Table 7. Summary of soil nitrate-N levels in irrigated potato fields over the growing season. Means and ranges of six commercial potato fields.

Ranges in total N fertilizer applied: 166 - 380 lb N/A
Ranges in total yield: 210 - 456 cwt/A

April 1988

Depth (ft)	Mean	Range
	lb NO_3-N/A	
0 - 1	15.8	2.4 - 36.0
1 - 2	11.2	2.4 - 30.0
2 - 3	9.6	3.2 - 16.8
Total	36.1	11.6 - 79.6

July 1988

Depth (ft)	Within Row Mean	Within Row Range	Between Row Mean	Between Row Range
	lb NO_3-N/A			
0 - 1	50.4	8.4 - 161.4	19.9	5.0 - 80.4
1 - 2	16.8	3.2 - 44.4	6.6	0.8 - 13.6
2 - 3	6.1	1.2 - 10.4	4.0	0.8 - 8.0
Total	73.7	12.8 - 186.2	30.4	9.8 - 94.0
Total in row + between row			104.1	23.2 - 279.0

September 1988

Depth (ft)	Within Row Mean	Within Row Range	Between Row Mean	Between Row Range
	lb NO_3-N/A			
0 - 1	16.5	5.4 - 31.2	11.3	3.2 - 16.8
1 - 2	14.6	3.0 - 29.8	5.3	3.0 - 8.8
2 - 3	8.5	2.4 - 15.4	4.9	2.4 - 7.0
Total	39.6	10.8 - 74.2	21.4	9.6 - 30.0
Total in row + between row			61.0	20.4 - 102.0

Table 8. Summary of soil ammonium-N levels in irrigated potato fields over the growing season. Means and ranges of six commercial potato fields.

April 1988

Depth (ft)	Mean	Range
	lb NH_4-N/A	
0 - 1	4.9	1.5 - 10.6
1 - 2	5.2	1.9 - 10.9
2 - 3	3.8	1.2 - 7.9
Total	13.9	6.1 - 29.4

July 1988

Depth (ft)	Within Row Mean	Within Row Range	Between Row Mean	Between Row Range
	lb NH_4-N/A			
0 - 1	23.0	5.5 - 42.0	13.2	1.1 - 56.4
1 - 2	4.5	2.2 - 6.2	2.5	0.6 - 7.4
2 - 3	2.3	1.7 - 3.2	1.7	0.9 - 2.6
Total	29.8	9.6 - 48.5	17.4	2.6 - 66.0
Total in row + between row			47.2	15.9 - 114.0

September 1988

Depth (ft)	Within Row Mean	Within Row Range	Between Row Mean	Between Row Range
	lb NH_4-N/A			
0 - 1	3.7	0.8 - 14.8	1.5	1.0 - 3.0
1 - 2	1.3	1.0 - 1.8	1.2	0.8 - 2.0
2 - 3	1.3	0.8 - 2.1	0.9	0.8 - 1.2
Total	6.3	2.6 - 6.7	3.6	2.8 - 18.7
Total in row + between row			9.9	6.4 - 22.5

EFFECT OF RATE AND PLACEMENT OF POTASSIUM ON EARLY GROWTH AND YIELD OF CORN.

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

ABSTRACT: Recent concerns for farm profitability have stimulated interest in placement of potash fertilizer for corn production. This study was initiated to evaluate broadcast and starter application of potash on the yield of 2 corn hybrids grown on a soil having a low to medium soil test for K. Early growth, K uptake, and grain yield were hindered by the 1988 drought. There was no significant response to applied K. When averaged over all rates of applied K and both placements, yield from Pioneer 3737 was significantly higher than the yield from the Pioneer 3732 variety.

Background and Justification:

The recent crisis in farm profitability and current attention to lower inputs in agriculture has stimulated a considerable amount of interest in fertilizer placement. There is considerable research to show that lower rates of fertilizer P are needed if phosphate is applied in a band close to the seed rather than broadcast and incorporated before planting. This practice reduces fertilizer cost thereby improving profitability. Since K, like P, is relatively immobile in soils, we can anticipate that the same principle will apply with this nutrient. Studies which focus on the effect of placement of fertilizer K on crop growth are very limited.

Soils in southeast Minnesota typically have low to medium levels of soil test K. These soils also usually have the ability to fix or "tie up" some of the fertilizer K needed for crop production in the region. In addition, substantial amounts of K are removed from the soil system when corn silage (a common use of corn) is harvested as part of the dominant dairy enterprise in the region.

From farmer experience, there is also some indication that corn hybrids may differ in their response to the use of fertilizer K. There has been no research information to support these observations.

The effect of placement of fertilizer K on corn production had not been studied extensively in Minnesota. Therefore, the study described in this report was designed to measure the effect of rate and placement of fertilizer K on early growth and yield of two corn hybrids in southeast Minnesota.

Experimental Procedures:

This study was conducted in Olmsted County in 1988. Soil samples were collected prior to fertilizer application.

Table 1. Relevant soil properties for the experimental site.

pH	5.8
P (Bray & Kurtz #1), lb./acre	34
K (1 N $NH_4C_2H_3O_2$), lb./acre	123
organic matter, %	2.6

Four rates of K (0, 40, 80, 160, 320) supplied as 0-0-60 were broadcast in mid-April. Urea was also applied at this time to supply 189 lb. N/acre. These fertilizers were incorporated with the disk soon after application.

Corn was planted on May 16. The 0-0-60 was used to supply 0, 20, 40, 80, and 160 lb. K/acre in a starter fertilizer at planting. In addition to the various rates of K, the starter supplied 23 lb. N and 23 lb. P_2O_5 per acre. All broadcast and starter treatments were applied to two hybrids (Pioneer 3732, Pioneer

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

3737). The planted population was 27,000 plants per acre. The recommended rate of the Lasso-Bladex combination was applied preemergence for weed control.

Whole plant samples were collected at 4 to 5 weeks after emergence. These samples were dried, weighed, ground, and analyzed for K. Potassium uptake was calculated from the plant weight and K concentration values. Grain yields were measured in mid-October.

Results and Discussion:

Grain Yield

The 1988 grain yields were depressed by the dry weather. Consequently, rate and placement of fertilizer K had no significant effect on yield. Yields resulting from broadcast applications are summarized in Table 2 while yields resulting from the starter placement are listed in Table 3.

Table 2. The effect of broadcast applications of K on the yield of two corn varieties. Olmsted County, 1988.

K Rate	Variety: Pioneer 3732	Variety: Pioneer 3737
lb./acre	bu./acre	
0	102.0	107.5
40	100.6	115.6
80	97.9	117.9
160	91.8	104.1
320	87.1	104.3
Ave:	95.9	109.9

Table 3. Effect of rate of K applied in a starter fertilizer on the yield of two corn varieties. Olmsted County, 1988.

K Rate	Variety: Pioneer 3732	Variety: Pioneer 3737
lb./acre	bu./acre	
0	97.0	101.8
20	100.8	128.8
40	97.6	110.0
80	93.3	102.5
160	96.8	112.4
Ave:	97.1	110.1

The lack of a response to fertilizer K indicates that this soil was capable of supplying the K needed to support a corn crop of approximately 100 bu./acre. If drought had not limited yields, a response to fertilizer K could have been expected.

Grain yield was significantly affected by the variety used. With both broadcast and starter placement of K, the yield from the Pioneer 3737 variety was significantly higher than the yield from the Pioneer 3732 variety. The yield difference was approximately 13 bu./acre for both placement situations.

Early Growth

Six whole plants were taken from each plot at 4 to 5 weeks after emergence to get a measure of the effect of treatment used on early growth. When K was broadcast, early growth was not affected by the rate of K applied (Table 4). The rate of K applied in the starter, however, produced significant differences in the weight of young corn plants (Table 5). This trend was toward a linear decrease over the range of K rates used. There is no ready explanation for the reduction in early growth with increasing rate of applied K.

Table 4. The influence of rate of broadcast K on the early growth of two corn varieties. Olmsted County, 1988.

K Rate	Variety: Pioneer 3732	Variety: Pioneer 3737
lb./acre	- - - - weight of 6 plants, gm. - - - -	
0	42.3	41.5
40	45.8	38.3
80	44.3	32.3
160	35.8	35.5
320	45.5	42.8
Ave:	42.7	38.1

Table 5. The effect of rate of K applied in a starter on the early growth of two corn varieties. Olmsted County, 1988.

K Rate	Variety: Pioneer 3732	Variety: Pioneer 3737
lb./acre	- - - - weight of 6 plants, gm - - - -	
0	42.5	32.0
20	60.0	46.8
40	41.8	38.5
80	37.5	31.3
160	28.0	31.8
Ave:	42.0	36.1

The variety used had no significant effect on early growth. This was consistent for both methods of K placement.

K Concentration

The effect of placement and variety on the concentration of K in young corn plants is summarized in Tables 6 and 7.

Table 6. The effect of rate of broadcast K on the K concentration in young corn plants, Olmsted County, 1988.

K Rate	Variety	
	Pioneer 3732	Pioneer 3737
lb./acre	- - - - - - - - - - % - - - - - - - - - -	
0	1.92	2.03
40	2.14	2.82
80	2.13	2.61
160	2.28	2.61
320	2.85	2.53
Ave:	2.26	2.72

Table 7. The influence of rate of K applied in a starter fertilizer on the K concentration in young corn plants, Olmsted County, 1988.

K Rate	Variety	
	Pioneer 3732	Pioneer 3737
lb./acre	- - - - - - - - - - % - - - - - - - - - -	
0	2.05	1.89
20	3.12	3.59
40	3.09	3.39
80	4.09	3.98
160	4.34	4.34
Ave:	3.34	3.44

As would be expected, the K concentration in the young corn plants increased as rate of applied K increased. The increase was linear for both broadcast and starter placement. Except for the control treatment, K concentration was higher when fertilizer K was applied near the seed at planting (starter placement). The use of 20 lb. K/acre in a starter produced a higher concentration than the broadcast application of 320 lb. K/acre. These data indicate that the K applied in a band near the seed at planting is used very effectively by the young corn plants. The root systems of the young plants were not able to effectively absorb the K that was broadcast and incorporated before planting.

K Uptake

Potassium uptake by the young plants was determined by multiplying dry weight by concentration values. Uptake values from broadcast and starter applications are summarized in Table 8 and 9 respectively.

Table 8. The effect of rate of K broadcast and incorporated before planting on the amount of K taken up by young corn plants. Olmsted County, 1988.

K Rate	Variety	
	Pioneer 3732	Pioneer 3737
lb./acre	- - - - - - gm in 6 plants - - - - - - -	
0	.81	.84
40	1.05	1.06
80	.97	.85
160	.93	.90
320	1.31	1.51
Ave:	.99	1.03

Table 9. The influence of rate of K applied in a starter fertilizer on the amount of K taken up by young corn plants. Olmsted County, 1988.

K Rate	Variety	
	Pioneer 3732	Pioneer 3737
lb./acre	- - - - - - gm in 6 plants - - - - - - -	
0	.86	.61
20	1.87	1.75
40	1.27	1.27
80	1.53	1.25
160	1.21	1.38
Ave:	1.35	1.25

The variety had no effect on K uptake. This was true for both placements.

Potassium uptake did increase with rate of K applied. This increase was linear for both the broadcast and the starter placement. Consistent with concentration values, K uptake was greater when the fertilizer K was applied in a starter. Potassium uptake during the latter part of the growing season was probably curtailed by the dry weather. Therefore, uptake values for early in the season were not related to yield.

Summary

There is very little to summarize from this study because yields were severely reduced by the very dry weather. Rate and placement of fertilizer K had no significant effect on grain yield of two varieties. The data collected from the analysis of young corn plants indicate that fertilizer K applied in bands close to the seed (starter fertilizer) is more readily absorbed than fertilizer K broadcast and incorporated before planting. This difference in uptake between the starter and broadcast applications was probably magnified by the dry year.

EVALUATION OF THE EFFICIENCY OF BAND PLACEMENT OF P FERTILIZER FOR CORN, SOYBEAN, AND WHEAT[1]

J.A. Lamb, G.W. Rehm, G.W. Randall, and W.W. Nelson[2]

ABSTRACT: The third year of a four-year study was completed looking at the effects of broadcast, knife, and starter placement of phosphorus on corn, soybean, and spring wheat in Minnesota. Preliminary conclusions are that broadcast application for soybean performed as well or better than the knife and starter placements. The starter placement for soybean did not perform well. In dry conditions, the knife placement may be superior because of the better soil moisture conditions at that placement point. Phosphorus application method in corn is not as crucial as originally thought. No one application method consistently performed superior under normal soil moisture conditions.

OBJECTIVE: Efficient P fertilizer use is continuing to be an important area of production management in finding the least cost method of production. Little information is available in the Northern Corn Belt about which methods application is best. Winter wheat growing areas (Kansas, Nebraska and Colorado), have found that a starter or row application of P can be many times more efficient than a broadcast application. This report is concerned with the results of the third year of a study conducted in Minnesota with the overall objective to evaluate the efficiency of band placement methods (starter, and knife) over the northern corn belt. Under this broad objective the two following specific objectives will be addressed.

1) Determine the efficiency of band applications of P as compared to broadcast on a spring wheat - soybean rotation in northwestern Minnesota and corn-soybean rotation at two locations in southern Minnesota.

2) Determine residual effects of band and broadcast placements of fertilizer P on P uptake and crop yield.

MATERIALS AND METHODS: The third of three years of this study was conducted in 1988 at Waseca, Lamberton, and Crookston, MN. Corn and soybeans were grown at Waseca and Lamberton and spring wheat and soybean grown at Crookston. Table 1 presents the soil test information for each location. The following variables were measured on corn at Waseca and Lamberton; grain yield, forage yield, forage P concentration and uptake, ear leaf P concentration at silking, and grain moisture content. Soybean variables measured at all locations were; grain yield, forage yield, forage P concentration and uptake, leaf P concentration at mid-flower, and grain moisture. At Crookston the parameters measured on the wheat were grain yield, grain protein content, bushel weight, grain moisture content, forage yield, and whole plant P concentration and uptake at anthesis. The grain moisture has been incorporated into the grain yield data. The corn, soybean, and wheat grain yields have been corrected to 15.5, 13.5, and 13.5% moistures, respectively. The wheat protein values are reported on a dry weight basis.

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

1 Funding provided by Fluid Fertilizer Foundation.

2 Assistant professor, professor, professor, and professor, Northwest Experiment Station, Crookston, MN; Soil Science Department, St. Paul, MN; Southern Experiment Station, Waseca, MN; and Southwest Experiment Station, Lamberton, MN.

Table 1. Soil test values for P-efficiency study, 1987.

	Crookston*		Waseca**		Lamberton**	
	Soybean	Wheat	Soybean	Corn	Soybean	Corn
pH	8.0	8.0	5.9	5.9	6.1	6.2
OM%	2.9	2.9	3.5	3.5	3.9	3.8
Salts mmho	0.3	0.3	-	-	-	-
NO_3^--N 0-24"	54	59	-	-	-	-
P lb A^{-1}	9	10	10	10	7	3
K lb A^{-1}	370	320	320	331	290	259

* $NaHCO_3$-P
** Bray-P

Table 2 lists the treatments that were established on all six sites. Four replications of a complete factorial arrangement of three methods of phosphorus placement and five phosphorus rates were established. The broadcast method was incorporated at all locations. The knife method at Waseca (corn

Table 2. Treatment description for project MN-1L.

Treatment Number	Factor: Placement	Factor: P Rate lb P/A
1	Broadcast	0**
2	Broadcast	10
3	Broadcast	20
4	Broadcast	30
5	Broadcast	40
6	Knife *	0
7	Knife *	10
8	Knife *	20
9	Knife *	30
10	Knife *	40
11	Starter +	0
12	Starter +	10
13	Starter +	20
14	Starter +	30
15	Starter +	40
16	Broadcast + Knife	20 + 20***
17	Broadcast + Starter	20 + 20***
18	Knife + Starter	20 + 20***

* 15-inch width at wheat-soybean location.
\+ 5-7 inches from row in soybean and corn - applied with seed in spring wheat.
** P rates are 0, 5, 10, 15, and 20 pounds P per acre at Crookston in 1987 and 1988.
*** At Crookston the P rate was 5 + 5.

and soybean) and Lamberton (corn and soybean), placed a preplant band of fertilizer at a 6-inch depth between the 30 inch width rows. At the Crookston (spring wheat) site the knife method placed preplant fertilizer 6 inches deep with a shank spacing of 15 inches. The knife method for Crookston soybean was two 15-inch width preplant bands between the 30-inch rows applied at a 6-inch depth. The starter method at Waseca (corn and soybean), Lamberton (corn and soybean), and Crookston (soybean) involved a band of fertilizer applied at planting 5 to 7 inches from the row and 2.5 to 3 inches deep. The Crookston (spring wheat) site starter treatment involved placement of fertilizer directly with the seed. At Waseca and Lamberton the phosphorus rates were 0, 10, 20, 30 and 40 lb P A^{-1}. At Crookston, the rates were 0, 5, 10, 15 and 20 lb P A^{-1}. Ammonium polyphosphate, 10-34-0, was the P source at all locations. Three extra treatments were added to the factorial to test effect of combined application methods. These were 20 + 20 lb P/A (5 + 5 lb P A^{-1} at Crookston) broadcast + knife, broadcast + row, and row + knife (Table 2). They were analyzed statistically as a method comparison with the broadcast, knife, and row treatment at the 40 lb P A^{-1} levels (10 lb P A^{-1} at Crookston).

RESULTS AND DISCUSSION:

Crookston - Spring Wheat - 1988: In 1988, grain yield and whole plant uptake were increased by the addition of phosphorus. The grain yield was maximized at the 5 pound P per acre (Table 3). The increase was five bushels per acre. No method effect occurred. The plant P uptake was affected similarily with a 1.8 pound per acre increase with 5 pounds P per acre rate maximizing uptake.

Crookston - Soybean - 1988: Grain yield was increased 6 bushels per acre by P fertilization (P=0.10, Table 3). The maximum yield occurred at 15 pounds P per acre. Again, method of application did not effect grain yield.

Lamberton - Corn - 1988: In 1988, the corn grain yield, young plant P concentration and young plant P uptake at Lamberton were significantly increased by P fertilization and method of application (Table 4). Both grain yield and young plant P uptake were increased linearly from 0 to 40 pounds P/acre treatment. The knife treatment increased grain yield and young plant P uptake greater than the broadcast applications. The starter application grain yield and young plant P uptake was intermediate. There was a significant method by P rate interaction for young plant P concentration. Phosphorus applied as starter or knife significantly increased the young plant P concentration. Broadcast applications of P did not effect the P concentrations. The knife application caused greater P concentrations than starter.

Lamberton - Soybean - 1988: Grain yield, forage yield, trifoliate leaf P concentration, whole plant P concentration, and P uptake were significantly increased by P application (Table 4). Knife P application caused the greatest grain yield. Broadcast P application increased the grain yield the least. The starter treatment was intermediate. Forage yield, whole plant P concentration, and P uptake were increased the most by knife application of P. Broadcast and starter application methods performed significantly poorer than knife P applications. Trifoliate leaf P concentrations were effected by a P rate by method of application interaction. Trifoliate leaf P concentrations were not effected by broadcast P application. The knife and starter methods increased the P concentration of the trifoliate leaf with increased application of P fertilizer. Knife P application increased leaf P greater than the starter method.

Waseca - Corn - 1988: Grain yield, young plant P concentration, young plant P uptake, and ear leaf P concentration were significantly increased with P applications (Table 5). These increases were linear increasing with increased rates of P.

Waseca - Soybean - 1988: Phosphorus application increased grain yield, forage yield, trifoliate leaf P concentration, whole plant P concentration, and P uptake of soybeans at Waseca (Table 5). Whole plant P concentration and P uptake responses were not effected by application methods. Grain yield, forage yield, and trifoliate leaf P concentration were greater when P was knife applied. The starter application caused the smallest increases with broadcast application only doing slightly better.

Table 3. Means and statistical analyses for Crookston spring wheat, 1988.

		Spring Wheat						Soybean				
Method	P Rate lb/A	Yield Bu/A	Forage lb/A	Plant P ppm	P Uptake lb/A	Plant Population Plant/A	Bushel wt. lb/Bu	Yield Bu/A	Forage lb/A	Trifoliate P ppm	Plant P ppm	P Uptake lb/A
Broadcast	0	45.1	3521	2873	9.9	798019	60.1	26.2	2169	3860	4018	8.8
	5	53.1	3525	2848	9.9	818928	60.2	26.0	2559	4157	3876	9.8
	10	52.3	3448	2864	10.0	893851	60.5	23.9	2294	3840	3541	8.3
	15	52.9	4144	2824	11.8	931313	60.4	30.3	2465	4256	3878	9.6
	20	49.6	3584	3054	10.9	889495	60.7	24.5	2300	4079	3649	8.3
Knife	0	49.0	3501	2449	8.5	824155	60.4	18.7	2085	3925	2980	6.3
	5	50.2	3760	3135	11.8	811958	60.5	28.0	2245	4245	3352	7.7
	10	50.8	3668	3155	11.6	865102	59.7	22.1	2110	3677	3372	7.2
	15	54.0	3516	3260	11.5	865973	60.1	25.9	2367	3979	3274	7.8
	20	49.6	3638	2881	10.4	811958	60.7	23.4	2582	4104	3899	10.0
Starter	0	48.3	3362	3017	10.2	883397	59.8	19.0	2093	3787	3665	7.7
	5	55.1	3868	3079	11.8	838966	60.6	24.2	2394	4070	3834	9.6
	10	54.1	3782	2892	11.0	865973	60.1	25.6	2447	4100	4089	10.0
	15	52.1	3868	2749	10.8	897336	60.3	25.7	2428	4323	4073	9.6
	20	60.0	4162	2903	12.2	797148	60.6	25.2	2297	4035	4452	10.2
P Rate	0	47.5	3461	2779	9.5	835190	60.1	21.3	2116	3358	3554	7.6
	5	52.8	3718	3021	11.2	823284	60.4	26.0	2399	4157	3687	9.0
	10	52.4	3632	2970	10.9	874975	60.1	23.9	2284	3872	3667	8.5
	15	53.0	3843	2944	11.3	898207	60.2	27.3	2420	4186	3742	9.0
	20	53.1	3794	2946	11.2	832867	60.7	24.3	2393	4072	4000	9.5
Method												
Broadcast		52.0	3675	2897	10.6	883397	60.4	26.2	2405	4083	3736	9.0
Knife		51.1	3645	3108	11.3	838748	60.2	24.8	2326	4001	3474	8.2
Starter		55.3	3920	2906	11.5	849856	60.4	25.2	2391	4132	4112	9.8
Method		+	NS	+	NS	NS	NS	NS	NS	NS	++	NS
P Rate		+	NS	NS	NS	++	NS	++	NS	++	NS	NS
Linear		++	+	NS	++	NS	+	+	+	+	NS	++
Quadratic		+	NS	NS	NS	++	NS	++	NS	NS	NS	NS
Method x P Rate		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.		12.3	14.7	11.2	20.4	8.6	1.2	21.4	18.7	8.3	22.5	28.3

+ and ++ are 0.20 and 0.10 significance levels, respectively.

Table 4. Means and statistical analyses for Lamberton corn and soybean, 1988.

		Corn			Soybean				
Method	P Rate lb P/A	Yield Bu/A	Young Plant P ppm	Young Plant P Uptake mg/plant	Yield Bu/A	Forage lb/A	Trifol-iate P ppm	Plant P ppm	P Uptake lb/A
Broadcast	0	53.7	3053	30.0	20.5	2879	3185	1594	4.6
	10	55.8	3183	31.6	19.3	2700	3031	1584	4.3
	20	55.1	3148	31.4	21.0	3119	3236	1887	5.9
	30	58.2	3630	36.5	20.6	2791	3295	1774	5.0
	40	58.2	3186	37.7	22.1	3062	3184	1751	5.4
Knife	0	50.9	2993	26.9	19.0	2805	3210	1471	4.1
	10	58.6	3354	36.9	22.4	3396	3629	1820	6.1
	20	63.7	3642	45.4	23.0	3600	3847	1848	6.6
	30	65.2	3756	44.3	23.5	3419	3976	1879	6.4
	40	72.6	4125	48.0	25.0	3648	4145	2095	7.6
Row	0	61.0	3097	29.7	18.4	2807	2860	1552	4.4
	10	62.3	3109	31.6	20.8	2869	3401	1758	5.1
	20	53.7	3227	33.1	21.9	3202	3535	1771	5.7
	30	59.4	3482	34.7	21.2	2966	3159	1691	5.0
	40	60.9	3538	36.3	22.9	3075	3176	1867	5.7
P Rate	0	55.2	3047	28.9	19.3	2830	3085	1539	4.4
	10	58.9	3215	33.0	20.8	2988	3354	1721	5.1
	20	57.5	3339	36.5	22.0	3307	3539	1835	6.1
	30	60.9	3623	38.6	21.7	3058	3477	1781	5.5
	40	63.9	3616	40.6	23.4	3261	3501	1904	6.2
Method									
Broadcast		56.8	3287	34.3	20.7	2918	3186	1749	5.1
Knife		65.0	3719	43.7	23.5	3515	3899	1911	6.7
Starter		59.1	3339	33.7	21.7	3028	3318	1772	5.4
Method		++	**	**	**	**	**	*	**
P Rate		+	**	**	**	**	**	**	**
Linear		*	**	**	**	**	**	**	**
Quadratic		NS	NS	NS	NS	NS	*	+	++
Method x P Rate		NS	*	NS	NS	NS	*	NS	NS
C.V.		15.2	7.4	22.6	4.6	11.2	7.8	10.5	14.3

** *, ++, and + are 0.01, 0.05, 0.10, and 0.20 significance levesl, respectively.

Table 5. Means and statistical analyses for Waseca corn and soybean, 1988.

		Corn				Soybean				
Method	P Rate lb P/A	Yield Bu/A	Young Plant P ppm	Young Plant P Uptake mg/plant	Ear P ppm	Yield Bu/A	Forage lb/A	Trifoliate P ppm	Plant P ppm	P Uptake lb/A
Broadcast	0	62.8	2873	14.6	1321	20.6	3082	2707	1434	4.5
	10	78.2	3162	19.4	1483	23.8	3111	2988	1584	4.9
	20	86.9	3207	23.0	1827	26.0	3310	3124	1766	5.9
	30	101.9	3138	18.1	1863	24.7	3242	3453	2199	7.1
	40	96.0	3542	27.2	2241	24.5	3548	3501	2189	7.7
Knife	0					20.9	3181	2851	1592	5.0
	10					26.3	3327	3404	1699	5.6
	20					26.3	3755	3753	1731	6.5
	30					27.3	3883	3981	1999	7.8
	40					28.9	3625	3988	1839	6.5
Row	0					19.5	2946	2790	1358	4.0
	10					16.8	3007	3056	1659	5.0
	20					23.8	3455	3203	1925	6.6
	30					24.7	3434	3139	1773	6.3
	40					28.5	3005	3479	2204	6.6
P Rate	0					20.3	3069	2782	1461	4.5
	10					22.3	3148	3149	1647	5.2
	20					25.4	3506	3360	1807	6.3
	30					25.6	3520	3524	1990	7.1
	40					27.3	3393	3656	2077	7.0
Broadcast						24.7	3303	3266	1934	6.4
Knife						27.2	3647	3782	1817	6.6
Starter						23.4	3225	3219	1890	6.1
Method						*	*	**	NS	NS
P Rate		+	+	++	*	**	*	**	**	**
Linear		*	*	*	**	**	*	**	**	**
Quadratic		NS	NS	NS	NS	NS	++	*	NS	++
Method x P Rate						+	NS	NS	NS	NS
C.V.		18.8	6.2	17.6	11.9	16.5	12.6	6.2	15.7	18.2

**, *, ++, and + are 0.01, 0.05, 0.10, and 0.20 significance levels, respectively.

Split Application Study - 1988: At Crookston, there was no response to the split application treatments in spring wheat or soybean (Table 6). At Lamberton, the knife treatment was superior to broadcast or starter and the split treatments performed well for corn yield, young plant P concentration, and young plant P uptake (Table 7). The knife alone was superior to the split applications for all measured Lamberton soybean parameters. At Waseca, the corn grain yield was not effected by P application method (Table 8). The knife alone and knife + broadcast treatments had the greatest amount of P in the plant as measured by young plant P concentration, young plant P uptake, and ear leaf P. Soybean grain yield was the greatest with the knife, starter, broadcast + knife, and broadcast + starter treatments. The unusual result was the lack of response with the knife + starter treatment. Knife and broadcast + knife treatments provided the great-est forage yields. No consistent increase from application method occurred for trifoliate leaf P concentration, plant P concentration, and plant P uptake. In summary, the split applications did not increase the effectiveness of P fertilization over a single application.

Summary - 1988: In 1988, Minnesota experienced a drought. This has influenced the effect of P application methods on the various measured parameters at Lamberton and Waseca. The knife application consistantly performed better than the other application methods. This probably occurred because the fertilizer was placed in the soil where there was moisture. The plant roots could be able to utilize that P fertilizer over broadcast and starter placed P because these other methods placed the P in dry soil where the roots could not grow to intersect the fertilizer. At Crookston, application method has not been a factor in P responses.

Overall summary for grain yield in P placement study 1986-1988:

Crookston: A grain yield response to P fertilizer occurred in all three years of the study for spring wheat and only in 1988 for soybeans (Fig. 1). The method of application did not effect yield for either crop at this location. This result was surprising for spring wheat. It was thought that knife or seed placement would have been superior. Results for this and other P studies indicate that some other factor is involved with the P nutrition of plants grown in this area. Possible processes include organic P mineralization and a failure of the sodium bicarbonate soil test to accurately predict plant available P.

Waseca: In 1986, 1987, and 1988 soybean grain yields were increased by P fertilization (Fig. 2). The method of application was only significant in 1988. The knife and broadcast placements performed better than starter placement at the lower P rates. At the 40 lb P/A rate, the starter treatment was similar to knife and the broadcast performed the worst. The knife treatment performed the best because the roots were better able to utilize the fertilizer P because of better soil moisture at this placement position than the others in 1988.

Corn yield consistently responded to P fertilizer throughout the whole study (Fig. 2). Grain yield was maximized in all years at 30 lb P/A. No application method effects occurred.

Lamberton: Corn grain yields responded to the P application in all three study years (Fig. 3). In 1986 there was no application effect. The broadcast application of phosphorus was superior to starter and knife in 1987. At the 10 and 20 lb P/A rate, starter and knife application performed similarly. At 40 lb P/A the knife treatment grain yields were greater than grain yield from starter application. In 1988, the knife treatment grain yields were superior to the broadcast and starter application yields. At P rate of 20 lb P/A and greater, the grain yields for broadcast and starter applications were similar. Again the dry conditions of 1988 caused the knife placement to be the best, mainly because of better soil moisture conditions at the point.

Table 6. Means and statistical analyses for Crookston wheat and soybean, 1988.

		Spring Wheat						Soybean				
Method	P Rate lb/A	Yield Bu/A	Forage lb/A	Plant P ppm	P Uptake lb/A	Plant Popul- tion Plant/A	Bushel wt. lb/Bu	Yield Bu/A	Forage lb/A	Trifol- iate P ppm	Plant P ppm	P Uptake lb/A
B + K	5+5	42.2	3257	3031	10.0	876427	59.8	24.9	2628	4177	4336	11.1
B + S	5+5	56.0	3722	2986	11.3	897336	60.3	22.7	2248	4101	4097	9.2
K + S	5+5	56.7	3907	2781	10.7	862488	60.1	27.1	2656	4231	3574	9.7
B	10	52.3	3448	2864	10.0	893851	60.5	23.9	2294	3840	3541	8.3
K	10	50.8	3668	3155	11.6	865101	59.7	22.1	2110	3677	3372	7.2
S	10	54.1	3782	2892	11.0	865973	60.1	25.6	2447	4100	4089	10.0
Check	0	47.5	3461	2779	9.5	835190	60.1	21.3	2116	3858	3554	7.6
Trt		*	NS	NS	NS	NS	NS	NS	+	++	NS	NS
LSD 0.05		9.4	781	610	3.5	54109	0.4	7.3	572	434	1258	3.7
C.V.		12.8	15.0	14.5	23.1	7.8	1.3	21.5	17.1	7.5	23.1	29.2

*, ++, and + are 0.05, 0.10, and 0.20 significance levels, respectively.

Table 7. Means and statistical analyses for Lamberton corn and soybean, 1988.

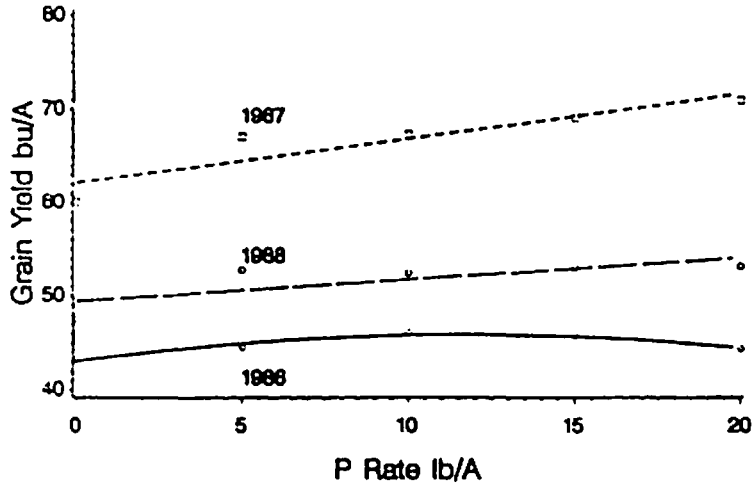
		Corn			Soybean				
Method	P Rate lb P/A	Yield Bu/A	Young Plant P ppm	Young Plant P Uptake mg/plant	Yield Bu/A	Forage lb/A	Trifol- iate P ppm	Plant P ppm	P Uptake lb/A
B + K	20+20	69.0	3899	52.1	23.1	3306	3674	1880	6.2
B + S	20+20	60.3	3312	37.7	22.4	2936	3541	1882	5.5
K + S	20+20	67.5	3706	52.4	23.7	3383	3693	2044	6.9
B	40	58.2	3186	37.7	22.1	3062	3184	1751	5.4
K	40	72.6	4125	48.0	25.0	3648	4145	2095	7.6
S	40	60.9	3538	36.3	22.9	3075	3176	1867	5.7
Check	0	55.2	3047	28.9	19.3	2830	3085	1539	4.4
Trt		*	**	**	**	**	**	**	**
LSD 0.05		14.0	331	3.7	1.9	482	401	309	1.4
C.V.		15.6	6.6	23.6	5.9	10.7	8.1	11.9	16.6

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

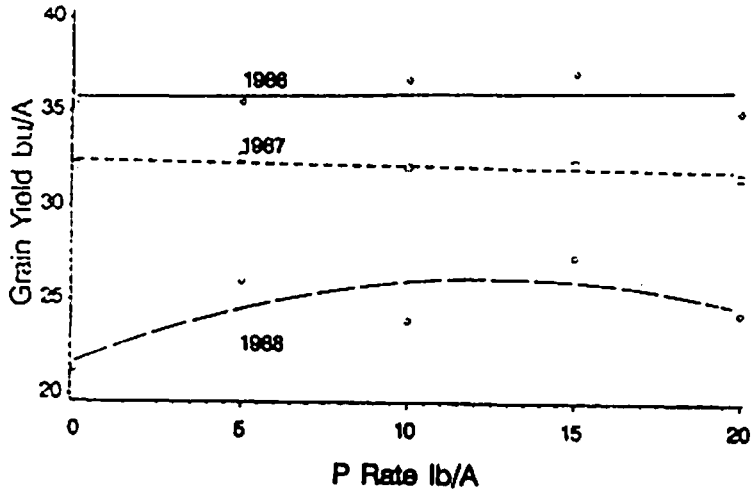
Table 8. Means and statistical analyses for Waseca corn and soybean, 1988.

		Corn					Soybean			
Method	P Rate lb P/A	Yield Bu/A	Young Plant P ppm	Young Plant P Uptake mg/plant	Ear Leaf P ppm	Yield Bu/A	Forage lb/A	Trifol-iate P ppm	Plant P ppm	P Uptake lb/A
B + K	20+20	102.8	3963	32.9	2465	27.1	3812	4008	2061	7.8
B + S	20+20	93.9	3630	28.1	2192	29.5	3561	3494	2077	7.4
K + S	20+20	99.5	3723	23.1	2350	21.8	3164	3917	2311	7.3
B	40	96.0	3542	27.2	2241	24.5	3548	3501	2189	7.7
K	40	95.0	4187	30.3	2538	28.9	3625	3988	1839	6.5
S	40	100.9	3505	27.4	2195	28.5	3005	3479	2204	6.6
Check	0	64.6	2813	14.0	1305	20.3	3069	2782	1461	4.5
Trt		**	**	**	**	**	*	**	**	**
LSD 0.05		18.5	305	5.9	210	4.2	621	289	350	1.5
C.V.		13.5	5.7	15.8	6.6	11.8	12.9	5.8	12.7	16.3

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

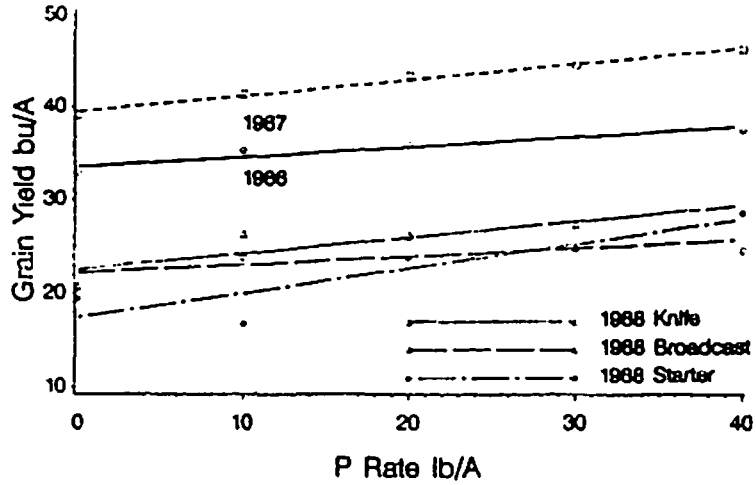


Crookston Spring Wheat

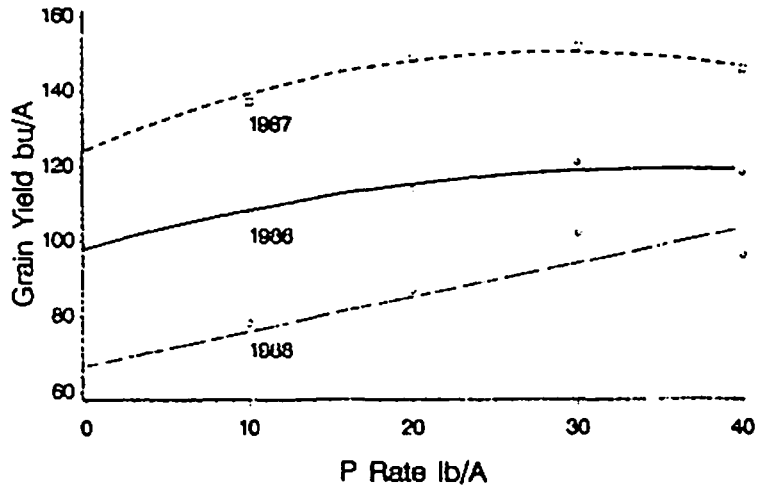


Crookston Soybean

Figure 1. Phosphorus rate response curves for spring wheat and soybean grain yields for 1986 through 1988 at Crookston, MN.



Waseca Soybean

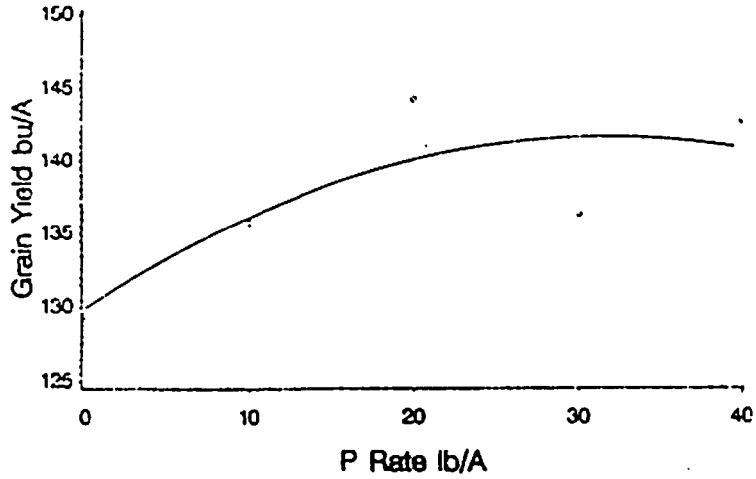


Waseca Corn

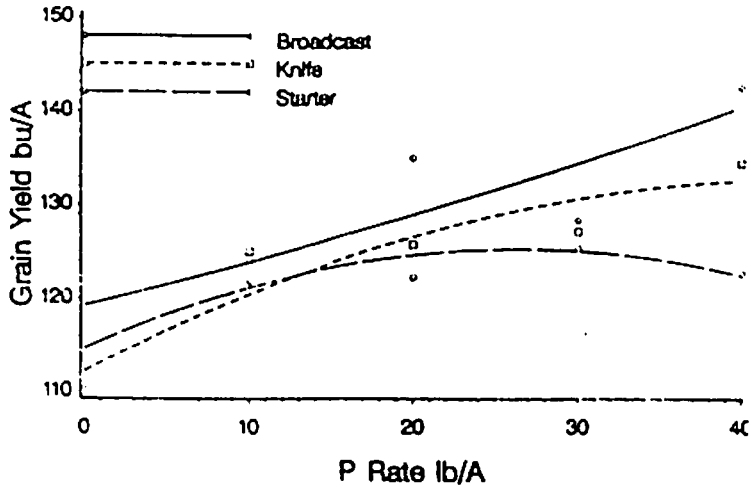
Figure 2. Soybean and corn grain yield responses for P fertilization at Waseca, MN, 1986 to 1988.

Soybean grain yields responded to P application and the method to which the fertilizer was applied (Fig. 4). In 1986 and 1987, the broadcast application method performed the best. In 1986 starter and knife caused similar grain yield responses while 1987 the knife application treatment had grain yields similar to broadcast at the 10 and 20 lb P/A rates. At the greater P rates, the knife behaved similar to the starter treatment. In 1988 the knife application was superior to both broadcast and starter applications of P fertilizer. Starter and broadcast had grain yields similar to each other. Again, the dry conditions caused the knife treatment to perform better.

The following general conclusions can be drawn from this study. With soybeans, the broadcast application performs as well or better than any other application method of P. In an abnormally dry season, knife placement may be superior in soybeans and corn. This is because of the better soil moisture conditions that occur in the soil at that placement point. The starter treatment consistently performed poorer than the other application methods for soybean production. Phosphorus application method in corn is not as crucial as originally thought. No one application method consistently performed superior.



Lamberton Corn 1986



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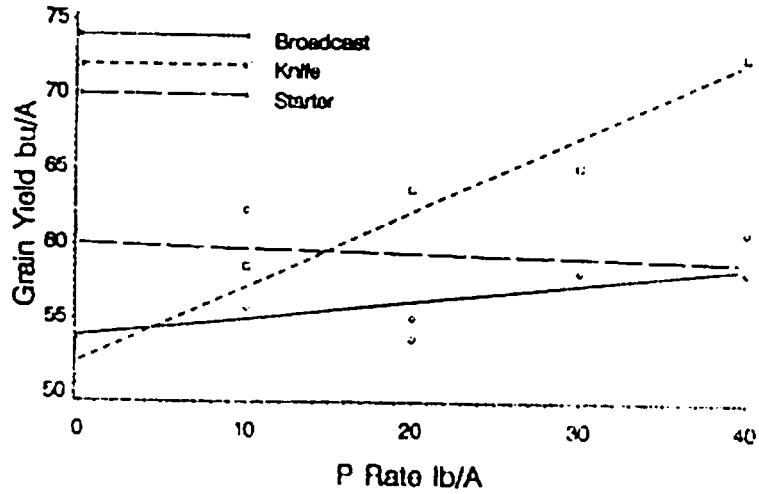
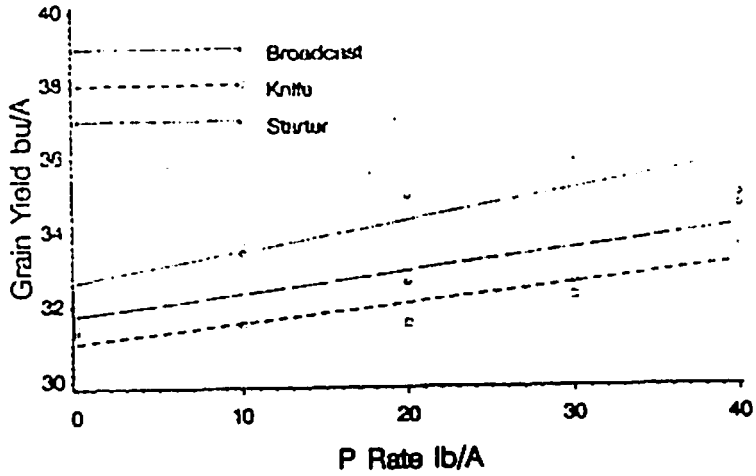
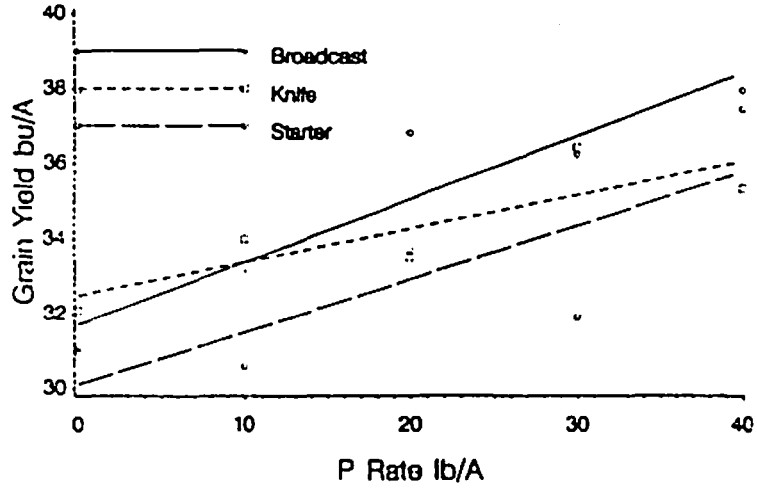


Lamberton Corn 1988

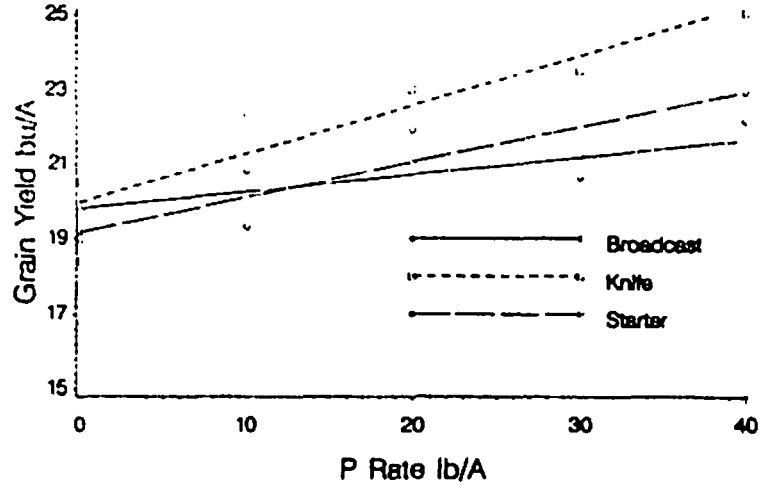
Figure 3. Corn grain yield responses to P application and method of application at Lamberton, MN, 1986 to 1988.



Lamberton Soybean 1986



Lamberton Soybean 1987



Lamberton Soybean 1988

Figure 4. Soybean grain yield responses to P application and method of application at Lamberton, MN, 1986 to 1988.

Precipitation Summary for Tillage Research on Farmer-Cooperator Farms, 1988

J.J. Kuznia, G.J. Spoden, and J.F. Moncrief[1]

The table presented below is a summary of the growing season precipitation for tillage demonstrations and research on farmer cooperator farms throughout Minnesota. The results from these demonstrations are published in this publication under the tillage section. Precipitation values are averaged weekly. Data is from the actual site when possible. When not available data was obtained from the high density weather observer network data base maintained by the Department of Natural Resources, State Climatologist Office. The nearest weather observer to the demonstration site ranged from 1 to less than 10 miles.

Table 1. Weekly precipitation for the 1988 growing season for tillage demonstrations on farmer cooperator farms.

	LOCATION																		
Date	Becker[2]	Dodge[2]	Douglas[3]	Fillmore[2]	Goodhue[3] Nord	Goodhue[3] Flueger	Isanti[1]	Lamberton[2]	Meeker[3]	Morris[3]	Norman[3]	Pine[2]	Stearns[3]	Steele[2]	Wabasha[3]	Wadena[3]	Waseca[2]	Winona[3]	Wright[2]
4/1-9	0.00	0.35	0.03	1.04	0.31	0.26	0.51	1.06	0.64	0.44	0.00	0.25	0.35	0.05	0.72	0.37	0.78	0.91	0.04
4/10-16	0.00	0.00	0.00	0.28	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02	0.00
4/17-23	0.00	0.61	0.00	0.00	0.56	0.64	0.09	0.80	0.23	0.00	0.00	0.05	0.25	0.52	0.00	0.00	0.77	0.41	0.02
4/24-30	0.00	1.50	0.00	0.17	0.81	0.54	0.08	0.78	0.32	0.13	0.00	0.16	0.40	0.80	1.63	0.01	0.88	1.10	0.38
Total	**0.00**	**2.46**	**0.03**	**2.49**	**1.69**	**1.46**	**0.68**	**2.64**	**1.19**	**0.57**	**0.00**	**0.46**	**1.00**	**1.37**	**2.35**	**0.40**	**2.43**	**2.44**	**0.44**
5/1-7	0.02	1.00	0.00	0.61	0.00	0.00	0.40	0.07	0.00	0.06	0.23	0.06	0.10	1.00	0.00	0.05	0.76	0.00	0.00
5/8-14	1.12	0.25	1.23	0.07	2.16	1.78	1.90	0.36	1.25	0.71	0.27	1.28	1.50	0.47	1.60	0.60	0.86	1.05	1.29
5/15-21	0.70	0.35	0.28	0.00	0.26	0.15	0.00	0.20	0.04	0.48	0.74	0.05	0.25	0.00	0.00	0.32	0.10	0.02	0.62
5/22-28	0.62	0.25	0.77	0.44	0.24	0.25	0.15	0.85	0.35	0.46	0.16	0.59	0.50	0.45	0.00	0.59	0.27	0.24	0.28
5/29-6/4	0.00	0.00	0.00	0.00	0.02	0.07	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**2.46**	**1.95**	**2.28**	**1.12**	**2.68**	**2.25**	**2.50**	**1.50**	**1.64**	**1.71**	**1.40**	**1.98**	**2.35**	**1.92**	**1.60**	**1.56**	**1.99**	**1.31**	**2.19**
6/5-11	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/12-18	1.27	0.15	0.65	0.00	0.12	0.07	0.00	0.39	0.24	0.41	1.25	0.45	0.00	0.20	0.00	0.39	0.35	0.00	0.17
6/19-25	0.75	1.22	0.32	1.01	0.69	0.52	0.10	0.20	0.00	0.08	0.90	0.10	0.10	0.88	1.20	1.21	0.55	0.97	0.00
6/26-7/2	0.02	0.00	0.00	0.03	0.00	0.02	0.15	0.18	0.00	0.03	0.00	0.10	0.00	0.09	0.38	0.00	0.45	0.34	0.00
Total	**2.04**	**1.37**	**0.97**	**1.04**	**0.81**	**0.61**	**0.30**	**0.77**	**0.24**	**0.52**	**2.15**	**0.71**	**0.10**	**1.17**	**1.58**	**1.60**	**1.35**	**1.31**	**0.17**
7/3-9	1.04	1.75	0.22	0.53	0.35	0.48	1.75	0.62	0.09	0.36	0.55	0.03	0.01	0.50	0.80	0.02	0.23	0.00	0.26
7/10-16	0.50	3.70	1.55	0.45	0.70	0.51	1.35	0.17	0.76	1.07	0.60	1.24	0.20	1.25	0.45	1.26	0.05	0.72	0.26
7/17-23	0.00	0.43	0.37	0.41	0.29	0.39	0.70	0.05	0.86	0.31	0.04	0.41	0.20	0.34	0.48	0.24	0.33	0.30	0.56
7/24-30	0.65	0.00	0.11	0.41	0.00	0.00	1.50	0.00	0.05	0.06	0.00	0.97	0.00	0.00	0.00	0.52	0.00	0.00	0.00
7/31-8/6	2.25	0.86	1.43	0.54	1.16	1.22	1.25	1.46	0.66	2.55	2.17	1.98	0.43	0.93	1.12	2.99	1.85	0.97	0.64
Total	**4.44**	**6.74**	**3.68**	**2.34**	**2.50**	**2.60**	**6.55**	**2.30**	**2.42**	**4.35**	**3.36**	**4.63**	**0.84**	**3.02**	**2.85**	**5.03**	**2.46**	**1.99**	**1.72**
8/7-13	1.70	0.65	1.78	1.72	0.75	1.17	2.40	0.98	0.55	1.72	3.21	1.53	1.65	0.95	1.50	2.65	1.18	1.54	1.76
8/14-20	0.15	0.25	1.72	0.37	0.11	0.25	0.00	0.63	0.70	0.00	0.04	1.06	0.00	0.05	0.25	0.00	0.05	0.72	0.00
8/21-27	0.39	0.65	0.57	1.41	0.97	0.89	0.40	1.36	0.71	0.36	0.08	0.05	1.15	0.83	1.37	0.68	0.61	1.39	0.68
8/28-9/3	0.17	0.25	0.30	0.04	0.72	0.64	0.30	0.05	0.39	1.05	0.00	0.36	0.25	0.15	0.30	0.73	0.97	0.08	0.26
Total	**2.41**	**1.80**	**4.37**	**3.54**	**2.55**	**2.95**	**3.10**	**3.02**	**2.35**	**3.13**	**3.33**	**3.00**	**3.05**	**1.98**	**3.42**	**4.06**	**2.81**	**3.73**	**2.70**
9/4-10	0.00	0.15	0.00	0.26	0.37	0.17	0.00	0.03	0.00	0.00	0.00	0.07	0.00	0.00	0.10	0.00	0.00	0.23	1.39
9/11-17	0.77	0.00	0.94	0.06	0.36	0.36	0.60	1.96	0.72	1.59	0.91	0.80	1.33	0.25	0.00	1.10	0.36	0.27	0.94
9/18-24	2.06	3.82	0.37	2.01	3.32	1.96	2.00	0.08	0.57	0.48	2.21	1.91	0.70	3.14	3.39	0.87	3.06	3.88	0.85
9/25-10/1	0.31	0.43	0.97	0.12	0.55	0.56	1.00	0.96	0.80	1.46	0.27	0.55	0.85	0.50	0.35	0.93	0.95	0.35	0.76
Total	**3.14**	**4.40**	**2.38**	**2.45**	**4.60**	**3.05**	**3.60**	**3.03**	**2.09**	**3.53**	**3.39**	**3.33**	**2.88**	**3.89**	**3.84**	**2.90**	**4.37**	**4.73**	**3.94**

1. Joe J. Kuznia and John F. Moncrief are Assistant Scientist and Associate Professor respectively in the Soil Scientist Department, University of Minnesota, St. Paul, MN. 55108. Greg J. Spoden is the Assistant State Climatologist, Department of Natural Resources, St. Paul, MN. 55108.
2. Precipitation values were obtained at the site.
3. Precipitation values were obtained from the nearest weather observer for the State Climatology office high density observer network.

Tillage Effects on Corn Production in Eastcentral Minnesota[1]

J.F. Moncrief, W.W. Schoper, T.I. Siira, and J.J. Kuznia[2]

Abstract: Tillage was evaluated for continuous corn production at two sites in northeastern Minnesota (Moldboard and chisel plowing, spring discing, and no tillage). Tillage affected early corn growth at two sites in 1987 and 1988. Early growth in 1988 was double that of 1987 at both sites. Grain yields were affected at both sites in 1987 and one site in 1988. Average yields were higher with chisel plowing at one site and lower with a no till treatment at the other site.

This is the second year of a study in Isanti and Pine counties in northeastern Minnesota to evaluate the effect of tillage system on continuous corn production. Tillage ranges from Moldboard plowing with secondary tillage to a no till approach. The planters at both sites are conventional planters with 2" fluted coulters mounted ahead of the planter units. There has been tillage effects at both sites. Following is a two year summary.

Pine County

The Pine county site is on a Cushing loam soil on a dairy farm in northeastern Minnesota. This is the third year of corn. The soil test P and K are in the high range. The average "in row" cover by corn residue after planting has been consistent between the two years (table 3). The disc and chisel plow systems resulted in about 35% cover in the row and about twice that with a no tillage approach. The 2" fluted coulter reduced the "in row" cover 3, 5, 9, and 18 per cent for the moldboard, chisel, disc, and no till treatments respectively.

The effect of in row cover by corn residue on early corn growth is shown in table 4. The growth at a given point in time in 1988 was about double of that in 1987. This reflects the early spring and warm conditions in 1988. There was a tillage affect on early growth in both years however. Early growth is closely correlated with in "row cover".

Tillage affected plant stand in 1987 but not in 1988 at this site (table 5). Chisel and Moldboard plowing had higher stands than the disc and no till treatments in 1987. This is probably due to the 1.26 inches of rainfall that occurred in 1988 during the week after planting (see weather data from tillage studies this publication).

In 1987 systems that eliminated primary tillage reduced the density of annual weeds on May 28 (table 6). Volunteer corn was the only weed affected by tillage on June 17, 1987. In 1988 there did appear to be an affect of tillage on the relative ranking of weed species but not on the total cover by weeds (tables 9 and 8 respectively). There were very few discernable trends of tillage on weeds at harvest in 1988 (table 10). Weeds were grouped into two categories based on assumptions as to their competitiveness. The results are shown in table 11. Less tillage increased weeds with a low growth habit (weak competitors). There was no significant affect of tillage on the strong competitors although the range was great.

Grain yields at this site were affected by tillage both years (table 12). In 1987 the no till grown corn resulted in a yield 14 bushels per acre less than discing or moldboard plowing. The chisel plowing system resulted in yields about 10 bushels per acre higher than these two systems. In 1988 less tillage and increased levels of residue resulted in higher yields. This site had about 7 inches of rainfall in July and early August that appeared to have resulted in a residue advantage in reducing runoff and increasing the amount of available water. Conservation tillage options at this site resulted in the highest two year average yields. Even though extremes in tillage options resulted in a .7 and .4 difference in early growth for 1987 and 1988 respectively,

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1 This project is supported in part by the Soil Conservation Service. Their support is greatly appreciated. Konval H. Bergum and Michael J. Muzzy, the District Conservationist in Pine and Isanti Counties respectively, helped collect much of the data presented. This study could not have been possible without their assistance.

2 John F. Moncrief and Joe J. Kuznia are associate professor and assistant scientist respectively in the Soil Science Department at the University of Minnesota, St. Paul, MN. 55108. Wayne W. Schoper and Tom I. Siira are county agricultural agents in Isanti and Pine Counties, Minnesota respectively.

grain moisture showed little influence.

In summary, tillage affected soil cover, early corn growth, and weed species both years at this site. Grain yields were higher with conservation tillage options.

PINE COUNTY

Table 1. Cultural practices at Pine County, MN. 1988.

Tillage
- No Till
- Fall Disc
- Fall Chisel Plow
- Fall Moldboard Plow-light disc spring

Cropping History
- 1986-Corn
- 1987-Corn Land O Lakes 1093

1988 Crop
- Land O Lakes 1093 Single cross hybrid (95 day)

Planting Information for 1987 & 1988 Crop Years

A four row 36 inch John Deere Max-Emerge planter with 2 inch fluted coulters was used.

Crop	Date	Rate	Harvested
Corn	May 4, 1987	26,700 plants/A	Oct. 6, 1987

Crop	Date	Rate	Harvested
Corn	May 6, 1988	25,700 plants/A	Oct. 14, 1988

Fertilizer 1987

Crop	Material Analysis (rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		--- lbs/A ---			
Corn	46-0-0 (250 lbs/A)	115	0	0	May 2, 1987
	10-15-35[1] (280 lbs/A)	28	42	98	May 4, 1987

1. Planter applied 2" beside and 2" below seed.

Fertilizer 1988

Crop	Material Analysis (rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		--- lbs/A ---			
Corn	46-0-0 (200 lbs/A)	92	0	0	April 25, 1988
	9-23-30[1] (200 lbs/A)	18	46	60	May 6, 1988

1. Planter applied 2" beside and 2" below seed.

Soil

The soil at this site is a Cushing (Glossic Eutroboralfs, fine-loamy, mixed) loam, soil is well drained.

Weed Control

2.5 qt/A (3.75 lbs/A) Bicep 6L (1.69 lbs/A Atrazine & 2.06 lbs/A Dual) surface applied preemergence.

Table 2. Soil test on April 7, 1987.

Nutrient	Sig. of Tillage	Tillage: No Till	Disc	Chisel	Moldboard
		lb/A			
P	(.193)	124	107	61	84
K	(.711)	471	411	464	422

Table 3. The effect of tillage on soil cover by corn residue on May 28, 1987 and May 13, 1988.

Location	Year	Tillage: No Till	Disc	Chisel	Moldboard
		%			
In Row	1987	56	42	26	1
	1988	69	32	37	7
Average		63	37	32	4
Between Row	1987	78	59	35	4
	1988	84	33	39	9
Average		81	46	37	7

Table 4. The effect of tillage on early corn growth.

Year	Date	No Till	Disc	Chisel	Moldboard	Sig.	n
		Tillage					
		------ leaves/plant			---------		
1987	5/24	1.7	1.9	2.0	2.3	.007	40
	6/17	5.3	5.5	6.1	6.3	.000	40
Average		3.5	3.7	4.1	4.3		
1988	5/27	3.6	3.5	3.5	3.7	.027	80
	6/24	9.5	10.2	10.2	10.3	.190	8
Average		6.6	6.9	6.9	7.0		

Table 5. The effect of tillage on corn stand, n=16.

Year	Date	No Till	Disc	Chisel	Moldboard	Sig.
		Tillage				
		----- 1000's plants/A			-------	
1987	5/24	23.2	22.1	26.5	27.2	.000
1987	6/17	23.4	22.0	25.6	27.3	.000
Average		23.3	22.1	26.1	27.3	
1988	5/27	22.3	23.1	22.6	23.1	.746

Table 6. The effect of tillage on the presence of weed species and density on May 28, 1987, n=32.

Weed	NoTill	Disc	Chisel	Mlbd	Sig.
	Tillage				
	---- plants/A x 10^{-3}			-----	
Pigweed	0.6	1.3	5.5	5.0	.059
Foxtail	0.0	0.7	3.8	8.0	.059
Crabgrass	5.9	8.5	0.0	0.0	
Nutsedge	72.9	24.7	63.9	39.7	.552
Ragweed	1.2	2.9	6.9	11.1	.288
Lambsquarter	0.0	2.4	7.7	3.8	.099
Smartweed	0.0	2.4	0.0	0.0	
Vol Corn	0.0	5.5	4.2	0.9	.330
Quackgrass	0.0	0.9	0.0	0.0	

Table 7. The effect of tillage on the presence of weed species and density on June 17, 1987, n=32.

Weed	NoTill	Disc	Chisel	Mlbd	Sig.
	Tillage				
	---- plants/A x 10^{-3}			-----	
Crabgrass	1.8	0.0	12.1	0.0	.400
Nutsedge	117.1	37.9	35.8	47.2	.320
Ragweed	0.3	1.2	4.9	0.3	.287
Lambsquarter	0.0	0.0	2.8	2.7	
Smartweed	0.0	0.0	2.0	0.3	
Vol Crn	0.1	15.9	11.8	5.2	.011
Quackgrass	2.8	2.1	5.8	3.9	.373

Table 8. The effect of tillage on percent soil cover by weeds in 1988.

Date	No Till	Disc	Chisel	Moldboard	Sig.
	Tillage				
	---------- %			----------	
5/27/88	14	28	19	10	.159
6/24/88	58	50	50	38	.730

Table 9. The effect of tillage on weed ranking[1].

Weeds	May 27, 1988 N-T	Disc	Chl	Mld	June 24, 1988 N-T	Disc	Chl	Mld
	Sampling Date							
	Tillage							
	-------- Numerical Rating --------							
Nutsedge	3	1	1	1	2	1	1	1
Foxtail	-	2	2	2	6	2	2	3
Quackgrass	1	3	2	-	1	-	4	-
Pigweed	-	-	-	3	-	5	3	4
Ragweed	-	-	-	4	-	4	5	2
Lambquarters	-	-	-	5	-	-	3	2
Dandelion	2	-	-	-	3	-	-	-
Vol. Corn	-	-	2	-	-	3	-	-
Milkweed	5	-	-	-	5	-	-	-
Horse Thistle	-	-	2	-	-	-	-	5
Alfalfa	4	-	-	-	-	6	-	-
Canada Thistle	5	-	-	-	-	-	-	-
White Cockle	-	-	-	-	4	-	-	-
Sow Thistle	-	-	-	-	5	-	4	-
Mushrooms	-	-	-	-	7	-	-	-

1. Weed species were ranked by visually estimating the most dominant species, based on percent soil cover, with 1 being the most dominant.

Table 10. Effect of tillage on cover by weeds in corn at Pine Co. Sept. 23, 1988, n=4.

Weed	Tillage: No Till	Disc	Chisel	Moldboard	Sig.
	% cover				
Yelnutedge	23.3	18.0	14.5	3.5	.184
Pensmartweed	0.0	0.3	0.1	0.8	
Foxtail	21.3	48.3	25.5	47.3	.334
W.Buckwheat	0.0	0.0	0.0	0.0	
Quackgrass	1.8	1.8	0.8	0.3	.598
RrtPigweed	1.8	8.3	22.5	14.0	.196
GtRagweed	1.8	1.0	3.0	10.3	.372
Lambquarter	1.0	0.5	4.3	8.8	.058
Dandelion	6.8	4.0	1.3	0.3	.153
Vol.Corn	0.7	3.0	2.8	0.0	
Milkweed	0.3	0.0	0.0	0.3	
Crabgrass	9.5	19.5	10.0	2.0	.509
Elmtree	0.1	0.0	0.0	0.0	
Alfalfa	2.3	6.5	0.3	0.5	.430
Canada This	1.8	0.0	0.0	0.0	
White Cockle	0.8	0.3	0.0	0.0	
Mushroom	0.0	0.3	0.5	0.8	
W.Prosomillt	18.8	1.3	5.0	1.0	.478
Barnydgrass	0.0	0.3	0.0	0.3	
Sowthistle	0.0	0.0	0.0	0.3	

Table 11. Effect of tillage on weed competitiveness in corn at Pine Co. Sept. 23, 1988, n=4.

Competitiveness	Tillage: No Till	Disc	Chisel	Moldboard	Sig.
	% cover				
Weak[1]	39.5	41.5	25.8	5.9	.084
Strong[2]	41.2	72.8	62.5	77.8	.738

1. Weak competitors are yellow nutsedge, dandelions, and crabgrass.
2. Strong competitors are foxtail, redroot pigweed, lambsquarters, giant ragweed, and volunteer corn.

Table 12. The effect of tillage on grain yield and moisture on Oct. 6, 1987 and Oct. 14, 1988 n=4.

Year	Tillage: No Till	Disc	Chisel	Moldboard	Sig.
	bu/A				
1987	141	158	166	155	.026
1988	73	53	65	45	.046
Average	107	106	116	100	
	% moisture				
1987	26.7	25.7	25.5	24.2	.329
1988	25.1	24.9	24.9	26.1	.000
Average	25.9	25.3	25.2	25.2	

Isanti County

The soil at this site is an Alstad fine sandy loam with somewhat poor internal drainage. Corn followed soybeans in 1987 and corn in 1988. There are very few weeds at this site.

Tillage affected early growth of corn by a full leaf only with the no till system on May 27, 1988 (table 16). This is the result of 35% vs 75% "in row" cover for the chisel and disc systems vs the no till system (table 14). The planter (conventional planter equipped with 2" fluted coulters) reduced in "row cover" 14% with no other tillage.

The plant population was reduced with no tillage by four thousand plants per acre in 1987 (table 15). This resulted in a 10 bushel per acre reduction in grain yield with this system (table 17). In 1988 plant stands were reduced with the no till and chisel plowing systems but were at a higher level than in 1987. These differences in stand did not affect grain yields. Tillage did affect grain moisture in both years however. Higher in row cover increased grain moisture.

In summary, corn early growth and plant stands were affected by tillage at this site. In 1987 no till grown corn resulted in 10 bushels per acre less grain yield than other systems. The yield reduction with the no till system in this year was strongly correlated to the stand loss. In 1988 there were stand losses associated with several tillage systems but this did not affect yields. The two year average yield was about 4 bushels per acre less with the no till system. It is important to note that if crop residue was cleared out of the row area at planting this small yield difference probably would not have happened.

ISANTI COUNTY

Table 13. Cultural practices at Isanti County, MN. 1988.

Tillage
- No Till
- Spring Disc
- Spring Chisel and disced
- Spring Moldboard

Spring tillage was done on April 26, 1988.
Tillage was followed by a light harrow to level the soil for planting.
Stalks were chopped in the fall on all tillage systems.

Cropping History
1986-Soybeans
1987-Corn Pioneer 3790

1988 Crop
Corn-Pioneer 3772

Planting Information for 1987 & 1988 Crop Years

A six row John Deere 7000 planter with 30 inch row spacing and equipped with 2 inch fluted coulters.

Crop	Date	Rate	Harvested	Crop	Date	Rate	Harvested
Corn	May 6, 1987	27,200 plants/A	Oct. 6, 1987	Corn	May 3, 1988	28,500 plants/A	Oct. 14, 1988

1987 Soil Test

Organic Matter	pH	Bray 1 Phosphorus	Potassium	Sulfur	Zinc
		lbs/A		ppm	
Medium	7.0	115	238	15	1.1

Fertilizer 1987

Crop	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Actual S	Actual Mg	Date Applied
			lbs/A					
Corn	12-14-26-4-3[1]	277 lbs/A	33	38	73	11	9	May 6, 1987
	82-0-0	146 lbs/A	120	0	0	0	0	June 5, 1987

1. Starter fertilizer applied with the planter 2" beside and 2" below the seed.

Fertilizer 1988

Crop	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Actual S	Actual Mg	Date Applied
			lbs/A					
Corn	12-14-26-4-3[1]	277 lbs/A	33	38	73	11	9	May 3, 1988
	82-0-0	220 lbs/A	180	0	0	0	0	June 3, 1988

1. Starter fertilizer applied with the planter 2" beside and 2" below the seed.

Soil

The soil at this site is a Alstad (Aquic Eutroboralfs, fine-loamy, mixed) fine sandy loam, 0 to 2 percent slope. Soil is somewhat poorly drained.

Weed Control

2 qt/A (2 lbs/A) Lasso Micro Tech + 1 qt/A (1 lb/A) Bladex + 1 qt/A (1 lb/A) Atrazine on May 5, 1988.

Table 14. The effect of tillage on soil cover by corn residue on May 27, 1988[1].

	Tillage			
	No Till	Disc	Chisel	Moldboard
Location	%			
In Row	75	38	33	4
Between Row	89	31	25	3

1. Tillage was significant < .100 in all cases, n=32.

Table 15. The effect of tillage on corn stand.

		Tillage					
		No Till	Disc	Chisel	Moldboard		
Year	Date	1000's plants/A				Sig.	n
1987	8/1	22.3	26.6	26.3	26.6	.014	6
1988	6/20	25.5	28.1	26.8	28.4	.002	16
Average		23.9	27.4	26.6	27.5		

Table 16. The effect of tillage on early corn growth on May 27, 1988.

Tillage					
No Till	Disc	Chisel	Moldboard		
leaves/plant				Sig.	n
3.2	4.2	4.2	4.3	.000	60

Table 17. The effect of tillage on corn yields and moisture harvested on Oct. 6, 1987 and Oct. 14, 1988 n=6.

	Tillage				
	No Till	Disc	Chisel	Moldboard	
Year	bu/A				Sig.
1987	157	166	168	168	.004
1988	146	145	147	147	.946
Average	152	156	157	157	
	% moisture				
1987	23.1	22.3	21.7	22.0	.006
1988	21.6	19.9	19.1	18.9	.000
Average	22.4	21.1	20.4	20.5	

The Effect of Tillage on Irrigated Corn Production Following Alfalfa on a Sandy Loam Soil[1]

J.F. Moncrief, M.J. Wiens, and J.J. Kuznia[2]

Abstract: Second year corn grown after alfalfa under irrigation on a sandy loam soil was influenced by tillage system. Emergence was slowed, early growth less, and grain yields reduced with conservation tillage options. Although there was a visual affect of tillage on nitrogen stress in late August it did not affect the nitrogen response of grain yield.

In 1987 plots were established at Staples, MN to evaluate the effect of tillage on the availability of nitrogen to corn from alfalfa the preceding year. This is the second year of that study. Tillage had a major influence on nitrogen available to first year corn (see this publication, 1988) but not on second year corn this year.

Corn was planted with a conventional planter equipped with 2" fluted coulters. Nitrogen was applied at about the 7 leaf stage as broadcast urea prior to irrigation in June (see table 1). A small amount of nitrogen was applied with the planter. A range in broadcast nitrogen rate expected to bracket the optimum was applied each year.

The effect of tillage on "in row" cover is shown in table 2. Corn yields ranged from 140 to 200 bushels per acre in 1987. This resulted in 90% cover with no tillage. Soil cover in the row ranged from 9 to 84%. There does appear to be an interaction between nitrogen rate in 1987 and tillage on soil cover in 1988 (tables 3 and 4). The authors don't have an explanation for the higher level of cover 50 lb N/acre rate with the spring discing treatment.

The effect of "in row" cover on emergence, plant stand, and early growth is shown in tables 5 and 6. Tillage affected emergence. No till corn was not fully emerged until about May 20 which was about ten days behind the moldboard plowing treatment (corn was planted on April 27). There was very little mortality of corn at this site. Growth of no till corn was delayed about 1 leaf per plant on May 9 and the discing treatment was intermediate. On June 10 the spread between moldboard plowing and no tillage was 2.5 leaves.

There was a nitrogen by tillage interaction on visual estimation of nitrogen stress on August 25 (table 7). This followed a similar trend in 1987 although tillage effects were less in 1988. The visual response to applied nitrogen was about three fold for no till corn. The response for corn grown with moldboard plowing was only a factor of two. The disc treatment was again intermediate. Based on these data it does appear that tillage affected the nitrogen response at this point in time.

The main effects of tillage on color and height are shown in table 8. Although no till corn was visually less green plants tended to be taller. The nitrogen response (color and height) is shown in table 9.

Soil samples were taken in one foot increments to a depth of five feet in the spring and fall of 1988. The effect of tillage, nitrogen, and depth on gravimetric water is shown in tables 10, 11, and 12 respectively. The disc treatment had lower levels of soil moisture in the spring and the no till treatment in the fall. The higher nitrogen rate resulted in higher levels of soil water in the spring. Most of the soil water is in the top 2 feet due to the textural horizonation of this soil. The higher levels of soil water with the moldboard plowing treatment were greater in the surface two feet (table 14).
Tillage had a significant effect on grain yields which appeared to be related to plant stand. The delay in

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growth resulted in a difference in grain moisture of 5.7 percent between the tillage extremes. Nitrogen affected grain and stover yields and final stand (table 16). There was no significant interaction between tillage and nitrogen response in 1988 (table 17). In light of the earlier visual nitrogen observations (table 7) this may have been due to tillage effects on stand (table 21) or the highest nitrogen rate was not high enough for the no till system (table 17).

In summary, tillage had a large influence on emergence and early growth of second year corn grown after alfalfa. Conservation tillage options also reduced grain yields. Although there was an effect of tillage on the visual nitrogen response on August 25, there was not an interaction on grain yields. It is suggested that the lack of a tillage influence on the grain nitrogen response may have been due to tillage effects on stand or because the nitrogen rates were not high enough.

WADENA COUNTY

Table 1. Cultural practices at Staples Irrigation Center, Wadena County, MN. 1988.

Tillage	Previous Crop	1988 Crop
No Till	1984-86 Alfalfa	Corn-Pioneer 3790
Spring Disc-twice on April 27, 1988	1987-Corn	
Moldboard Plow-on April 27, 1988 and then disced once		

Planting and Harvest Date

The planter is a John Deere Max-Emerge planter equipped with 2" fluted coulters.

	Planting		
Crop	Date	Rate	Harvested
Corn	April 27, 1988	35,600 plants/A	September 29, 1988

Fertilizer 1987

Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Actual S	Date Applied
		lbs/A				
17-7-23-6[1]	93 lbs/A	16	6	21	6	May 11, 1987
46-0-0[2]	0 lbs/A	0	0	0	0	June 16, 1987
46-0-0[2]	75 lbs/A	35	0	0	0	June 16, 1987
46-0-0[2]	146 lbs/A	67	0	0	0	June 16, 1987
46-0-0[2]	221 lbs/A	102	0	0	0	June 16, 1987

1. Planter applied 2" below and 2" beside row.
2. Broadcast as urea and irrigated in.

Fertilizer 1988

Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Actual S	Date Applied
		lbs/A				
24-8-15-8[1]	85 lbs/A	20	7	13	7	April 27, 1988
46-0-0[2]	0 lbs/A	0	0	0	0	June 1, 1988
46-0-0[2]	137 lbs/A	63	0	0	0	June 1, 1988
46-0-0[2]	254 lbs/A	117	0	0	0	June 1, 1988
46-0-0[2]	400 lbs/A	184	0	0	0	June 1, 1988

1. Planter applied 2" below and 2" beside row.
2. Broadcast as urea and irrigated in.

Soil

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

Weed Control

1.5 pt/A (1.5 lb/A) Dual + 1.3 qt/A (1.3 lbs/A) Bladex on May 14, 1987.

Table 2. The effect of tillage on soil covered by corn residue in Wadena Co. on May 11, 1988, n=32.

	Tillage			
	No Till	Disc	Moldboard	
Location	%			Sig.
In Row	84.0	63.8	8.5	.000
Between	90.0	56.8	6.4	.000

Table 3. The effect of nitrogen rate on soil cover by corn residue in in Wadena Co. on May 11, 1988, n=24.

	Nitrogen rate lbs N/A[1]				
	16	51	83	118	
Location	%				Sig.
In Row	47.3	53.7	51.5	55.8	.150
Between	48.3	57.8	48.5	49.5	.004

1. These are the 1987 N rates.

Table 4. The effect of tillage and nitrogen rate on soil cover by corn residue on May 11, 1988, in Wadena Co., n=8.

	Tillage					
	No Till		Disc		Moldboard	
	In row[1]	Betw row[2]	In row	Betw row	In row	Betw row
Nitrogen[3]	%					
16 lbs/A	75.0	87.0	58.0	49.5	9.0	8.5
51 lbs/A	84.0	93.0	70.5	74.5	6.5	6.0
83 lbs/A	91.5	89.5	55.5	50.0	7.5	6.0
118 lbs/A	85.5	90.5	71.0	53.0	11.0	5.0

1. The p value for the tillage by nitrogen rate interaction is .126.
2. The p value for the tillage by nitrogen rate interaction is .006.
3. These are the 1987 N rates.

Table 5. Effect of tillage on corn population at Wadena Co. 1988, n=16.

		Tillage		
	Sig. of	No Till	Disc	Moldboard
Date	Tillage	plants/A x 10^{-3}		
May 9	(.000)	5.4	20.3	31.7
May 11	(.005)	10.7	23.8	32.7
May 14	(.048)	20.1	28.7	33.2
May 16	(.196)	26.7	29.0	32.2
May 18	(.396)	28.9	29.3	31.9
May 20	(.615)	30.3	30.2	31.9
May 23	(.529)	30.2	30.2	31.9
May 25	(.427)	29.8	30.2	32.0
May 27	(.498)	29.9	30.0	31.8
June 1	(.423)	29.5	30.2	31.9
June 6	(.475)	29.5	30.3	31.8
June 8	(.393)	29.5	30.2	32.0
June 10	(.403)	29.3	30.2	31.8

Table 6. Effect of tillage on early growth of corn at Wadena Co. 1988, n=16.

		Tillage		
	Sig. of	No Till	Disc	Moldboard
Date	Tillage	leaves/plant		
May 9	(.000)	0.3	0.8	1.3
May 11	(.000)	0.6	1.3	2.0
May 14	(.000)	1.2	2.0	2.7
May 16	(.000)	1.8	2.7	3.2
May 18	(.000)	2.2	3.0	3.8
May 20	(.001)	2.8	3.3	4.2
May 23	(.000)	3.3	4.0	4.9
May 25	(.001)	3.8	4.5	5.5
May 27	(.002)	4.4	5.1	6.1
June 1	(.001)	6.5	7.4	8.6
June 6	(.000)	8.2	9.1	10.4
June 8	(.001)	8.3	9.6	11.1
June 10	(.000)	8.6	9.7	11.1

Table 7. The effect of tillage and nitrogen rate on plant color on Aug. 25, 1988, at Wadena Co.[1]

	Tillage		
	No Till	Disc	Moldboard
Nitrogen	----- color index[2] -------		
20 lbs/A	3.3	3.8	5.0
80 lbs/A	5.5	6.0	6.8
140 lbs/A	9.0	6.5	7.8
200 lbs/A	9.8	9.3	10.0

1. The p value for the tillage by nitrogen interaction is .010, n=4.
2. Color index ranges from 1=yellow to 10=dark green.

Table 8. The effect of tillage on plant color and height on August 25, 1988, at Wadena Co.

	Tillage			
	No Till	Disc	Moldboard	
Variable	---- color index[1] ------			Sig.
Color	6.9	6.4	7.4	.079
	-------- feet ----------			
Plant height	7.5	7.3	7.2	.127

1. Color index ranges from 1=yellow to 10=dark green, n=16.

Table 9. The effect of nitrogen rate on color and plant height on August 25, 1988, at Wadena Co.

	Nitrogen rate lbs N/A				
	20	80	140	200	
Variable	--- color index[1] ----				Sig.
Color	4.0	6.1	7.8	9.7	.000
	------- feet --------				
Plant height	6.8	7.4	7.5	7.5	.009

1. Color index ranges from 1=yellow to 10=dark green, n=12.

Table 10. The effect of tillage on soil moisture at Wadena Co. in 1988, n=80.

	Tillage			
	No Till	Disc	Moldboard	
Date	-------- %w/w ----------			Sig.
4/14/88	5.2	4.8	5.3	.085
10/25/88	5.0	5.1	6.2	.087

Table 11. The effect of nitrogen rate on soil moisture at Wadena Co. in 1988, n=60.

	Nitrogen rate lbs N/A				
	20	80	140	200	
Date	------- %w/w --------				Sig.
4/14/88	5.0	5.0	5.0	5.3	.089
10/25/88	5.4	5.6	5.5	5.4	.191

Table 12. The effect of depth on soil moisture at Wadena Co. in 1988, n=48.

	Depth (ft.)					
	0-1	1-2	2-3	3-4	4-5	
Date	--------- %w/w ---------					Sig.
4/14/88	9.4	5.7	3.6	3.5	3.4	.000
10/25/88	10.1	6.8	3.6	3.3	3.5	.000

Table 13. The effect of nitrogen rate and tillage on soil moisture at Wadena Co. in 1988.

	4/14[1]			10/25[2]		
	Tillage					
	N-T	Dsc	Mld	N-T	Dsc	Mld
N (lbs/A)	---------- %w/w ----------					
20	5.5	4.7	4.9	4.8	5.3	6.0
80	4.8	5.0	5.2	5.2	5.2	6.3
140	4.9	4.8	5.3	5.0	5.0	6.4
200	5.7	4.5	5.7	5.2	4.9	6.1

1. The p value for the tillage by nitrogen interaction is .002, n=20.
2. The p value for the tillage by nitrogen interaction is .176, n=20.

Table 14. The effect of depth and tillage on soil moisture at Wadena Co. in 1988.

	4/14[1]			10/25[2]		
	Tillage					
	N-T	Dsc	Mld	N-T	Dsc	Mld
Depth (ft.)	---------- %w/w ----------					
0-1	9.6	8.7	9.8	9.8	9.8	10.8
1-2	5.8	5.0	6.3	5.6	6.0	8.6
2-3	3.8	3.3	3.6	3.3	3.2	4.3
3-4	3.6	3.4	3.4	3.1	3.1	3.6
4-5	3.4	3.4	3.3	3.4	3.3	3.7

1. The p value for the tillage by depth interaction is .021, n=16.
2. The p value for the tillage by depth interaction is .000, n=16.

Table 15. Effect of tillage on yield and moisture, and final stand in Wadena Co. on September 29, 1988, n=16.

Variable	Tillage: No Till	Disc	Moldboard	Sig.
	bu/A			
Grain:Yield	134.8	147.3	157.1	.004
	%			
Moisture	28.4	23.6	22.7	.000
	t/A			
Stover Yield	2.48	2.61	2.75	.276
	%			
Moisture	65.1	62.4	61.8	.039
	plants/A x 10^{-3}			
Final Stand	29.6	31.7	32.4	.006

Table 16. Effect of nitrogen rate on yield, moisture, and final stand in Wadena Co. on September 29, 1988, n=12.

Variable	Nitrogen rate lbs N/A: 20	80	140	200	Sig.
	bu/A				
Grain:Yield	94.7	148.8	166.1	176.0	.000
	%				
Moisture	25.0	24.7	24.4	25.6	.316
	t/A				
Stover:Yield	2.12	2.65	2.84	2.84	.000
	%				
Moisture	62.1	62.8	62.4	65.2	.003
	plants/A x 10^{-3}				
Final Stand	29.9	32.1	31.7	31.2	.058

Table 17. The effect of nitrogen rate and tillage on yield at Wadena Co. on September 29, 1988[1].

N (lbs/A)	Tillage: No Till	Disc	Moldboard
	bu/A		
20	78.3	93.1	112.6
80	137.7	146.2	162.4
140	155.3	173.0	170.1
200	168.0	176.9	183.2

1. The p value for the tillage by nitrogen interaction is .588, n=4.

Table 18. The effect of nitrogen rate and tillage on grain moisture at Wadena Co. on Sept. 29, 1988[1].

N (lbs/A)	Tillage: No Till	Disc	Moldboard
	%		
20	28.6	23.7	22.8
80	27.9	23.7	22.4
140	27.7	23.0	22.7
200	29.6	24.1	23.1

1. The p value for the tillage by nitrogen interaction is .649, n=4.

Table 19. The effect of nitrogen rate and tillage on stover yield at Wadena Co. on Sept. 29, 1988[1].

N (lbs/A)	Tillage: No Till	Disc	Moldboard
	tons/A		
20	1.86	2.05	2.45
80	2.58	2.62	2.74
140	2.72	2.94	2.87
200	2.75	2.83	2.93

1. The p value for the tillage by nitrogen interaction is .373, n=4.

Table 20. The effect of nitrogen rate and tillage on stover moisture at Wadena Co. on Sept. 29, 1988[1].

N (lbs/A)	Tillage: No Till	Disc	Moldboard
	%		
20	65.2	62.4	58.7
80	64.4	63.0	60.9
140	64.5	60.8	61.9
200	66.2	63.7	65.6

1. The p value for the tillage by nitrogen interaction is .058, n=4.

Table 21. The effect of nitrogen rate and tillage on final stand at Wadena Co. on Sept. 29, 1988[1].

N (lbs/A)	Tillage: No Till	Disc	Moldboard
	plants/A x 10^{-3}		
20	26.6	32.7	30.6
80	32.3	30.3	33.7
140	29.4	32.7	32.8
200	29.9	31.0	32.6

1. The p value for the tillage by nitrogen interaction is .019, n=4.

The Effect of Tillage System and Deep Chisel Plowing on Corn Production on a Udollic Ochraqualf Soil[1]

J.F. Moncrief, T.L. Wagar, and J.J. Kuznia[2]

Abstract: Tillage systems were evaluated for corn production on a soil with a thin loess cap over laying dense glacial till with poor internal drainage. Plots were split with deep chisel plowing. Tillage did not affect grain yields. Deep chisel plowing resulted in a 5 bushel per acre increase in yield.

This is the first year of this study. Continuous corn is grown with four tillage systems. Tillage systems are: fall moldboard and chisel plowing, ridge till, and fall disc. In addition each plot is split with a deep fall chisel plowing (8" to 10" deep) done on 28" spacing (same as row spacing).

Soil cover by residue measurements were made after cultivation (table 2). At this point in time the soil cover is similar for all the conservation tillage systems. The cultivation concentrated the residue in the row. These cover measurements would not be expected to be correlated with early growth. Early growth was not affected by tillage (table 3). Corn stands were reduced 2 to 4 thousand plants per acre with the conservation tillage systems.

The effect of tillage on weed severity is shown in table 4. Foxtail is the dominant weed. Ridge tillage resulted in less foxtail.

Grain yields are shown in table 5. There was no significant difference in grain yields due to tillage. Deep chiseling increased yields 5 bushels per acre and reduced grain moisture slightly (table 6). There was no interaction between tillage system and deep chiseling on grain yields (table 7). It should be noted that a split plot design increases the resolution of subplot effects at the expense of the main plots. Average yields between tillage systems ranged about 14 bushels per acre and the deep chiseling subplots only 6 bushel per acre. Tillage effects were not statistically significant but deep chiseling treatments were.

DODGE COUNTY

Table 1. Cultural practices at Dodge County, MN. 1988.

Tillage
- Ridge Till
- Fall Disc-Light spring disc twice
- Fall Chisel Plow-Light spring disc twice
- Fall Moldboard Plow-Light spring disc twice

All plots split with a deep chisel, 8-10 inches deep, done in the fall prior to fall tillage. Shanks are spaced on 28 inch centers and are a point type that run in the center of the row.

All plots were culitvated once and 10 days latter ridges formed.

Preceding Crop
1985-87 Corn

1988 Crop
Corn-Pioneer 3732

1 This project was supported in part by the Soil Conservation Service. Their support is greatly appreciated. Data collection and information dissemination was aided by Dave H. Hanson, Dodge County Agricultural Extension Agent.

2 John F. Moncrief and Joe J. Kuznia are Associate Professor and Assistant Scientist respectively in the Soil Science Department at the University of Minnesota, St. Paul, MN. 55108. Tim L. Wagar is an Area Crops and Soils Extension Specialist, University of Minnesota, Rochester, MN.

Planting and Harvest Date

A six row John Deere 7000 with 28 inch row spacing was used.

Crop	Planting Date	Planting Rate	Harvested
Corn	April 20, 1988	27,700 plants/A	October 3, 1988

Fertilization History

Crop	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Date Applied	Method of Application
			--- lb/A ---				
Corn:	46-0-0	370 lbs/A	170	0	0	April 16, 1987	Broadcast
	7-21-7	10 gal/A	8	24	8	April 29, 1987	Applied with the seed

Fertilizer 1988

Crop	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Date Applied	Method of Application
			--- lb/A ---				
Corn:	82-0-0	213 lbs/A	175	0	0	April 5, 1988	Injected
	7-21-7[1]	5.5 gal/A	4	13	4	April 20, 1988	Applied with the seed

Soil

The soil at this site is a Skyberg (Udollic Ochraqualfs, fine-loamy, mixed mesic) silt loam, with 0 to 2 percent slope. This soil is somewhat poorly drained.

Weed Control

1 qt/A (2 lbs/A) Dual + 2.5 lbs/A (2.25 lbs/A) Bladex 90 DF applied on April 23, 1988.

Table 2. Effect of tillage on soil covered by corn residue in Dodge Co. on June 23, 1988[1].

Residue Location	Moldboard	Ridge	Disc	Chisel	Sig.
	Tillage				
	---------- % cover --------				
In Row	14.7	35.3	30.7	32.3	.012
Between Row	15.0	22.3	24.7	26.7	.276

1. Cover was measured on subplots without deep chiseling after cultivation, n=12.

Table 3. Effect of tillage on early corn growth and population in Dodge Co. on June 23, 1988[1].

Variable	Moldboard	Ridge	Disc	Chisel	Sig.
	Tillage				
	-------- leaves/plant -----				
Growth Stage	6.4	5.7	5.9	6.1	.157
	----- plants/A x 10^{-3} -----				
Population	28.0	25.9	25.9	24.3	.043

1. Growth stage and population was measured on subplots without deep chiseling after cultivation, n=12.

Table 4. Effect of tillage on weed severity in corn at Dodge Co. on June 7, 1988[1].

Weed	Moldboard	Ridge	Disc	Chisel	Sig.
	Tillage				
	---------- % cover --------				
Foxtail	18.3	5.0	21.7	15.0	.163
Velvetleaf	0.0	0.0	0.0	3.3	
Quackgrass	3.3	0.2	8.3	3.3	.226
Barnyard grass	6.7	0.0	8.7	16.7	
Yellow nutsedge	0.3	0.0	0.0	1.7	

1. Cover by weeds was visually estimated on the entire main tillge plots, n=3.

Table 5. The effect of tillage on corn yield and moisture at Dodge Co. on October 3, 1988[1].

Variable	Moldboard	Ridge	Disc	Chisel	Sig.
	Tillage				
	---------- bu/A ----------				
Grain:Yield	124.2	118.1	115.3	110.6	.349
	---------- % ----------				
Moisture	16.3	16.9	17.4	16.8	.485

1. Averaged over the deep chisel subplots, n=6.

Table 6. The effect of chisel on corn yield and moisture at Dodge Co. on October 3, 1988, n=12.

Variable	Chisel: Deep Chisel	Chisel: No Chisel	Sig.
	bu/A		
Grain:Yield	119.8	114.3	.108
	%		
Moisture	16.6	17.0	.072

Table 7. The effect of tillage system and chiseling on corn yield and moisture at Dodge Co. on October 3, 1988[1].

Variable		Tillage: Moldboard	Ridge	Disc	Chisel
		bu/ac			
Grain:Yield	Deep Chisel	129.6	116.5	118.9	114.2
	No Chisel	118.9	119.7	111.6	106.9
		%			
Moisture	Deep Chisel	16.2	16.6	17.4	16.4
	No Chisel	16.5	17.1	17.3	17.1

1. The p value for the tillage by chiseling interaction was .432 and .441 for grain yield and moisture respectively, n=3.

The Effect of Tillage and Cultivation on the Nitrogen Response by Corn Following Alfalfa on a Typic Hapludalf[1]

J.F. Moncrief, J.J. Kuznia, T.L. Wagar, and G.P. Cremers[2]

Abstract: Tillage and cultivation effects on the nitrogen response following alfalfa were evaluated on a silt loam soil in southeastern Minnesota. The nitrogen response was 10 bushels per acre. Tillage and cultivation did not affect the nitrogen response. Tillage did not affect corn yields. Cultivation was responsible for a 20 bushel per acre increase in corn yield largely due to control of woolly cupgrass and did not interact with tillage.

In southeastern Minnesota soils are very vulnerable to erosion. Any sustainable cropping system in this area of the state will include some form of conservation tillage to control erosion. Preliminary data has shown that tillage can greatly affect the amount of nitrogen that is released from alfalfa for succeeding corn crops. The fractured limestone aquifer in this area of the state is also vulnerable to contamination by nitrate nitrogen. In an effort to assess the effect of tillage on the response of corn following alfalfa to applied nitrogen, plots were established in Winona County, Minnesota with a range of tillage from moldboard plowing to a no till approach in the spring of 1988.

A summary of treatments and site history is shown in table 1. This study is located on a dairy farm and the crop rotation has been three years of alfalfa and two years of corn. The soil is a Typic Hapludalf (Seaton silt loam) with good internal drainage. Nitrogen was applied four days before tillage in the spring as broadcast urea. The statistical design is a split split plot with tillage main plots with first subplots cultivation and second subplots nitrogen with four replications. Main tillage plots are 100 by 40 feet, cultivation plots are 100 by 20 feet, and nitrogen plots are 20 by 25 feet.

The existing stand of alfalfa is characterized in table 2. The density of alfalfa ranged from 1.2 to 2.4 crowns per square foot. The two weeds present in the spring were dandelion and bromegrass. There was a positive and negative correlation between alfalfa and dandelions and bromegrass respectively.

Tillage treatments were: moldboard and chisel plowing, heavy disc, and no till. All but the no till treatment received one pass with a light finishing disc before planting. The effect of an aggressive cultivation was also evaluated. All plots were split with one cultivation with a ridge till cultivator on June 20.

There was .6 to .8 leaf less growth by the no till corn on June 20 (table 5). This occurred even though the "in row" soil cover by crop residue was only 6 to 8% higher than the disc and chisel systems (table 3). The planter used at this site is equipped with small clearing discs. The width of the cleared area over the row was only about 4 to 6 inches. This may have been partially responsible for the delayed growth. Tillage did not affect plant stand. The drought stress in 1988 did affect the mortality of corn at this site (table 6). Corn stands went from 28,000 to 22,000 plants per acre over the growing season, drop of 28 per cent.

Soil water content to a depth of 5 feet is shown in tables 7, 8, and 9. The initial water content in the spring before establishment of the tillage treatments was low throughout the profile due to extraction by the alfalfa the previous year (table 7 and 9). At the end of the season the no till treatment had higher levels of soil moisture. The no till plots had higher levels of soil water in the 2 to 5 foot depth. This suggests that corn grown with this system had less roots at these depths. The authors do not have an explanation for the interaction of tillage and cultivation illustrated in table 8 at this time.

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1 This project is supported in part by the following: United States Fish and Wildlife Service, Minnesota Department of Agriculture, and the Soil Conservation Service. Their support is greatly appreciated. Data collection was assisted by Neil R. Broadwater and Stanley F. Musielewicz, the Winona County Agricultural Extension Agent and Winona Soil Conservationist respectively. This project would not have been possible without their help.

2 John F. Moncrief, Joe J. Kuznia, and Greg P. Cremers are Associate Professor and Assistant Scientists, respectively in the Soil Science Department at the University of Minnesota, St. Paul, MN. 55108. Tim L. Wagar is an Area Crops and Soils Extension Specialist, University of Minnesota, Rochester, MN.

The dominate weed at this site is woolly cupgrass. Tillage did not affect the density or species of weeds present (tables 10 and 11). Cultivation had a large influence on weeds however (table 12). Woolly cupgrass is very difficult to control in corn chemically. There was no interaction between tillage and cultivation on effectiveness of weed control.

Tillage influenced corn phenology (table 13). Differences in plant water stress due to tillage were not present on July 12.

Tillage did not affect grain or stover yields (table 14). No till grown corn had 3 percent higher grain moisture however. There was a small but statistically significant response to applied nitrogen (table 15). Tillage did not affect the nitrogen response.

The main effects of cultivation and the interaction with tillage on yield and moisture is shown in table 16. The average cultivation response was 20 bushels per acre. The moldboard and no till systems resulted in about a 25 bushel per acre cultivation response. The disc system resulted in only a 10 bushel per acre response to cultivation.

Cultivation increased final plant stands 1.2 thousand plants per acre. The large yield increases due to cultivation is primarily due to control of woolly cupgrass. Increases in final stand to a lesser extent may have been responsible for the increase in yield with the moldboard and chisel systems.

In summary there was no effect of tillage on corn yields following alfalfa on a silt loam soil in southeastern Minnesota. Tillage did not affect corn stands but mortality was 28% over the growing season. At the end of the season soil water was higher at the 2 to 5 feet depth with the no tillage system. The response to nitrogen was 10 bushels per acre and not affected by tillage. Cultivation was responsible for a 20 bushel per acre yield response primarily due to control of woolly cupgrass. Cultivation also increased final corn stands by about a thousand plants per acre.

WINONA COUNTY

Table 1. Cultural practices at Winona County, MN. 1988.

Tillage

No Till
Spring Disc-heavy disc followed by a light finishing disc
Spring Chisel Plowed-then a light finishing disc once
Spring Moldboard Plowed-then a light finishing disc once
All tillage was done just prior to planting on May 2, 1988

Cropping History

1979-81 Alfalfa, 1982-83 Corn,
1984 Oats and Alfalfa, 1985-87 Alfalfa

Manure History

20 loads of solid dairy manure (300 bu. spreader) in 1980, 1982, and 1983

1988 Crop

Corn Pioneer 3737

Planting Information for 1988 Crop Year

A four row International 800 planter with 38 inch row spacing and equiped with factory clearing disks.

Crop	Date	Rate	Harvested
Corn	May 2, 1988	30,500 plants/A	October 6, 1988

Fertilizer 1988

Crop	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Actual S	Actual Zn	Date Applied	Method of Application
			------- lbs/A --------						
Corn	16-42-5-7-20	110 lbs/A	18	46	6	8	22	May 2, 1988	Starter 2" x 2" with planter
	46-0-0	65 lbs/A	30	0	0	0	0	April 29, 1988	Broadcast
	46-0-0	130 lbs/A	60	0	0	0	0	April 29, 1988	Broadcast
	46-0-0	196 lbs/A	90	0	0	0	0	April 29, 1988	Broadcast

Soil

Seaton (Typic Hapludalfs, fine-silty, mixed, mesic) silt loam, 3-6% slope, soil is well drained.

Weed Control

Applied 2 qt/A (1.5 lb/A) Roundup + .5 pt/A (.25 ai/A) Banvel + .5 pt/A (.5 lb/A) 2,4-D on April 29, 1988.
Applied 3 pt/A (1.5 lb/A) Prowl + 2 lb/A (1.8lb/A) Bladex 90 DF on May 18, 1988.
Applied 50% Roundup on non-cultivated rows with a hand held rope wick on July 8, 1988.
Main tillage plots were split with cultivation on June 20, 1988.

Table 2. Variability of alfalfa stand and weeds present prior to establishment of tillage treatments at Winona Co. April 21, 1988, n=16.

Weed	Rep 1	stdv	Rep 2	stdv	Rep 3	stdv	Rep 4	stdv	Sig.
	---------- plants/square foot ----------								
Alfalfa	1.2	.62	1.8	.44	2.6	.61	2.4	.44	.000
Dandelion	0.4	.26	0.5	.27	1.1	.39	2.6	.72	.000
Bromegrass	3.1	1.96	2.0	1.43	2.3	1.68	1.4	1.04	.030

Table 3. Effect of tillage on soil covered by alfalfa residue in Winona Co.

	Tillage NoTill	Disc	Chisel	Moldbd	Sig.	n
5/18/88	------- % cover ---------					
In Row	14.0	8.0	6.0	1.5	.003	8
Betwn Row	62.0	10.0	14.0	5.0	.000	8
6/20/88[1]						
In Row	48.0	8.8	8.3	3.8	.000	32
Betwn Row	37.0	8.6	7.5	3.5	.000	32

1. Averaged over cultivation.

Table 4. Effect of tillage and cultivation on soil covered by alfalfa residue at Winona Co. June 20, 1988, n=16.

	Tillage No Till	Disc	Chisel	Moldboard	Sig.[1]	Cultivation	Sig.[2]
In row	--------- % cover ----------					- % cover—	
Cultivation	43.5	7.8	8.0	3.8	.026	15.8	.013
No cultivation	52.5	9.8	8.5	3.8		18.6	
Between row							
Cultivation	22.3	7.0	5.8	2.8	.000	9.4	.000
No cultivation	51.8	10.3	9.3	4.3		18.9	

1. This is the p value of the interaction between tillage and cultivation, n=16.
2. This is p value of the main effect of cultivation, n=64.

Table 5. Effect of tillage on early corn growth and population at Winona Co. on June 20, 1988.

Variable	Tillage NoTill	Disc	Chisel	Moldbd	Sig.	n
	----- leaves/plant ------					
Stage	8.0	8.6	8.9	8.8	.000	80
	-- plants/A x 10^{-3} ------					
Stand	23.8	25.4	25.9	25.5	.199	16

Table 6. Effect of time and tillage on corn mortality in Winona Co. 1988.

Variable	Tillage No Till	Disc	Chisel	Moldboard	Sig.	n
	------ plants/A x 10^{-3} ---------					
May 18	28.0	29.5	28.9	27.8	.580	8
June 20	23.8	25.4	25.9	25.5	.199	16
Oct. 7	22.1	22.4	22.9	23.7	.334	64

Table 7. Effect of tillage on the average soil moisture to a depth of five feet in Winona Co. 1988.

	Tillage					
	No Till	Disc	Chisel	Moldboard		
Variable	%w/w				Sig.	n
4/20/88[1]	15.8	16.2	16.4	15.8	.597	20
11/9/88	22.2	20.6	20.0	20.0	.003	40

1. Soil samples were taken before tillage.

Table 8. Effect of tillage and cultivation on soil moisture in Winona Co. Nov. 9, 1988.[1]

	Tillage			
	No Till	Disc	Chisel	Moldboard
	%w/w			
Cultivation	22.2	20.7	20.7	19.7
No cultivation	22.1	20.5	19.4	20.3

1. The p value of the tillage by cultivation interaction is .030, n=20.

Table 9. Effect of tillage and depth on soil water at Winona Co. 1988.

	Tillage									
	No Till		Disc		Chisel		Moldboard		Depth	
	Spring[1]	Fall[2]	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Depth (feet)	% moisture									
0-1	13.8	24.7	14.2	24.6	14.1	24.3	14.0	25.1	14.0	24.7
1-2	15.9	24.2	16.4	23.8	17.0	23.7	16.0	22.6	16.3	23.6
2-3	16.1	19.2	16.9	16.5	17.0	15.8	16.3	14.3	16.5	16.4
3-4	16.8	19.7	16.7	17.5	17.4	16.6	16.8	16.6	16.9	17.6
4-5	16.7	23.1	16.9	20.8	16.6	19.8	15.7	21.3	16.5	21.3
Average	15.9	22.2	16.2	20.6	16.4	20.0	15.8	20.0	16.1	20.7

1. This is before establishment of tillage treatments. The p value of spring sampling (April 21, 1988) for the tillage by depth interaction is .993, n=4; and for depth .003, n=16.
2. The p value of fall sampling (November 9, 1988) for the tillage by depth interaction is .001, n=8; and for depth .001, n=32.

Table 10. Effect of tillage on cover by weeds in corn at Winona Co. on June 20, 1988, (observations made before cultivation.), n=4.

	Tillage				
	No Till	Disc	Chisel	Moldboard	
Weed	% cover				Sig.
Pigweed	0.8	0.5	3.3	0.5	.344
Lambsquarter	0.3	1.0	0.3	0.7	.455
Velvetleaf	2.0	3.7	3.0	5.3	.353
Wcupgrass	50.0	48.8	47.5	46.3	.995
Smartweed	0.0	0.3	0.0	0.3	
Alfalfa	2.3	0.0	0.0	0.0	
Horsetail	6.3	0.0	0.3	0.0	
Yelnutsedge	0.0	0.0	0.3	0.0	

Table 11. Effect of tillage on cover by weeds in corn at Winona Co. July 8, 1988[1]. n=8.

	Tillage				
	No Till	Disc	Chisel	Moldboard	
Weed	% cover				Sig.
Wcupgrass	38.1	29.1	32.5	25.4	.276
Alfalfa	1.3	0.3	0.3	0.3	.016
Pigweed	0.0	0.0	0.6	0.0	
Velvetleaf	0.0	0.0	0.0	0.2	

1. Values are averaged over cultivation. The p value for the tillage by cultivation interaction was < .100 for all weed species, n=8.

Table 12. Effect of cultivation on cover by weed in corn at Winona Co. July 8, 1988[1].

Weed	Cultivation: Cult.	Cultivation: No Cult.	Sig.
	-- % cover -----		
Wcupgrass	10.4	52.2	.000
Alfalfa	0.4	0.6	.343
Pigweed	0.0	0.3	.343
Velvetleaf	0.0	0.1	.356

1. The tillage by cultivation interaction has a p value of .260, n=16.

Table 13. Effect of tillage on corn phenology and water stress in Winona Co. July 12, 1988, n=8.

Variable	Tillage: No Till	Disc	Chisel	Moldboard	Sig.
Percent Silked Plants	0.0	9.4	18.8	37.5	.046
Silk Stage[1]	1.0	1.8	1.8	2.3	.005
Tassle Stage[2]	1.6	3.6	3.5	3.5	.007
	--------- (-bars) ----------				
Leaf water potential	12.1	11.7	12.4	12.3	.486

1. Silk stage:1=no silk, 2=silk emerging 0-1", 3=silk emerged 1-3", 4=silk red, 5=silk brown.
2. Tassle stage:1=no tassle, 2=spike, 3=expanding, 4=pollen shed, 5=tassel brown.

Table 14. Effect of tillage on grain and stover yields and moisture, in Winona Co. 1988, n=64.

Variable	Tillage: No Till	Disc	Chisel	Moldboard	Sig.
	---------- bu/A ----------				
Grain:Yield	94.2	102.1	99.8	101.2	.746
	---------- % ----------				
Moisture	19.1	16.6	16.4	16.1	.000
	---------- t/A ----------				
Stover:Yield	1.62	1.77	1.69	1.71	.463
	---------- % ----------				
Moisture	49.2	49.2	51.7	48.8	.221

Table 15. Effect of nitrogen rate on grain and stover yields and moisture in Winona Co. on Oct 7, 1988, n=64.

Variable	Nitrogen Rate lbs./A[1]: 0	30	60	90	Nrate[2]	NxT[3]
	---------- bu/A -------					
Grain:Yield	95.7	96.1	100.5	105.0	.010	.591
	---------- % ---------					
Moisture	17.1	17.5	16.7	16.9	.119	.485
	---------- t/A --------					
Stover:Yield	1.66	1.66	1.73	1.73	.316	.244
	---------- % ---------					
Moisture	49.9	49.6	49.2	50.2	.569	.873

1. And additional 18 lbs/A was applied with the starter fertilizer.
2. The p values for nitrogen rate.
3. The p value for the tillage by nitrogen interaction.

Table 16. Effect of tillage and cultivation on yield, moisture and final stand in Winona Co. on Oct.7, 1988.

Variable	Tillage (n=32): No Till Cult.	No Till No Cult.	Disc Cult.	Disc No Cult.	Chisel Cult.	Chisel No Cult.	Moldboard Cult.	Moldboard No Cult.	Sig.[1]	Cultivation (n=128): Cult.	Cultivation (n=128): No Cult.	Sig.[2]
	---------- bu/A ----------											
Grain:Yield	106.2	82.1	107.7	96.5	109.5	90.1	114.0	88.5	.038	109.4	89.3	.000
	---------- % ----------											
Moisture	18.9	19.3	16.9	16.2	17.0	15.8	15.7	16.5	.010	17.1	17.0	.476
	---------- t/A ----------											
Stover:Yield	1.68	1.56	1.72	1.81	1.72	1.66	1.77	1.65	.024	1.72	1.67	.051
	---------- % ----------											
Moisture	50.2	48.3	50.3	48.1	51.8	51.5	49.9	47.7	.432	50.6	48.9	.002
	---------- plants/A x 10^{-3} ----------											
Stand	21.8	22.4	22.8	22.1	24.2	21.7	24.7	22.7	.152	23.4	22.2	.026

1. This is the p value of the interaction of tillage and cultivation.
2. This is the p value of the main effect of cultivation.

The Effect of Tillage and Cultivation on Corn Production on a Typic Argiudoll in Southeastern Minnesota[1]

J.F. Moncrief, T.L. Wagar, and J.J. Kuznia[2]

Abstract: Tillage did not affect continuous corn yields on a Typic Argiudoll soil in southeastern Minnesota. Tillage and cultivation affected the level of velvetleaf and giant foxtail differently. Discing resulted in the highest levels of velvetleaf. The no till system resulted in the highest levels of giant foxtail. Cultivation did not reduce velvetleaf stands with no tillage but was effective with other systems. Giant foxtail was reduced with cultivation in all tillage systems.

This is the fourth year of a study designed to evaluate tillage and cultivation on corn production in southeastern Minnesota. The soil is a deep silt loam soil with a high intrinsic yield potential. The planter used is a conventional planter equipped with clearing discs to clean the row area.

The soil cover in the row ranged from 6% to 43% for the moldboard and no till systems respectively (table 2). The disc and chisel systems resulted in similar cover in the row (about 25%). Early growth was not affected until "in row " cover was greater than 30% (no till system-table 3). Plant population was not affected by tillage. This site received 1.68 inches of rain (see weather summary of tillage studies this publication) shortly after planting which was likely responsible for the lack of tillage and residue effects on stand establishment.

The dominate weeds at this site are foxtail and velvet leaf. Early weed growth was not affected by tillage treatments (table 4). At harvest there was a tillage affect on both of these species (table 5). Moldboard plowed plots had the fewest weeds and no till the most. Cultivation reduced both foxtail and velvet leaf densities to slight (table 6).

There was an interaction between tillage and cultivation response (table 7). There were no foxtail in moldboard plots likely due to lower seed reserve and more effective herbicide control. The disc and chisel treatments had intermediate levels of foxtail and similar control with cultivation. No till plots had severe levels of foxtail. Although cultivation reduced the foxtail it was not entirely effective in controlling this weed. The cultivator used at this site is a conventional cultivator (no coulters or wide sweeps). A conservation tillage cultivator would have done a much better job.

The velvet leaf was the most prevalent in the disc and chisel treatments where cultivation was not done. The moldboard plowing and no till treatments without cultivation resulted in about the same amount of velvet leaf. The highest infestation of velvet leaf occurred in the disced plots without cultivation. The lack of control with cultivation in no till plots is due to the conventional cultivator used that is not designed for this system.

Grain yields and moisture are shown in table 8. There was no significant effect of tillage on grain yields although the yield trend appeared to follow the weed observations. In light of the small effect of residue on early growth it is surprising to have a 4% spread in grain moisture which closely follows "in row" cover. The average cultivation response was about 13 bushels per acre (table 9).

The interaction between cultivation and tillage was not statistically significant (table 10). This may have been due more to the three replications at this site. However, the cultivation response across tillage systems

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1 This project is supported in part by the Soil Conservation Service. Their support is greatly appreciated. Data collection was aided by the Fillmore County Extension and SCS office. This project would not have been possible without this assistance.

2 John F. Moncrief and Joe J. Kuznia are Associate Professor and Assistant Scientist respectively in the Soil Science Department at the University of Minnesota, St. Paul, MN. 55108. Tim L. Wagar is an Area Crops and Soils Extension Specialist, University of Minnesota, Rochester, MN.

followed similar trends to weed observations. Corn grown with moldboard plowing had a response to cultivation of 5 bushels per acre (fewest weeds). The chisel and disc systems resulted in 18 bushels per acre. The foxtail and velvetleaf was a problem for the chisel system and velvetleaf a problem for disc system. The no till grown corn response to cultivation was intermediate at 11 bushels per acre. The velvet leaf was not controlled with cultivation. Most of the response was due to foxtail control.

FILLMORE COUNTY

Table 1. Cultural practices at Fillmore County, MN. 1988.

Tillage
No Till
Fall Disc-Light disc in the spring
Fall Chisel Plow-Light disc in the spring
Fall Moldboard Plow-Light disc in the spring

Cropping History
1985-87 Corn

1988 Crop
Corn-Pioneer 3737

Cultivation
Each plot was split with cultivation on June 14, 1988.

Planting and Harvest Date
Planter was a John Deere Max-Emerge 4 row (38") planter equipped with John Deere row cleaners.

	Planting		
Crop	Date	Rate	Harvested
Corn	May 3, 1988	28,000 plants/A	October 4, 1988

Fertilization History
1983-injected 5-6000 gal/ac of liquid dairy manure.

			Actual			
	Material		N	P_2O_5	K_2O	
Crop	Analysis	Rate	---	lbs/A	----	Date Applied
Corn:	16-41-8[1]	125 lb/A	20	51	10	May 6, 1985
	82-0-0	134 lb/A	110	0	0	May 22, 1985
Corn:	9-23-30[1]	125 lb/A	11	29	38	May 7, 1986
	82-0-0	244 lb/A	200	0	0	May 22, 1986
Corn:	9-23-30[1]	100 lb/A	9	23	30	April 29, 1987
	82-0-0	232 lb/A	190	0	0	May 12, 1987

1. Applied 2" beside and 2" below seed.

Fertilizer

			Actual			
	Material		N	P_2O_5	K_2O	
Crop	Analysis	Rate	---	lbs/A	----	Date Applied
Corn:	9-23-30[1]	100 lbs/A	9	23	30	May 3, 1988
	82-0-0	232 lb/A	190	0	0	June 9, 1988

1. Applied 2" beside and 2" below seed.

Soil
Tama (Typic Argiudolls, fine-silty, mixed, mesic) and Downs (Mollic Hapludalfs, fine-silty, mixed, mesic) silt loams, eroded, 2 to 6 percent slopes. Soil is well drained.

Weed Control

1 qt/A (2 lbs/A) Dual + 2.5 qts/A (2.5 lbs/A) Bladex on May 6, 1988.

Insect Control

6.9 lbs/A (1 lb/A) of Counter 15G at time of planting.

Table 2. Effect of tillage on soil covered by corn residue in Fillmore Co. on June 9, 1988, n=12.

	Tillage				
	No Till	Disc	Chisel	Moldboard	
Residue Location	% cover				Sig.
In Row	43.0	25.3	28.3	6.0	.000
Between Row	71.3	37.7	29.0	6.7	.000

Table 3. Effect of tillage on early corn growth and population in Fillmore Co. on June 9, 1988.

	Tillage					
	No Till	Disc	Chisel	Moldboard		
Variable	leaves/plant				Sig.	n
Growth Stage	5.5	5.8	5.8	5.7	.004	60
	plants/A x 10^{-3}					
Population	27.9	27.4	26.6	26.3	.300	12

Table 4. Effect of tillage on weed severity in corn at Fillmore Co. on June 9, 1988, n=3.

	Tillage				
	No Till	Disc	Chisel	Moldboard	
Weed	% cover				Sig.
Velvetleaf	6.7	15.0	13.3	5.7	.158
Foxtail	11.0	4.3	8.0	9.3	.875
Yellwnutedge	0.0	0.0	0.0	0.7	
Dandelion	0.2	0.3	0.0	0.2	
Milkweed	0.2	0.0	0.0	0.0	

Table 5. Effect of tillage on weed severity in corn at Fillmore Co. on Oct. 4, 1988, n=6.

	Tillage				
	No Till	Disc	Chisel	Moldboard	
Weed	weed severity[1]				Sig.
Velvetleaf	2.3	3.2	2.5	1.7	.010
Foxtail	4.3	1.0	1.7	0.0	

1. Weed severity scale; 1=slight to 5=severe.

Table 6. Effect of cultivation on weed severity in corn at Fillmore Co. on Oct 4, 1988, n=12.

	Cult.	No Cult.	
Weed	weed severity[1]		Sig.
Velvetleaf	1.8	3.0	.001
Foxtail	1.3	2.3	.013

1. Weed severity scale; 1=slight to 5=severe.

Table 7. Effect of tillage and cultivation on weeds in corn at Fillmore Co. on Oct. 4, 1988[1].

		Tillage			
		No Till	Disc	Chisel	Moldboard
Weed		weed severity[2]			
Foxtail	Cultivation	3.7	0.7	0.7	0.0
	No Cultivation	5.0	1.3	2.7	0.0
Velvetlf	Cultivation	2.3	2.0	1.7	1.3
	No Cultivation	2.3	4.3	3.3	2.0

1. The p value for the tillage by cultivation interaction is .023, n=3.
2. Weed severity scale; 1=slight and 5=severe.

Table 8. Effect of tillage on yield and moisture in Fillmore Co. on Oct. 4, 1988, n=6.

Variable	Tillage: No Till	Disc	Chisel	Moldboard	Sig.
	bu/A				
Grain Yield	101.9	97.3	103.1	110.6	.511
	%				
Moisture	20.5	18.6	18.6	16.6	.000

Table 9. Effect of cultivation on corn yield and moisture at Fillmore Co. on Oct. 4, 1988, n=12.

Variable	Cult.	No Cult.	Sig.
	bu/A		
Grain Yield	109.9	96.5	.001
	%		
Moisture	18.6	18.5	.659

Table 10. Effect of tillage and cultivation on corn yield and moisture at Fillmore Co. on Oct. 4, 1988.

Variable		Tillage: No Till	Disc	Chisel	Moldboard	Sig.[1]
		bu/A				
Grain Yield	Cultivation	107.5	106.8	112.3	113.2	
	No Cultivation	96.3	87.9	93.9	108.1	.165
		%				
Moisture	Cultivation	20.6	18.7	18.5	16.7	
	No Cultivation	20.3	18.5	18.6	16.5	.944

1. This is the p value for the cultivation by tillage interaction, n=3.

EFFECT OF TILLAGE AND SWINE MANURE ON N UPTAKE AND CORN YIELD[1]

J.R.Joshi, J.F.Moncrief, D.A.Andow, J.B.Swan, and G.L.Malzer[2]

Abstract: This was the second year of the study initiated in 1987 in Goodhue County to evaluate the effects of tillage, and rate and frequency of injected liquid swine manure on corn. Averaged grain yields were lower than normal ranging from 90 bu/A for anhydrous ammonia (170 lbs N/A) to 77 bu/A for low rate of manure (92 lbs N/A). Ridge till resulted in about 16 bu/A increase over chisel plow. Most growth and yield parameters were higher during the year of application of manure or fertilizer than in the year following application. Soil moisture both in fall and spring was fairly uniform throughout the profile. Soil N levels were about twice as high in fall than in spring.

INTRODUCTION

In 1987, a study was initiated in Goodhue County, MN to evaluate the effects of tillage and frequency of manure application on corn yield and N uptake. This was the second and completion year of initial establishment of the treatments.

Liquid swine manure is injected every alternate years (on an even and odd year basis) at two rates (high manure, approximately 12,000 gal/A, and low manure, approximately 7,300 gal/A) on ridge till and chisel till treatment. Additional treatments included a fertilized treatment, applied annually and every alternate year with anhydrous ammonia at a recommended rate of 170 lbs N/A, and a check treatment receiving neither manure nor fertilizer. Various cultural practices followed are summarized in Table 1. These observations include fall and spring soil sampling to a depth of 5' to monitor profile N.

RESULTS

Residue Cover. Residue cover measurements were made on June 15 on treatments receiving manure at high and low rates, annual anhydrous ammonia and check(Table 2). In general, residue was higher between the rows than in the rows. Exception to this was observed in anhydrous treatment in ridge till where residue was higher in the rows. Since anhydrous was applied before these measurements, residue may have been swept in the rows during the operation. Ridge till had higher residue between the rows; whereas, chisel plowed treatments had higher residue in the rows with the exception of the anhydrous treatment in ridge till.

Early Whole Plant Analysis. The results of dry matter and N analysis made on early whole plant samples taken on July 15 are summarized in Table 3. Anhydrous treatment yielded highest dry matter, N concentration in the tissue and total N uptake at this stage. High rate of manure yielded higher dry matter, tissue N and N uptake in the year of application, but lower in the year after application of manure when compared to the low rate of manure. Tillage did not affect total dry matter and N uptake but ridge till had significantly greater N in the tissue than the chisel treatment.

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Leaf Water Potential. In order to measure the moisture stress in the plants, leaf water measurements were made on July 27 and the results are presented in Table 4. Tillage had no significant effect on leaf water stress. Fertilized treatment showed highest stress followed by those receiving manure at high rates and then by those receiving low rates of manure. The stress was greatest in the year of application than in the year after except in anhydrous treatment where the results were opposite, especially in the chisel plow.

Plant Population and Stover Yield. Total plant population at harvest was higher in the ridge treatment than the chisel treatment (Table 5) but the difference was not significantly different. Similarly, manure applied at higher rate had higher population, the difference not being significant. Stover dry matter was higher with chisel plow with regard to tillage and with anhydrous ammonia with regards to fertility treatments. There was a significant difference in stover yield due to the year of application-higher yields in the application year than the carry over year. Stover moisture was not affected by tillage or N treatments.

Grain Yields, Grain Moisture and Total Dry Matter. The summary of total grain yields, grain moisture and total dry matter is given in Table 6. Ridge till yielded about 16 bu/A more grains than chisel plow, the greatest yield being in anhydrous treatment in the year of application. The high rate of manure had generally higher yields than the low rate except in the ridge till treatment that received manure at low rate in 1988. Grain moisture was greater in the year after application of manure or fertilizer than the year of application. Total dry matter was greater for the year of application than year after. Tillage had no significant effect on grain moisture or total dry matter. Chisel treatment yielded higher dry matter in the application year for high manure, and both in the year of and year after application of anhydrous ammonia.

Grain N (1987). The results of the analysis of grain samples from 1987 season are presented in Table 7. Anhydrous treatment had higher grain N in the year of application followed by high rate of manure and the low rate of manure. In the year after application, however, low rate of manure had higher grain N than the high rate. Tillage had no significant effect on grain N.

Grain and Stover N (1988). Neither grain nor stover N were affected by tillage in 1988 (Table 8). The highest grain N concentration was observed in anhydrous treatment followed by high rate and then low rate of manure, respectively. Also, it was higher in the year of application than the year after application. Stover N followed the similar trend except in the year after application when low rate of manure had higher stover N than the high rate of manure. Highest N uptake was associated with anhydrous treatments followed by low manure treatment and finally the high manure treatments. The difference between these manure treatments was particularly striking in the ridge till applied with low manure, the results being similar to grain yields.

Harvest Index. Tillage had marked influence on the harvest index, a ratio of total grain dry matter to that of total dry matter (grain and stover combined, Table 9). Ridge till had in higher index values than the chisel treatment, indicative of the higher grain yields as compared to stover yields in chisel plow. The harvest index was higher in the year of application than the year after application of manure or fertilizer.

Soil Moisture. Gravimetric soil moisture of the samples taken to a depth of 5 ft before planting in the third week of April are summarized in Table 10. Soil moisture increased gradually with depth in the profile, and ranged from 19.4% in the top 6" to 23.9% in the bottom 3 ft increment. Tillage had no significant effect on soil moisture.

In fall, the soil moisture in the top 1 ft ranged from 21.5 to 23.6% (wt./wt., Table 11). The moisture up to top 2 ft. were fairly uniform underlain by slightly drier region below (2-4 ft), moisture ranging from 16.4 to 21.1%. Soil moisture in the lowest 1 ft depth was same as in the surface. Soil moisture was not affected by tillage or location of samples with respect to row position. Manure applied at the high rate maintained higher soil moisture throughout the profile than the anhydrous application. In the check treatment, moisture throughout the profile was fairly uniform - similar to the surface levels.

Soil Nitrogen (Spring). The results of the soil analysis for N in 5 ft soil profile is given in Table 12. Main effects of tillage was not significant in any N forms. Anhydrous ammonia resulted in highest soil N followed

by low rate of manure (Table 13). The high rate of manure had lowest N. Probably this high rate of N in the profile is probably the reason for higher yields in the low rate over the high rate of manure applied. About 1/3 of soil N was in nitrate form in the anhydrous treatment; whereas, most of the N in the manure treatment was in ammonium form. There was a tillage by depth interaction (Table 14) with respect to nitrate-N, ridge till had higher nitrate in all depths except the 1-2 ft increment where chisel plow exceeded the ridge till. N levels in the year of application were higher in the top 2 ft but less below that as compared to carry over manure treatment (Table 15). The nitrate levels were higher throughout the profile with anhydrous in both tillages; however, high rate of manure had higher nitrate-N in ridge till and the low rate of manure had higher nitrate-N in the chisel treatment.

Soil Nitrogen (Fall). Total, ammonium and nitrate N levels in the 5 ft profile were higher in fall than in spring (Table 17). Although there was no significant effect of tillage or N rate on any of these forms of N, anhydrous treatment had higher N than manure or check in ridge till and almost no difference in chisel treatment (Table 18). Ridge till had higher N in each depth of the profile (Table 19). Anhydrous treatment had generally higher N levels throughout the profile except in the 3-4 ft increment where high rate of manure had higher N than both anhydrous and check (Table 20). Check treatment had higher N in the first two feet than the high rate of manure. More N in was present between the rows up to 3 feet but less below that than in-row samples (Table 21). Manure treatment had higher N deeper in the profile (>3 ft) in the row but had lower N between the rows than check or anhydrous treatments (Table 22). Total N was highest between the rows in the anhydrous treatment, and check treatment was the lowest. Manure treatments were intermediate.

Table 1. Cultural practices at Goodhue County, MN 1988.

Tillage
Ridge Till-cultivated June 22
Chisel Plow-Chiseled on May 16

Cropping History
Corn since 1974
1988-Corn Pioneer 3737

Manure Application
Injected liquid swine manure with following rate and analysis on May 4-5, 1988.

		Rate		
		Mean	StDev	n
High Rate				
Manure	(gal/A)	11988	779	8
Total-N	(lbs/A)	152	10	8
NH_4-N	(lbs/A)	71	4	8
Low Rate				
Manure	(gal/A)	7272	448	8
Total-N	(lbs/A)	92	6	8
NH_4-N	(lbs/A)	43	3	8

Planting Information for 1988 Crop Year
A two row Series 1 Econo till planter equipped with a 2" fluted coulter.

Crop	Date	Rate	Harvested
Corn	May 18,1988	32,000 plants/A	October 8-10, 1988

Fertilizer 1988

Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Date Applied	Method of Application
		---	lb/A	---		
82-0-0	207 lbs/A	170	0	0	May 26, 1988	Injected

Soil

Seaton (Typic Hapludalfs, fine-silty, mixed, mesic) silt loam, Mt. Carroll (Mollic Hapludalfs, fine-silty, mixed, mesic) silt loam and a Port Byron (Typic Hapludolls, fine-silty, mixed, mesic) silt loam.

Insect Control

9 lbs/A (1.35 lb/A) Counter 15G applied on May 18, 1988.

Table 2. Surface residue cover as affected by tillage, and N source and rate of application in Goodhue Co. MN on June 15, 1988.

	Residue Cover			
	Ridge Till		Chisel	
Rate &	In Row	Bet rows	In Row	Bet rows
and Source of N	%			
Manure (High rate)	7.0	36.0	11.0	7.0
Manure (Low rate)	8.8	27.2	10.0	21.0
Anhy.Amm. (annual)	35.0	28.0	15.0	19.0
Check	13.3	42.7	14.4	20.8

Table 3. The effect of tillage, and N source and rate on stover dry matter, stover N, and N uptake in Goodhue Co. MN on July 15, 1988.

		STOVER DRY MATTER			N CONCENTRATION			N UPTAKE		
Rate &		Ridge	Chisel	Mean	Ridge	Chisel	Mean	Ridge	Chisel	Mean
Source of N	Year[1]	g/plant			%			mg/plant		
Manure	Yr.of	28.3	40.6	34.4	2.25	1.64	1.95	643	679	661
(Low rate)	Yr.after	25.1	26.2	25.7	2.06	1.74	1.90	521	452	487
	Mean	26.7	33.4	30.1	2.16	1.69	1.92	582	566	574
Manure	Yr.of	31.7	42.4	37.0	2.14	1.86	2.00	671	774	722
(High rate)	Yr.after	21.6	24.3	22.9	1.93	1.67	1.80	414	395	405
	Mean	26.6	33.3	30.0	2.04	1.76	1.90	542	585	563
Anhydrous	Yr.of	33.0	37.6	35.3	2.68	2.33	2.51	889	872	880
Ammonia	Yr.after	38.7	41.6	40.1	2.40	1.86	2.13	927	757	842
	Mean	35.8	39.6	37.7	2.54	2.10	2.32	908	815	861

Pr>F

	Tillage(T)	N Rate(N)	Year(Y)	T*N	T*Y	Y*N	Y*N*T
Dry matter	.214	.233	.216	.749	.363	.059	.134
N conc.	.025	.010	.019	.574	.889	.468	.446
N uptake	.805	.027	.095	.544	.623	.093	.941

[1] Year refers to the year of application of the biennial treatments.

Table 4. The effect of tillage, and N source and rate of application on leaf water potential in Goodhue Co.,MN, on July 27, 1988.

Rate & Source of N	Year[1]	LEAF WATER POTENTIAL Ridge	Chisel	Mean	Source	Pr>F
		-----	(-bar)	----		
Manure	Yr.of	14.3	15.4	15.2	Tillage(T)	.619
(Low rate)	Yr.after	14.6	13.2	14.9	N Rate (N)	.096
	Mean	14.5	14.3	13.9	Year (Y)	.763
Manure	Yr.of	15.5	15.3	15.4	T*N	.119
(High rate)	Yr.after	13.2	14.0	13.6	T*Y	.276
	Mean	14.3	14.6	14.5	Y*N	.005
Anhydrous	Yr.of	14.9	14.7	14.6	Y*N*T	.295
Ammonia	Yr.after	14.3	16.1	15.8		
	Mean	14.6	15.4	15.2		

[1] Year refers to the year of application of the biennial treatments.

Table 5. The effect of tillage and N source and rate on total plant population at harvest, stover dry matter, and stover moisture at harvest in Goodhue Co. MN in 1988.

Rate & Source of N	Year[1]	PLANT POPULATION Ridge	Chisel	Mean	STOVER DRY MATTER Ridge	Chisel	Mean	STOVER MOISTURE Ridge	Chisel	Mean
		- plants/A*10^{-3} -			----- tons/A ----			-------- % ------		
Manure	Yr.of	27.2	25.7	26.5	1.74	1.94	1.84	51.6	44.7	48.2
(Low rate)	Yr.after	26.7	25.6	26.2	1.40	1.66	1.53	53.3	47.3	50.3
	Mean	27.0	25.6	26.3	1.57	1.80	1.68	52.5	46.0	49.3
Manure	Yr.of	27.5	27.1	27.3	1.47	2.06	1.77	46.5	46.3	46.4
(High rate)	Yr.after	27.4	26.4	26.9	1.35	1.55	1.45	45.6	49.4	47.5
	Mean	27.4	26.8	27.1	1.41	1.81	1.61	46.1	47.8	47.0
Anhydrous	Yr.of	26.7	25.6	26.2	1.76	2.08	1.92	49.9	51.2	50.6
Ammonia	Yr.after	26.2	25.0	25.6	1.80	2.22	2.01	49.9	51.0	50.5
	Mean	26.5	25.3	25.9	1.78	2.15	1.97	49.9	51.1	50.5
Mean		27.0	26.0	26.5	1.59	1.92	1.75	49.5	48.3	48.9

Pr>F

	Tillage(T)	N Rate(N)	Year(Y)	T*N	T*Y	Y*N	Y*N*T
Population	.145	.474	.232	.804	.996	.953	.722
Stover dry matter	.051	.039	.019	.679	.696	.022	.191
Stover moisture	.219	.243	.322	.081	.241	.341	.479

[1] Year refers to the year of application of the biennial treatments.

Table 6. The effect of tillage and N frequency and rate on grain yields, grain moisture and total dry matter in Goodhue Co. MN in 1988.

Rate & Source of N	Year[1]	GRAIN YIELD Ridge	Chisel	Mean	GRAIN MOISTURE Ridge	Chisel	Mean	TOTAL DRY MATTER Ridge	Chisel	Mean
		------ bu/A -----			------- % -------			----- tons/A ----		
Manure	Yr.of	109.5	68.5	89.3	22.1	25.7	23.9	4.39	3.16	3.77
(Low rate)	Yr.after	74.8	53.2	64.0	27.2	26.6	26.9	3.20	2.61	3.90
	Mean	92.2	60.8	76.6	24.6	26.2	25.4	3.80	2.88	3.34
Manure	Yr.of	98.1	97.0	97.6	24.4	22.9	23.7	3.69	4.25	3.97
(High rate)	Yr.after	74.7	69.3	72.0	25.4	24.9	25.2	3.01	2.89	2.95
	Mean	86.4	83.1	84.8	24.9	23.9	24.5	3.35	3.57	3.46
Anhydrous	Yr.of	129.3	110.7	120.0	25.6	27.0	26.3	4.98	5.08	5.03
Ammonia	Yr.after	103.0	96.4	99.6	25.5	26.0	25.8	4.37	4.75	4.56
	Mean	116.1	103.5	109.8	26.6	26.5	26.1	4.67	4.92	4.79
Mean		98.2	82.6	90.4	25.0	25.5	25.5	3.94	3.79	3.86

Pr>F

	Tillage(T)	N Rate(N)	Year(Y)	T*N	T*Y	Y*N	Y*N*T
Grain Yield	.035	.003	.030	.152	.161	.772	.338
Grain moisture	.571	.187	.029	.647	.307	.059	.528
Total dry matter	.424	.105	.028	.105	.806	.426	.079

[1] Year refers to the year of application of the biennial treatments.

Table 7. The effect of tillage, N source and frequency of application on grain N in Goodhue Co. MN in 1987.

Rate & Source of N	Year[1]	GRAIN N Ridge	Chisel	Mean	Source	Pr>F
		-------- (%) ------				
Manure(Low rate)	Yr.of	1.58	1.53	1.56	Tillage(T)	.757
	Yr.after	1.60	1.54	1.57	N rate (N)	.082
	Mean	1.59	1.54	1.57	Year (Y)	.044
Manure(High rate)	Yr.of	1.55	1.61	1.58	T*N	.003
	Yr.after	1.43	1.41	1.42	T*Y	.649
	Mean	1.49	1.51	1.50	Y*N	.009
Anhydrous	Yr.of	1.71	1.70	1.71	Y*N*T	.711
Ammonia	Yr.after	1.45	1.48	1.47		
	Mean	1.58	1.59	1.59		

[1] Year refers to the year of application of the biennial treatments.

Table 8. The effect of tillage and N rate and source on grain N, stover N, grain N recovery, and total N uptake in Goodhue Co. MN in 1988.

Rate & Source of N	Year[1]	GRAIN N Ridge	GRAIN N Chisel	STOVER N Ridge	STOVER N Chisel	GRAIN N UPTAKE Ridge	GRAIN N UPTAKE Chisel	TOTAL N UPTAKE Ridge	TOTAL N UPTAKE Chisel
		---- % -----		---- % -----		-- lbs/A ---		-- lbs/A ---	
Manure	Yr.of	1.42	1.33	0.63	0.57	73.5	43.1	95.5	65.2
(low rate)	Yr.after	1.27	1.24	0.49	0.56	44.9	31.2	58.7	49.8
	MEAN	1.35	1.29	0.56	0.57	58.9	37.1	76.5	57.6
Manure	Yr.of	1.29	1.40	0.53	0.60	59.9	64.2	75.4	88.9
(high rate)	Yr.after	1.22	1.26	0.46	0.45	43.1	41.3	55.5	55.3
	MEAN	1.26	1.33	0.50	0.53	51.5	52.3	65.6	71.5
Anhydrous	Yr.of	1.51	1.51	0.72	0.71	92.3	79.1	117.7	108.6
Ammonia	Yr.after	1.37	1.39	0.58	0.73	66.7	63.4	87.6	95.8
	MEAN	1.44	1.45	0.65	0.72	79.1	71.0	102.2	101.9

Pr>F

Source	Tillage(T)	N Rate(N)	Year(Y)	T*N	T*Y	Y*N	Y*N*T
Grain N	.422	.003	.010	.141	.900	.947	.662
Stover N	.220	.029	.113	.611	.368	.811	.226

[1] Year refers to the year of application of the biennial treatments.

Table 9. Total grain dry matter and harvest index as affected by tillage, and N source and rate of application in Goodhue Co. MN in 1988.

Rate & Source of N	Year[1]	HARVEST INDEX Ridge	Chisel	Mean
Manure	Yr.of	0.59	0.35	0.47
(Low rate)	Yr.after	0.54	0.37	0.46
	Mean	0.57	0.36	0.46
Manure	Yr.of	0.59	0.50	0.55
(High rate)	Yr.after	0.55	0.45	0.50
	Mean	0.57	0.47	0.52
Anhydrous	Yr.of	0.65	0.59	0.62
Ammonia	Yr.after	0.58	0.52	0.55
	Mean	0.61	0.55	0.58
Mean		0.58	0.46	0.52

[1] Year refers to the year of application of the biennial treatments.

Table 10. The effect of tillage, and N source and rate on soil moisture in Goodhue Co. MN on April 19-21, 1988.

Rate & Source of N	Year[1]	0-6 in. Ridge	0-6 in. Chisel	6-12 in. Ridge	6-12 in. Chisel	1-2 ft Ridge	1-2 ft Chisel	2-5 ft Ridge	2-5 ft Chisel
		% (wt./wt.)							
Manure	Yr.of	20.2	19.8	22.2	21.7	22.6	22.1	23.5	22.9
(Low rate)	Yr.after	20.8	19.9	22.1	21.4	22.3	22.3	23.9	23.4
	MEAN	20.5	19.9	22.2	21.6	22.5	22.2	23.7	23.2
Manure	Yr.of	19.4	19.8	21.3	22.0	22.3	21.9	23.4	23.3
(High rate)	Yr.after	19.9	19.1	21.4	19.9	21.5	21.8	22.7	23.4
	MEAN	19.7	19.5	21.4	21.0	21.9	21.9	23.1	23.4
Anhydrous	Yr.of	19.5	21.2	21.0	21.6	21.9	22.2	23.6	23.8
Ammonia	Yr.after	19.9	19.1	21.5	21.9	21.8	22.5	23.5	23.5
	MEAN	19.7	20.2	21.3	21.8	21.9	22.4	23.6	23.7

Pr>F

Source	Tillage(T)	N Rate(N)	Year(Y)	T*N	T*Y	Y*N	Y*N*T
0-6in	.791	.629	.614	.530	.158	.710	.546
6-12in	.802	.515	.378	.526	.141	.213	.561
1-2′	.933	.396	.625	.181	.185	.701	.873
2-5′	.927	.749	.947	.446	.155	.258	.410

[1] Year refers to the year of application of the biennial treatments.

Table 11. Gravimetric soil moisture as affected by tillage, and N source and rate of application in Goodhue Co. MN on Oct 31-Nov 1, 1988.

Rate & Source[1]	Row[2]	0-1 FT Ridge	0-1 FT Chisel	1-2 FT Ridge	1-2 FT Chisel	2-3 FT Ridge	2-3 FT Chisel	3-4 FT Ridge	3-4 FT Chisel	4-5 FT Ridge	4-5 FT Chisel
		% (wt./wt.)									
Manure	IR	22.7	22.8	23.6	23.6	20.4	19.7	19.3	18.3	21.2	22.4
(High)	BR	22.3	23.0	22.6	23.1	18.3	18.7	18.3	17.6	22.4	22.5
Anhydr.	IR	21.4	22.6	21.7	22.4	17.1	16.9	16.4	17.7	19.1	22.0
ammonia	BR	21.9	22.5	21.5	22.0	17.6	16.0	18.3	17.8	20.2	21.5
Check	IR	22.3	21.8	23.3	22.6	21.1	18.7	20.2	19.7	20.1	22.5
	BR	22.6	21.8	22.9	23.0	21.0	19.9	20.3	20.0	20.9	23.0

Pr>F

Source	Tillage(T)	N Rate(N)	Depth(D)	T*N	T*D	D*N	D*N*T
Moisture (avg. over row)	.965	.102	.000	.751	.668	.004	.930

[1] Only the treatments of the year of application.
[2] Row position for soil sampling, IR=in row and BR=between rows.

Table 12. The effect of tillage, and N source and rate on soil profile N in Goodhue Co. MN on April 19-21, 1988.

N Rate & Source of N	Year[1]	0-6 in. Ridge	0-6 in. Chl	0-6 in. Mean	6-12 in. Ridge	6-12 in. Chl	6-12 in. Mean	1-2 ft Ridge	1-2 ft Chl	1-2 ft Mean	2-5 ft Ridge	2-5 ft Chl	2-5 ft Mean	0-5 ft Ridge	0-5 ft Chl	0-5 ft Mean
		lbs/A														
								TOTAL-N								
Manure	Yr.aft	6.9	4.4	5.7	6.6	5.9	6.2	11.9	10.9	11.4	33.9	25.5	29.7	59.3	46.7	53.0
(High rate)	Yr.of	5.4	4.5	5.0	7.9	4.6	6.2	14.2	9.7	12.0	30.9	26.6	28.7	58.4	45.4	51.9
	MEAN	6.2	4.5	5.3	7.3	5.3	6.2	13.0	10.3	11.7	32.4	26.1	29.2	58.9	46.2	52.4
Anhydrous	Yr.aft	6.7	4.3	5.5	7.0	6.7	6.8	12.4	9.7	11.0	52.2	32.2	42.2	78.3	52.9	65.5
ammonia	Yr.of	11.7	6.1	8.9	9.8	7.9	8.9	23.7	36.6	30.1	36.1	31.4	33.8	81.3	82.0	81.7
	MEAN	9.2	5.2	7.2	8.4	7.3	7.9	18.0	23.1	20.6	44.1	31.8	38.0	79.7	67.4	73.7
Manure	Yr.aft	6.2	6.6	6.4	5.6	7.2	6.4	10.6	10.6	10.6	35.9	28.3	32.1	58.3	52.7	55.5
(low rate)	Yr.of	6.1	5.9	6.0	6.3	6.6	6.4	11.8	11.2	11.5	28.3	26.3	27.3	52.5	50.0	51.2
	MEAN	6.2	6.2	6.2	6.0	6.9	6.4	11.2	10.9	11.1	32.1	27.3	29.7	55.5	51.3	53.4
								AMMONIUM-N								
	Year	Ridge	Chl	Mean	Ridge	Chl	Mean	Ridge	Chl	Mean	Ridge	Chl	Mean	Ridge	Chl	Mean
Manure	Yr.aft	5.1	3.9	4.5	5.4	5.3	5.4	10.1	10.4	10.2	28.0	24.7	26.3	48.6	44.3	46.4
(High rate)	Yr.of	3.6	3.9	3.8	4.8	4.5	4.6	10.8	9.4	10.1	24.9	25.8	25.4	44.1	43.6	43.9
	MEAN	4.4	3.9	4.1	5.1	4.9	5.0	10.4	9.9	10.2	26.5	25.2	25.9	46.4	43.9	45.2
Anhydrous	Yr.aft	4.8	3.6	4.2	5.4	5.8	5.6	9.6	8.0	9.3	26.9	30.0	28.4	46.7	47.4	47.5
ammonia	Yr.of	9.3	4.9	7.1	5.3	5.6	5.4	9.9	9.3	9.6	23.6	26.3	25.0	48.1	46.1	47.1
	MEAN	7.0	4.2	5.6	5.3	5.7	5.5	9.7	9.1	9.4	25.2	28.2	26.7	47.2	47.2	47.2
Manure	Yr.aft	4.5	3.6	4.0	4.6	5.0	4.8	8.7	8.6	8.7	29.2	24.4	26.8	47.0	41.6	44.3
(low rate)	Yr.of	5.4	4.7	5.1	4.7	5.7	5.2	9.7	10.1	9.9	25.8	22.4	24.1	45.6	42.9	44.3
	MEAN	4.9	4.2	4.6	4.6	5.3	5.0	9.2	9.4	9.3	27.5	23.4	25.5	46.2	42.3	44.4
								NITRATE-N								
	Year	Ridge	Chl	Mean	Ridge	Chl	Mean	Ridge	Chl	Mean	Ridge	Chl	Mean	Ridge	Chl	Mean
Manure	Yr.aft	1.8	0.4	1.1	1.2	0.5	0.8	1.9	0.4	1.2	5.9	0.8	3.3	10.8	2.1	6.4
(High rate)	Yr.of	1.8	0.7	1.2	3.1	0.2	1.6	3.4	0.4	1.9	5.9	0.8	3.3	14.2	2.1	8.0
	MEAN	1.8	0.6	1.2	2.1	0.4	1.2	2.6	0.4	1.5	5.9	0.8	3.3	12.4	2.2	7.2
Anhydrous	Yr.aft	1.9	0.6	1.2	1.6	0.9	1.2	2.7	0.8	1.8	25.3	2.2	13.8	31.5	4.5	18.0
ammonia	Yr.of	2.4	1.2	1.8	4.5	2.3	3.4	13.7	27.3	20.5	12.6	5.1	8.9	33.2	35.9	34.6
	MEAN	2.1	0.9	1.5	3.1	1.6	2.3	8.2	14.1	11.1	19.0	3.6	11.3	32.4	20.2	26.2
Manure	Yr.aft	1.8	2.9	2.4	1.1	2.4	1.7	1.9	3.3	2.6	6.8	3.9	5.3	11.6	12.5	12.0
(low rate)	Yr.of	0.6	1.2	0.9	1.6	0.9	1.2	2.1	1.0	1.6	2.5	3.9	3.2	6.8	7.0	6.9
	MEAN	1.2	2.0	1.6	1.3	1.6	1.5	2.0	2.1	2.1	4.6	3.9	4.3	9.1	9.6	9.5

Pr>F

Source	Tillage(T)	N Rate(N)	Year(Y)	T*N	T*Y	Y*N	Y*N*T	Depth(D)	T*D	N*D	Y*D	T*N*D	T*Y*D	N*Y*D	T*N*Y*D
Total-N	.237	.086	.570	.655	.213	.363	.668	.001	.169	.399	.036	.452	.266	.108	.824
NH_4-N	.440	.782	.309	.745	.770	.798	.845	.001	.851	.972	.004	.325	.638	.569	.973
NO_3-N	.234	.072	.472	.223	.373	.436	.379	.029	.021	.032	.128	.005	.426	.119	.667

[1] Year refers to the year of application of the biennial treatments.

Table 13. The effect of rate and source of N on soil N in Goodhue Co.,MN, in 5′ depth (avg. over tillage) on April 19-21, 1988.

Rate & Source of N	Total-N	NH_4-N	NO_3-N
	--------	lbs/A	------
Manure (low)	67.0	55.0	12.0
Manure (high)	65.5	56.5	9.0
Anhydrous	92.0	59.0	33.0
Pr>F			
N Rate and source	.0857	.7823	.0719

Table 14. The effect of tillage and depth on nitrate-N (avg. over N treatments) in Goodhue Co. MN on April 19-21, 1988.

Depth	Ridge Till	Chisel
	----- lbs/A	------
0-6"	1.7	1.2
6-12"	2.1	1.2
1-2′	4.3	5.5
2-5′	9.8	2.8

Till*depth Pr>F=.0212

Table 15. Effect of depth and N rate and source on soil N in Goodhue Co. on April 21, 1988.

Depth	Yr.	Total-N	NH_4-N	NO_3-N
		--------	lbs/A	------
0-6"	Yr aft.	5.9	4.3	1.6
	Yr of	6.6	5.3	1.3
0-12"	Yr aft.	6.5	5.3	1.2
	Yr of	7.2	5.1	2.1
1-2′	Yr aft.	11.2	9.3	1.9
	Yr of	17.9	9.9	8.0
2-5′	Yr aft.	34.7	27.2	7.5
	Yr of	30.0	24.8	5.2
	Pr>F	.0358	.0037	.1228

Table 16. The effect of depth, tillage and N source and rate on nitrate N in Goodhue Co. MN on April 19-21, 1988.

	Ridge Till			Chisel		
	Manure (L)	Manure (H)	Anhy	Manure (L)	Manure (H)	Anhy
Depth	----------	----------	lbs/A	----------	----------	----------
0-6"	6.1	6.1	9.2	6.2	4.5	5.2
6-12"	6.0	7.3	8.5	6.9	5.3	7.3
1-2′	11.2	13.0	17.8	11.6	10.3	23.1
2-5′	32.1	32.4	44.1	27.3	26.1	31.9

Pr>F Till*N Rate*Depth= .005

Table 17. The effect of tillage, and N source and rate on soil profile N in Goodhue Co. MN on Oct 31-Nov 1, 1988.

N Rate & Source[1]	Row[2]	0-1 FT Ridge	0-1 FT Chl	0-1 FT Mean	1-2 FT Ridge	1-2 FT Chl	1-2 FT Mean	2-3 FT Ridge	2-3 FT Chl	2-3 FT Mean	3-4 FT Ridge	3-4 FT Chl	3-4 FT Mean	4-5 FT Ridge	4-5 FT Chl	4-5 FT Mean	0-5 FT Ridge	0-5 FT Chl	0-5 FT Mean
		lbs/A																	
		TOTAL-N																	
Manure	IR	18.7	18.7	18.7	15.5	16.1	15.8	15.6	16.0	15.8	12.5	11.7	12.1	12.2	12.3	12.3	74.5	74.8	74.7
(High)	BR	18.9	19.4	19.1	15.5	16.2	15.8	14.4	15.2	14.8	10.0	10.4	10.1	11.6	12.0	12.8	70.4	73.2	71.7
	MEAN	18.8	19.0	18.9	15.5	16.2	15.8	15.0	15.6	15.3	11.2	10.9	11.1	11.9	12.1	12.0	72.4	73.8	73.2
Anhydr.	IR	22.1	19.0	20.2	16.4	16.0	16.2	14.6	14.1	14.3	10.8	11.1	10.9	10.9	11.7	11.8	74.8	71.9	73.4
ammonia	BR	51.9	21.4	36.7	20.9	15.9	18.4	15.2	14.6	14.9	10.9	10.1	10.5	12.0	11.6	11.8	110.9	73.6	92.3
	MEAN	37.0	20.2	28.6	18.6	16.0	17.3	14.9	14.3	14.6	10.9	10.6	10.7	11.4	11.7	11.6	92.8	72.8	82.8
Check	IR	19.7	18.1	18.9	16.3	15.0	15.7	15.6	13.2	14.4	11.2	10.1	10.6	12.6	12.2	12.4	75.4	68.6	72.0
	BR	22.8	16.7	19.8	18.6	16.2	17.4	15.6	14.2	14.9	10.6	11.1	10.9	11.6	9.9	10.8	79.2	68.1	73.5
	MEAN	21.2	17.4	19.3	17.5	15.6	16.6	15.6	13.7	14.6	10.9	10.6	10.7	12.1	11.1	11.6	77.3	68.4	72.8
		AMMONIUM-N																	
	Row	Ridge	Chl	Mean	Ridge	Chl	Mean	Ridge	Chl	Mean	Ridge	Chl	Mean	Ridge	Chl	Mean	Ridge	Chl	Mean
Manure	IR	15.3	16.4	15.8	13.6	15.0	14.3	14.2	14.9	14.6	11.3	10.7	11.0	10.8	11.6	11.2	65.2	68.6	66.9
(High)	BR	15.8	17.2	16.5	15.9	15.0	15.5	13.1	14.8	13.9	8.6	9.4	9.0	10.3	11.3	10.8	63.7	67.7	65.7
	MEAN	15.6	16.8	16.2	14.8	15.0	14.9	13.7	14.8	14.2	10.0	10.1	10.0	10.5	11.4	11.0	64.5	68.1	66.3
Anhydr.	IR	18.3	17.4	17.9	13.9	15.2	14.4	12.5	13.3	12.9	8.6	9.7	9.2	8.9	10.6	9.8	62.2	66.2	64.2
ammonia	BR	25.6	18.1	21.8	15.7	15.1	15.4	13.9	13.2	13.5	9.3	9.2	9.2	9.6	10.9	10.3	74.1	66.5	70.3
	MEAN	22.0	17.8	19.9	14.8	15.2	15.0	13.2	13.2	13.2	8.9	9.4	9.2	9.3	10.8	10.1	68.2	66.4	67.3
Check	IR	17.0	16.7	16.9	15.4	13.9	14.6	14.2	12.3	13.2	9.8	7.6	8.7	10.7	11.3	11.0	67.1	61.8	64.5
	BR	19.1	15.0	17.0	16.2	14.6	15.4	13.4	13.3	13.4	8.8	9.9	9.3	10.1	34.2	22.2	67.6	87.0	77.3
	MEAN	18.1	15.8	17.0	15.8	14.2	15.0	13.8	12.8	13.3	9.3	8.7	9.0	10.4	22.8	16.6	67.4	74.3	70.9
		NITRATE-N																	
	Row	Ridge	Chl	Mean	Ridge	Chl	Mean	Ridge	Chl	Mean	Ridge	Chl	Mean	Ridge	Chl	Mean	Ridge	Chl	Mean
Manure	IR	3.3	2.5	2.9	1.9	0.6	1.2	1.4	1.2	1.3	1.2	0.9	1.0	1.4	0.6	1.0	9.2	5.8	7.5
(High)	BR	3.0	2.1	2.6	1.4	1.2	1.3	1.3	0.4	0.9	1.4	0.7	1.0	1.3	0.7	1.0	8.7	5.1	6.9
	MEAN	3.2	2.3	2.7	1.6	0.9	1.3	1.4	0.8	1.1	1.3	0.8	1.0	1.4	0.7	1.0	8.9	5.5	7.2
Anhydr.	IR	3.8	1.5	2.7	2.4	0.7	1.6	2.0	0.7	1.4	2.1	1.4	1.8	2.0	1.2	1.6	12.3	5.5	8.9
ammonia	BR	26.4	3.4	14.9	5.3	0.7	3.0	1.3	1.4	1.4	1.7	1.1	1.4	2.4	0.6	1.5	37.1	7.2	22.2
	MEAN	15.1	2.4	8.8	3.8	0.7	2.3	1.7	1.1	1.4	1.9	1.2	1.6	2.2	0.9	1.6	24.7	6.3	15.5
Check	IR	2.6	1.4	2.0	0.8	1.2	1.0	1.5	0.8	1.2	1.3	4.4	2.8	1.9	0.9	1.4	8.1	8.7	8.4
	BR	3.7	1.9	2.8	2.4	1.6	2.0	2.1	0.8	1.5	1.8	1.2	1.5	1.4	2.6	2.0	11.4	8.1	9.3
	MEAN	3.2	1.6	2.4	1.6	1.4	1.5	1.8	0.9	1.3	1.6	2.8	2.2	1.6	1.7	1.7	9.8	8.4	9.1

Pr>F

Source	Tillage(T)	N Rate(N)	Row(R)	T*N	T*R	R*N	R*N*T	Depth(D)	T*D	N*D	R*D	T*N*D	T*R*D	N*R*D
Total-N	.279	.333	.233	.074	.311	.122	.163	.001	.018	.003	.017	.132	.272	.036
NH_4-N	.401	.599	.327	.526	.487	.427	.370	.001	.318	.442	.515	.930	.139	.0001
NO_3-N	.214	.122	.218	.152	.353	.411	.310	.026	.168	.200	.144	.275	.387	.194

[1] Only the treatments of the year of application.
[2] Position of soil sampling with respect to row, IR=in row, BR= between rows.

Table 18. The effect of N source and rate on total soil N averaged over tillage in 5' depth in Goodhue Co. MN on Oct 31-Nov 1, 1988.

N rate	Ridge Till	Chisel
	------- lbs/A	-----
Manure (High)	72.5	73.5
Anhydrous	93.0	73.0
Check	77.0	68.5

Pr>F =.074

Table 19. The effect of tillage and depth on on soil N averaged over N treatments in Goodhue Co. MN on Oct 31-Nov 1, 1988.

Depth	Ridge Till	Chisel
	------- lbs/A	-----
0-1'	25.7	18.9
1-2'	17.2	15.9
2-3'	15.1	14.5
3-4'	10.9	10.8
4-5'	11.7	11.6

Pr>F =.018

Table 20. Effect of N source and depth on total soil N averaged over tillage in Goodhue Co. MN on Oct 31-Nov 1, 1988.

Depth	Manure (H)	Anhydr	Check
	----------	lbs/A	-------
0-1'	19.0	28.7	19.3
1-2'	15.8	17.3	16.6
2-3'	15.3	14.6	14.6
3-4'	11.0	10.8	10.7
4-5'	12.0	11.6	11.5

Pr>F =.003

Table 21. Effect of location of sampling on total soil N averaged over no till and chisel, and N rate and source in Goodhue Co.

Depth	In Row	Between rows
	-------	lbs/A ------
0-1'	19.4	25.2
1-2'	15.8	17.2
2-3'	14.9	14.9
3-4'	11.2	10.5
4-5'	11.9	11.5

Pr>F=.017

Table 22. Effect of N source and rate, sampling location and depth on total N (avg over tillage) in Goodhue Co. on Oct 31- Nov 1, 1988.

	Check		Manure (H)		Anhydrous	
	----------		lbs/A		----------	
Depth	IR [1]	BR	IR	BR	IR	BR
0-1'	18.9	19.8	18.7	19.1	20.5	36.7
1-2'	15.7	17.4	15.8	15.8	16.2	18.4
2-3'	14.4	14.9	15.8	14.8	14.3	14.9
3-4'	10.6	10.9	12.0	10.1	10.9	10.6
4-5'	12.4	10.8	12.2	11.8	11.3	11.8

Pr>F=.003

[1] IR= in row, BR=between rows.

EFFECT OF TILLAGE AND FREQUENCY OF MANURE APPLICATION ON THE AVAILABILITY OF N TO CORN[1]

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Abstract: A study to determine the effect of the frequency of liquid dairy manure application on corn yield, N uptake and N levels was initiated in Goodhue county in 1983. Despite the severe drought of 1988, the yields obtained at this site were comparable to previous years. Annual application of manure produced greater grain yields, stover dry matter, N uptake and harvest index than biennial manure or the annual fertilizer check. These effects were not significantly different with respect to the two tillage systems (no till and chisel plow), although no till had higher grain and stover moisture and greater soil water content in November than did chisel tillage. A residual effect from additional potassium was reflected in higher grain yields and higher plant population at harvest. At the spring sampling soil water was uniform with depth. Only the upper two feet of soil was recharged at the fall sampling. The soil nitrogen levels were not affected by tillage. Total profile N was highest in the ammonium nitrate plots which had more than twice the N as NO_3 of any of the manure treatments both in the spring and fall. Soil N levels were 2 to 3 times higher in the fall than in the spring.

INTRODUCTION

The objective of the study is to determine the effects of tillage and frequency of manure application on corn yields, N uptake, and soil nitrogen levels. The site is located on a Timula silt loam on the Dale Flueger Farm near Redwing, MN in Goodhue Co. The study was initiated in 1983.

Liquid dairy manure is injected either annually, biennially or triennially on chisel-plowed treatments and annually or biennially on no-till treatments. A check treatments which does not receive any nitrogen and a fertilized check treatment which received ammonium nitrate annually at the rate of 210 lbs N/A on no till plots and 170 lbs N/A on chisel plots are included in the study. Cultural practices are similar to previous years (Table 1). Since tillage is associated with manure injection, no till plots are not 'no till' in the strict sense. In 1988, the no till plots were ridged for improved weed control which changed the tillage comparison to ridge till vs. chisel tillage system.

Manure treatments were split with 0 and 200 lbs K_2O in the previous years. The application of this extra potassium has been stopped since 1987. To evaluate residual effects of additional potassium data in this report are presented on split basis with respect to K_2O rates whenever possible.

Profile nitrogen was measured on spring and fall soil sampling to the 5 ft depth on April 14-15, 1988 and November 2-3, 1988, respectively.

RESULTS

Residue Cover. Residue cover measurements from biennial manure treatments are presented in Table 2. No till receiving manure in 1987 (year after manure application) had higher residue cover than any other treatment. No till had higher residue levels both in and between the rows than chisel tillage except for in row cover during year of application where chisel had higher in row residue cover.

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