x PD x Rs	67		
Loc x PD x Rs	43		
Yr x Loc x Till x Rs	87		
Loc x Till x PD x Rs	31		
Yr x Loc x PD x Rs	20		
Yr x Till x PD x Rs	83		
Yr x Loc x Till x Pd x Rs	88		
Blocks x Rs (Yr x Loc x Till x PD)	--		

Figure 1: The effect of tillage previous crop, row spacing, and year on soybean yields at Morris, MN.

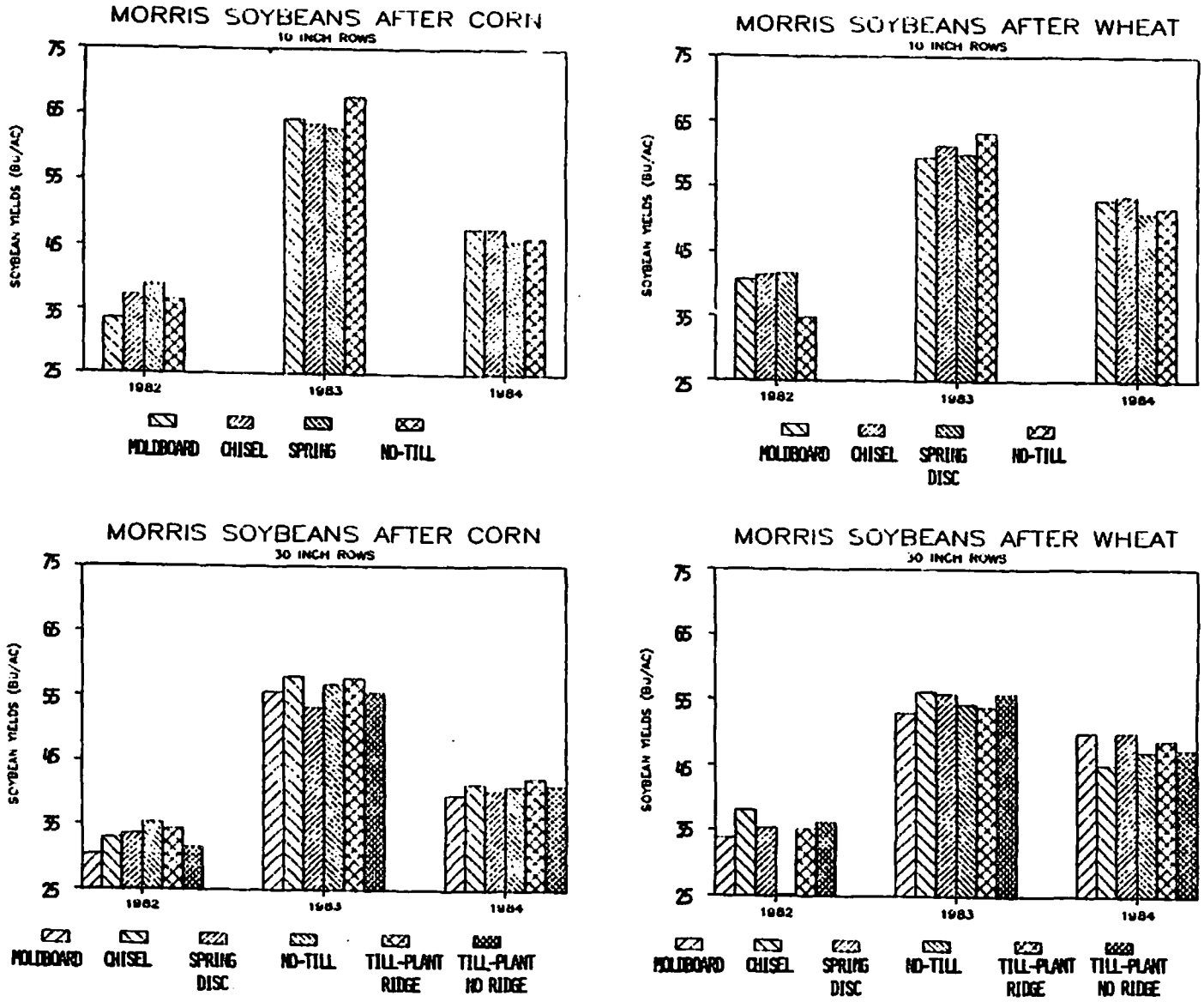


Figure 2: The effect of tillage, row spacing and year in soybean yields at Lamberton and Waseca, MN.

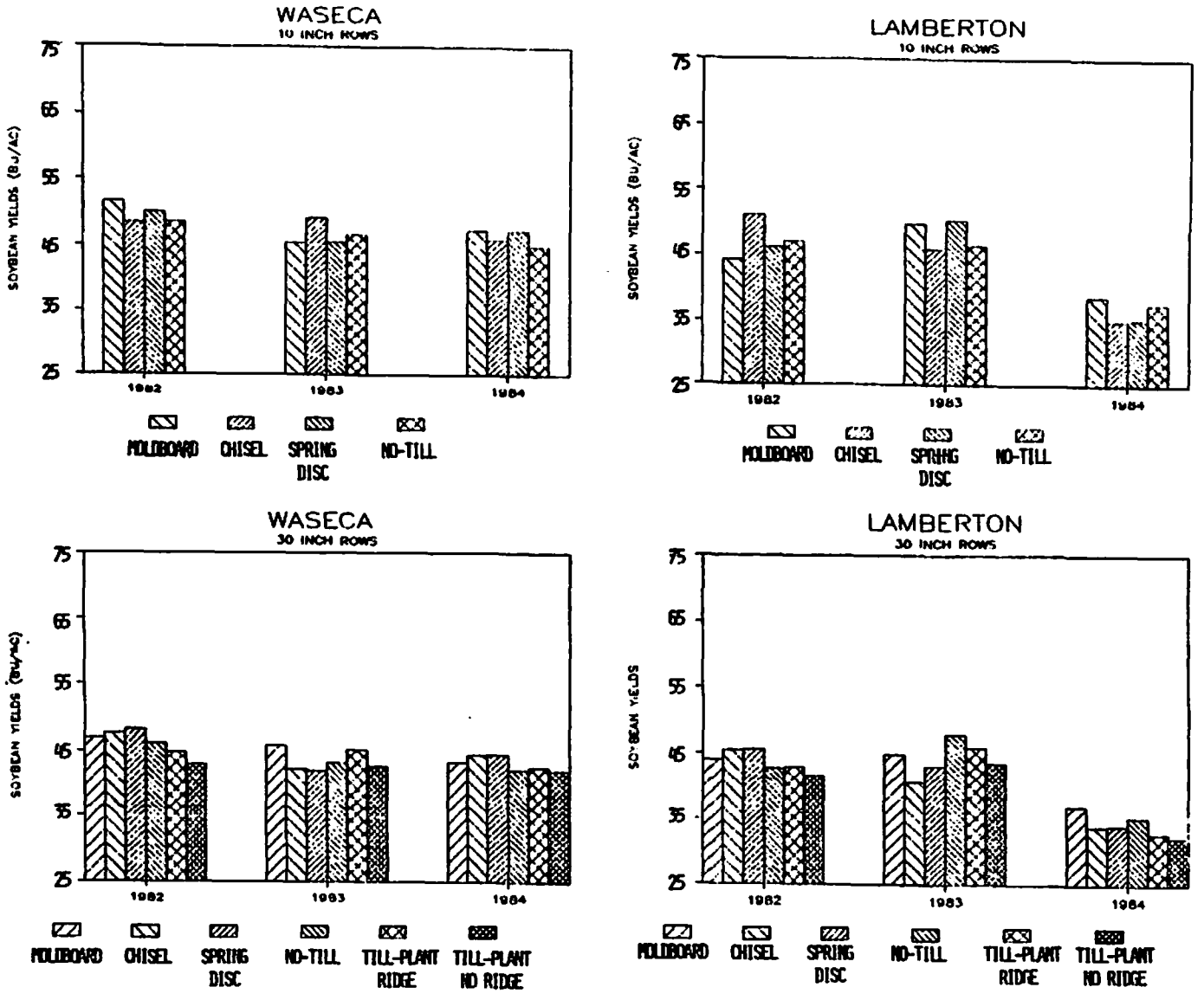
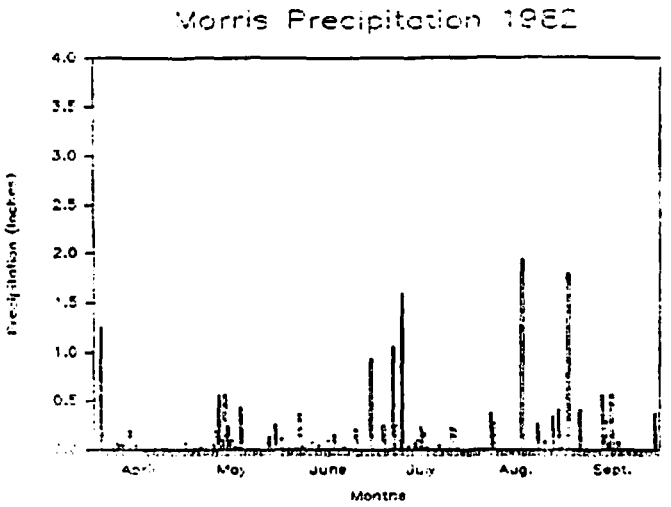
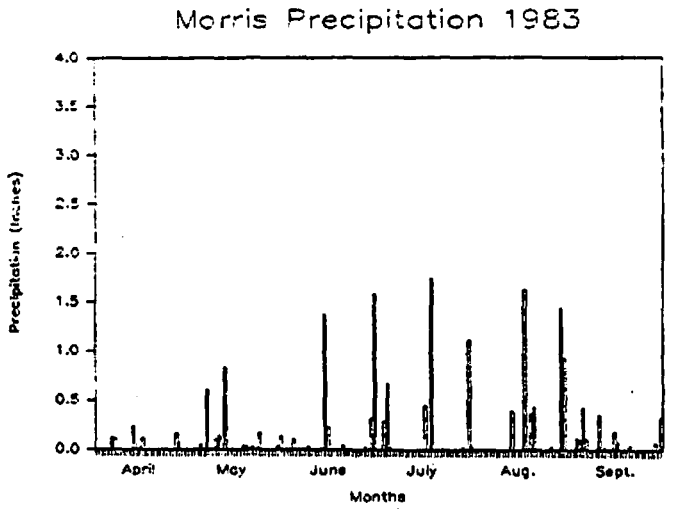


Figure 3a: Growing season precipitation for Morris respectively for 1982, 83,84.





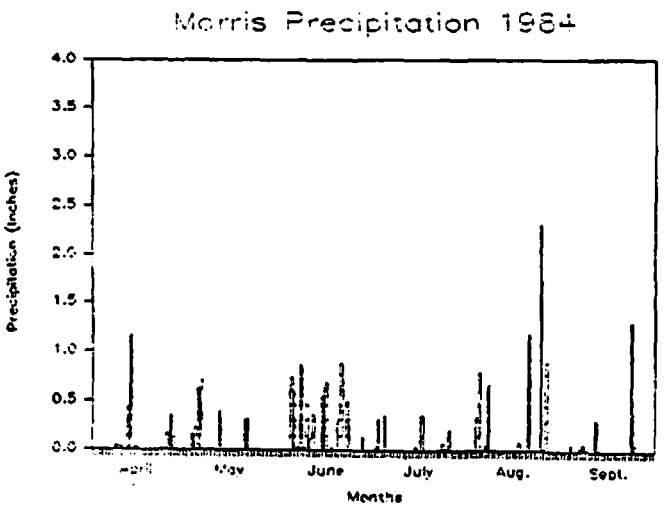
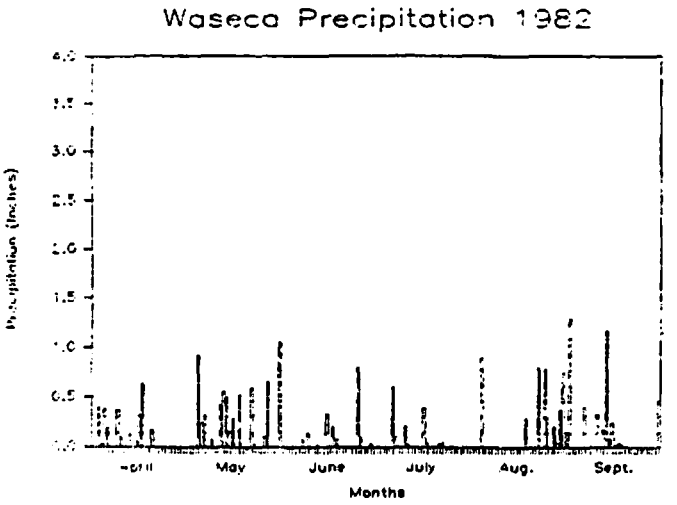
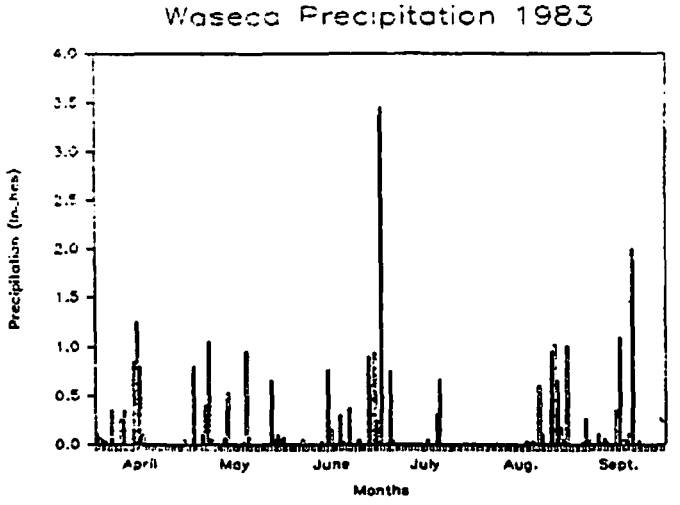


Table 3b: Growing season precipitation for Waseca respectively for 1982, 83, 84.





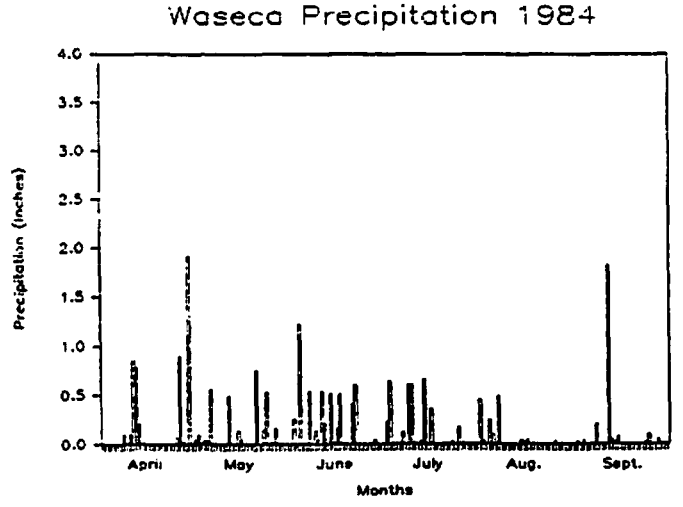
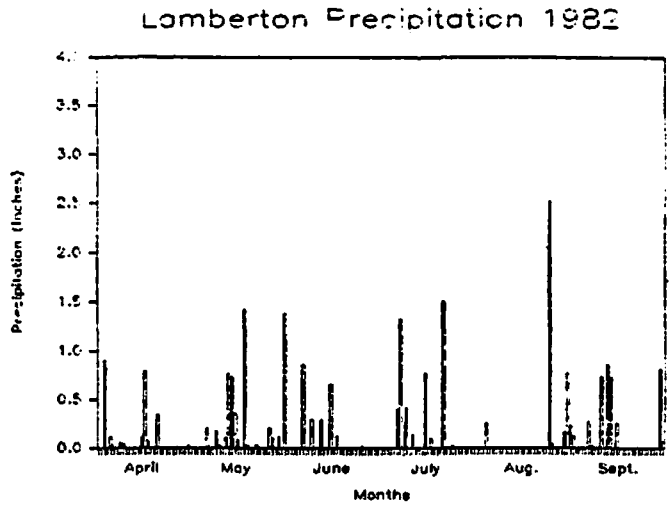
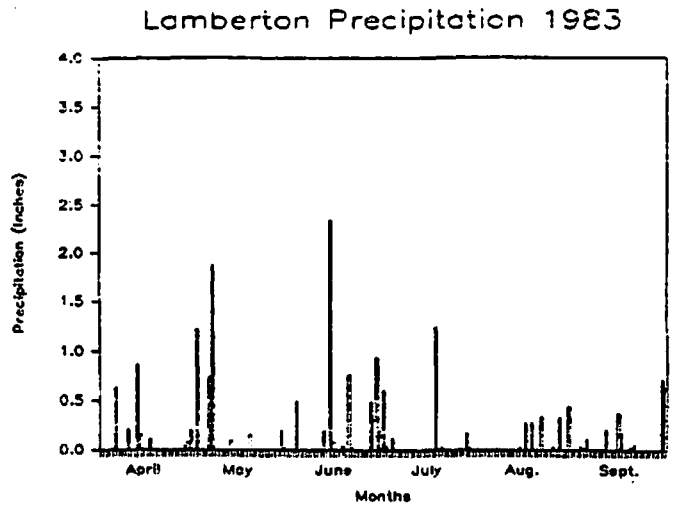
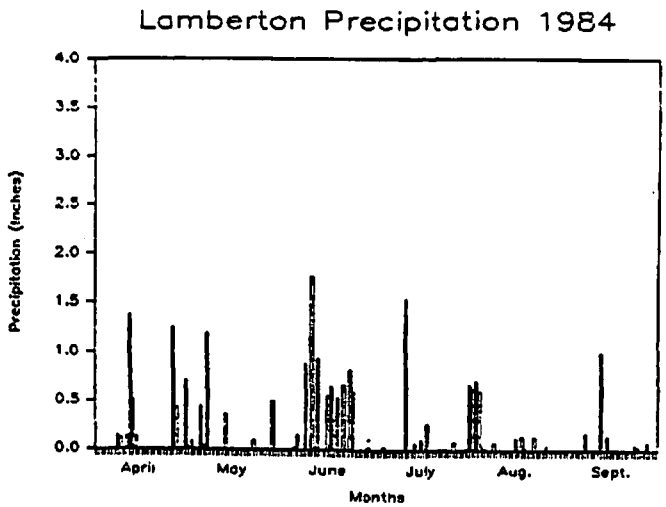


Table 3c: Growing season precipitation for Lamberton respectively for 1982, 83, 84.







RESEARCH IN WILD RICE FERTILIZATION - 1984

John Grava, Michael Meyer and Paul R. Bloom

Research during 1984 focused on nitrogen fertilization and nitrogen loss mechanisms in paddy soil and water. Soil, water and air temperatures were monitored during the growing season at Grand Rapids and St. Paul. A nitrogen source experiment was conducted with the K2 variety on a mineral soil at Grand Rapids, and a second experiment on peat in 4 x 4 ft. boses at St. Paul.

A. WEATHER CONDITIONS AND PLANT DEVELOPMENT

Average air temperatures at four locations were below normal during May, near normal during June, followed by below normal July and above normal during August (Table 1.).

Soil, water and air temperatures were measured at Grand Rapids within the experimental paddy No. 1 East, and on the St. Paul Campus within an area where experiments in 4 x 4 boxes were conducted (Fig. 1 and 2).

At Grand Rapids, K2 wild rice emerged on May 26, reached the jointing stage on July 6, 41 days after emergence and was harvested on August 23, 91 days after emergence. At St. Paul, K2 wild rice was seeded on May 14, reached the jointing stage on July 5 and reached maturity on August 22.

B. NITROGEN SOURCE STUDIES ON MINERAL SOIL

A nitrogen source and placement experiment with 2nd year stand of K2 wild rice was conducted in paddy No. 1 East at the North Central Experiment Station, Grand Rapids. The soil is classified as an Indus clay loam (very fine, montmorillonitic, frigid Typic Ochraqualf). Soil tests (Table 2) indicated a very high level of Bray-1 extractable phosphorus (102 lb/A) and a medium level of exchangeable potassium (195 lb/A).

Nitrogen fertilizers included in the experiment were as follows: granular urea (GU), 46% N; sulfur coated urea (SCU), 37% N; isobutylidene diurea (IBDU), 31% total N (28% water insoluble, 3% water soluble). Nitrogen was applied at a rate of 40 lb/A, either on May 15 and incorporated into the soil by rototilling or topdressed at jointing on July 6. A radomized block design was used in this experiment. Each treatment was replicated four times. Individual plots occupied a 14 x 14 ft. area and were separated from adjoining plots by 5 ft. wide alleys. Water level was maintained at 8 to 12 inches. Ten plants were collected at random from each plot at jointing, and five plants at late flowering for weight measurement and plant analysis. A 32 sq. ft. area from each plot was hand-harvested on August 23.

Individual plants at jointing had accumulated over 2 grams of dry matter (Table 3). All nitrogen fertilizers increased the plant weight above the control when incorporated into the soil. Deep placed granular urea produced the largest plants which accumulated 75 milligrams of nitrogen each. Surface applied urea had no effect on growth, nitrogen concentration of 2nd leaf or N uptake by wild rice. Fertilization with IBDU was nearly as effective as deep placed granular urea. At late flowering the plant had accumulated from 8.69 to 12.43 grams of dry matter and from 116 to 170 milligrams of nitrogen (Table 4). The grain yield (7% moisture) ranged from 212 to 314 pounds per acre (Table 4). Although deep placed nitrogen fertilizers tended to produce bigger plants and more grain than the control, however, the differences were not significant.

The growth of wild rice in this experiment was affected by a heavy infestation of water plantain. Although the stand was hand-weeded on July the weed problem became more serious as the season progressed. Water plantain appeard to affect the stand density, growth and tillering of wild rice and minimized the effectiveness of nitrogen.

Table 1. Average air temperature as measured at four weather stations.[1/]

Station Year	Month April	May	June	July	August	5 Month Average	GDD T_b=40
	----------average air temperature, °F ----------						
Fosston, Polk Co.							
Normal[2/]	41.0	54.6	63.6	69.4	67.5	59.2	2955
1974	41.0	50.5	63.4	71.6	62.8	57.9	2744
1975	34.8	55.7	61.9	70.5	64.6	57.5	2852
1976	46.6	54.9	66.8	68.8	70.9	61.6	3315
1977	49.1	66.4	64.6	70.3	60.6	62.2	3446
1978	41.7	59.2	63.4	67.8	67.7	60.0	3060
1979	36.0	48.7	63.6	69.6	63.6	56.3	2627
1980	48.9	61.3M[3/]	68.5	71.0	64.6	62.9	3466
1981	44.4	55.3	60.8	68.1	65.7	58.8	2898
1982	37.0	55.1	55.5	66.8	63.0	55.5	2477
1983	37.7	50.5[4/]	63.7[4/]	69.0	68.5	57.9	2819
1984	45.0	52.6	63.4	67.8	70.2	59.8	2906
Grand Rapids, N.C. School							
Normal	39.9	52.7	62.0	67.4	65.1	57.4	2681
1974	41.6	49.4	62.7	70.7	62.8	57.4	2670
1975	34.7	57.0	62.2	71.5	65.2	58.1	2951
1976	47.1	54.4	66.1	68.2	67.4	60.6	3166
1977	48.2	63.8	64.0	69.2	60.2	61.1	3284
1978	41.3	57.9	62.8	66.5	66.0	58.9	2892
1979	37.1	49.5	61.5	68.1	62.6	55.8	2511
1980	46.1	59.9	64.0	69.0	66.4	61.1	3237
1981	43.9	54.8	62.0	68.0	67.0	59.1	2941
1982	38.6	57.7	58.5	68.0	64.4	57.6	2753
1983	39.0	49.7	62.5	71.1	70.1	58.5	2873
1984	44.6	50.8	63.8	67.8	69.6	59.3	2842
Aitkin							
1974	42.9	49.8	63.1	71.1	63.3	58.0	2770
1975	39.0M	59.4M	64.4M	72.1	66.2M	60.2	3141
1976	47.5	54.8	66.8	69.3M	68.1	61.3	3267
1977	48.3M	64.4M	65.4M	70.3M	61.0	61.9	3446
1978	40.7M	57.5,	64.1M	67.0M	66.9	59.2	2938
1979	37.7	50.6	62.0	68.1M	63.4	56.4	2585
1980	53.9	58.3	64.0	68.5	66.0	62.1	3394
1981	45.1M	53.8	62.1M	67.5	66.0	58.9	2902
1982	38.3	57.4	57.6	68.6	64.8	57.3	2723
1983	39.6M	49.3M	60.3M	72.1M	71.9M	58.6	2881
1984	43.9	53.9M[5/]	64.4	69.1[5/]	69.3	60.1	2985
St. Paul, U of M							
1982	43.4	61.3	62.4	73.9	67.3	61.6	3332
1983	42.1	55.2	68.7	76.4	76.0	63.7	3640
1984	47.7	57.2	69.1	72.2	73.9	64.0	3478

1/ Source: Climatological Data, Minnesota, Vol. 90 (1984), U.S. Dept. of Commerce.
2/ Normals for the period 1931-1960.
3/ M = less than 10 days record missing.
4/ Northwest Divisional Data.
5/ East Central Divisional Data.

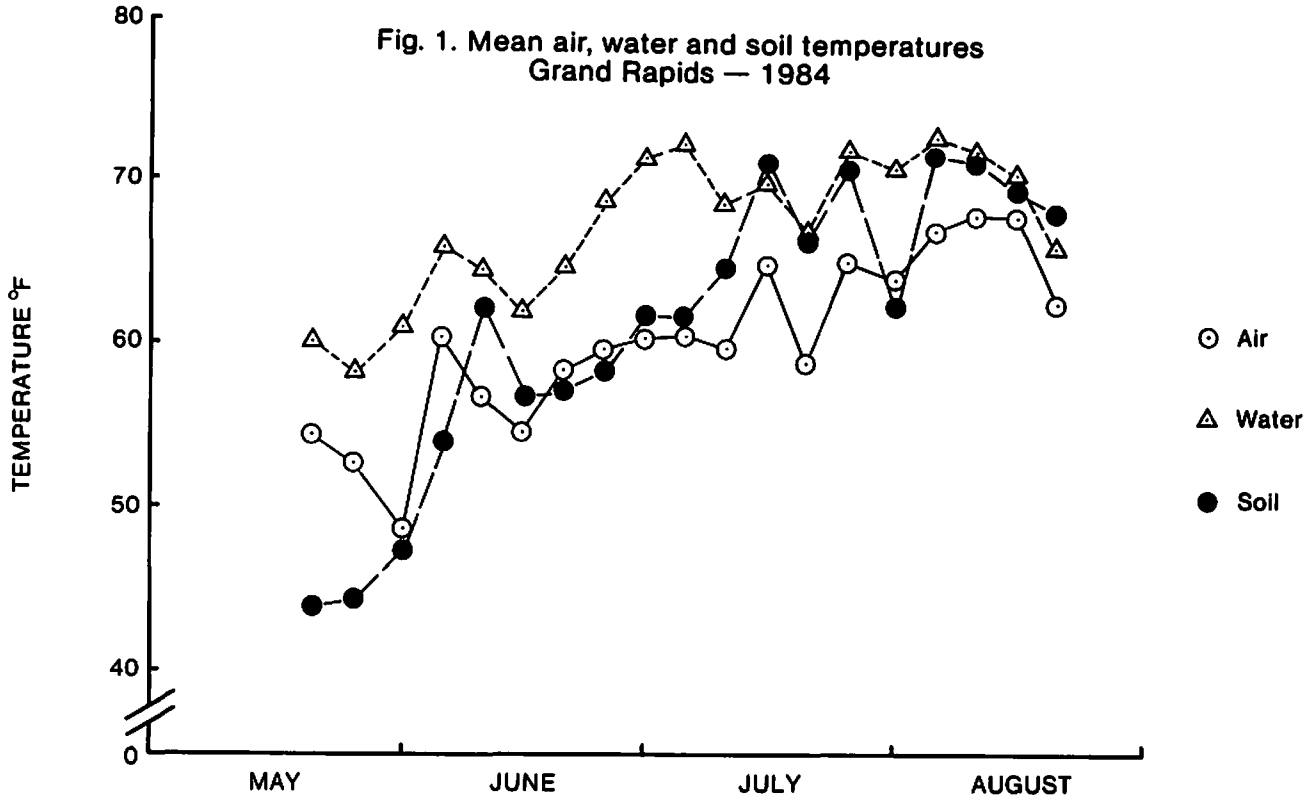


Fig. 1. Mean air, water and soil temperatures
Grand Rapids — 1984
TEMPERATURE °F
80
70
60
50
40
0
MAY
JUNE
JULY
AUGUST
Air
Water
Soil

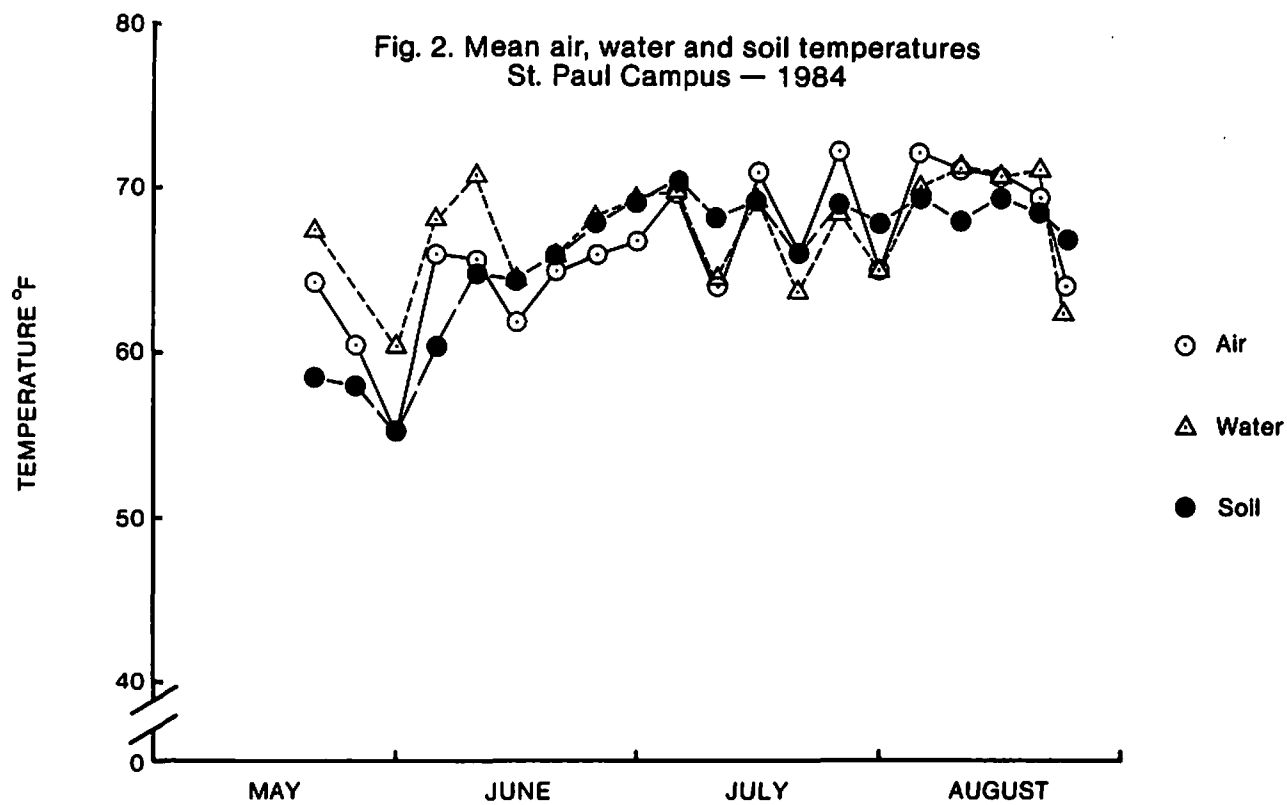


Fig. 2. Mean air, water and soil temperatures
St. Paul Campus — 1984
TEMPERATURE °F
80
70
60
50
40
0
MAY
JUNE
JULY
AUGUST
Air
Water
Soil

Table 2. Soil test values of experimental paddy No. 1 East, Grand Rapids[1)]

pH	Extract-able P pp2m	Exchange-able K pp2m	Nitrate-N lb/A	Organic Matter %	Zn ppm	S ppm	Cu ppm	Mg pp2m
5.6	102	195	17	2.8	7	8	1.7	514

1) Samples collected from 0-6 inch depth on 5/15/84.

Table 3. Effect of nitrogen source and placement on weight of dry matter, N-concentration in 2nd leaf, and total uptake of N by the wild rice plant at jointing. Grand Rapids, 1984.

Treatment	Dry matter grams per plant	N% in dry matter of 2nd leaf	N uptake in milligrams per plant
1. Control	2.08	3.05	49
2. GU, Surf applied	2.06	3.13	47
3. GU, 4-inch depth	2.92	3.30	75
4. SCU, 4-inch depth	2.20	3.23	57
5. IBDU, 4-inch depth	2.52	3.51	70
Significance	*	ns	**
BLSD (0.05)	0.11	0.43	15
C.V., %	13	7	17

Table 4. Effect of nitrogen source and placement on grain yield, dry matter production and total N uptake at late flowering. Grand Rapids, 1984.

Treatment	Grain yield lb/A[1/]	Dry matter at late flowering grams per plant	Total N uptake milligrams per plant
1. Control	224	8.91	119
2. GU, Surf applied	212	8.69	116
3. GU deep placed	300	12.43	170
4. SCU	282	11.34	164
5. IBDU	314	11.28	148
Significance	ns	ns	ns
BLSD (0.05)			
C.V., %	23	23	28

[1/] 7% moisture

C. NITROGEN SOURCE STUDIES IN BOXES

A nitrogen source and placement experiment was conducted in 4 x 4 wooden boxes on the St. Paul Campus. The following four nitrogen fertilizers were investigated: granular urea (GU); urea supergranule (USG), 2 gram granule; sulfur coated urea (SCU); and isobutylidene diurea (IBDU). Seven fertilizer treatments were replicated four times. Nitrogen fertilizers were applied at an 80 lb/A rate; all boxes received 60 lb P_2O_5/A and 120 lb. K_2O/A.

A 12-inch thick layer of partly decomposed hypnum peat (hemic), pH 6.4, was placed in the boxes. Properties of the peat are reported in Table 5. Phosphorus, potassium and deep placed nitrogen fertilizers were covered with a 4-inch unfertilized layer of peat. Seed of K2 variety was placed in rows and covered with about 1-inch layer of peat on May 14. On-surface application of nitrogen was made after seeding. Two extra boxes with deep placed granular urea were set up; No. 51 with wild rice and No. 52 without wild rice. The water depth in all boxes was maintained at 6 inches. In a split-application treatment, half of the granular urea was deep placed (4-inches) at seeding and half topdressed at jointing on July 5. Copper sulfate was applied to all boxes to control algae.

The wild rice plants were vigorous and lodged readily. Nitrogen produced dark green colored leaves and stems in contrast to the light green-yellowish colored plants of the control. Average plant density was 27 plants per box.

The grain yield (7% moisture) ranged from 173 to 274 grams per box (Table 6). Calculated on a field basis, the yield would correspond to 1179 and 1864 lb/A of grain. All applications of nitrogen produced significantly more grain than the control. Deep placed SCU and USG produced higher yield than IBDU and surface applied GU.

Ammonium N Depletion in Peat by Wild Rice

Two of the boxes at the St. Paul Campus were set aside for the study of the depletion of available nitrogen by a wild rice crop. Both boxes received 80 lb N/A as granular urea placed at the 4-inch depth. Box No. 51 was seeded with wild rice, Box No. 52 was maintained without plants. Wild rice in Box No. 51 produced 280 grams (1907 lb/A) of grain (7% moisture). Three ceramic cups 6.3 cm in diameter with 100 cm long plastic tubes were placed in each box to a depth of 15 cm. Soilwater was extracted from the tubes for ammonium N analysis.

Soil samples were collected from the boxes with a Macaulay peat sampler at 0-20 cm and 20-38 cm depths. Random triplicate samples were collected from each box on four different dates (6/11, 6/25, 7/13, 8/2). A grid sampling system insured that the same spot was not penetrated more than once with the sampler. Soil samples were extracted with 1M KCl and distilled. Ammonium N in soilwater was determined by direct distillation.

The amounts of ammonium N in soilwater and in the soil are reported in Tables 7 and 8. There was a slight increase in ammonium N from June 11 to June 25. This may have been due to mineralization of organic N in peat as the soil temperature increased. A striking decrease in ammonium N in soilwater and in the soil occurred in Box No. 51 with wild rice between June 25 and July 13. This coincided with the date of jointing on July 5, and early boot about a week later. Our previous research has shown that wild rice takes up 70% of total nitrogen between the jointing stage and maturity. It is evident that at the start of jointing the plant uptake of N is very great and acts as a sink for nitrogen.

In the box with wild rice, nitrogen depletion in the 20-38 cm zone was equal to that in the 0-20 cm zone. This demonstrates that wild rice in peat is able to utilize nitrogen from well below the reported rooting depth of 20 cm.

CONCLUSIONS

Nitrogen incorporation into the soil at the 4-inch depth during seedbed preparation was superior to on-surface application. Granular urea was as effective as the more expensive slow-release sources of nitrogen.

Table 5. Soil test values of peat. St. Paul, 1984

pH	Extractable P pp2m	Exchangeable K pp2m	Zn ppm	S ppm	Cu ppm	Mg pp2m	Ash %
6.4	11	29	5.7	38	0.9	648	27.5

Table 6. Effect of nitrogen source placement and time of application on grain yield of wild rice grown on peat in 4 x 4 ft. boxes. St. Paul, 1984

Treatment	Grain yield grams per 14 sq. ft. area 1/
1. Control	173
2. GU, Surf applied	227
3. GU, 4-inch depth	242
4. USG, 4-inch depth	265
5. SCU, 4-inch depth	274
6. IBDU, 4-inch depth	221
7. GU, Split-application 2/	252
Significance	**
BLSD (0.05)	34
C.V., %	121

1/ 7% moisture

2/ Split-application = 1/2 prior to seeding, 4-inch depth; 1/2 topdressed at jointing.