Table 8. Effects of tillage and depth on bulk density, fall 1990.

Trt.	Depth (inches) 0-6	6-12	12-18	18-24	Mean
	g/cm³				
Moldboard	1.10	1.37	1.38	1.43	1.32
Chisel	1.13	1.37	1.36	1.44	1.33
Spring Disk	1.14	1.43	1.43	1.49	1.37
No-Till	1.14	1.40	1.45	1.51	1.38
Mean	1.13	1.39	1.41	1.47	

Table 9. Effects of subsoiling and depth on bulk density, fall 1990.

Trt.	Depth (inches) 0-6	6-12	12-18	18-24	Mean
	g/cm³				
SS	1.12	1.37	1.40	1.46	1.34
NSS	1.13	1.41	1.41	1.47	1.36
Mean	1.13	1.39	1.41	1.47	

Table 10. Effects of wheel traffic and depth on bulk density, 1990.

	Spring, 1990 Depth (inches)					Fall, 1990 Depth (inches)				
Trt.	0-6	6-12	12-18	18-24	Mean	0-6	6-12	12-18	18-24	Mean
	g/cm³					g/cm³				
Nwt	.81	1.34	1.41	1.51	1.27	.97	1.36	1.41	1.46	1.30
Wt	1.07	1.41	1.44	1.51	1.36	1.28	1.42	1.40	1.47	1.39
Mean	.94	1.38	1.43	1.51		1.13	1.39	1.41	1.47	

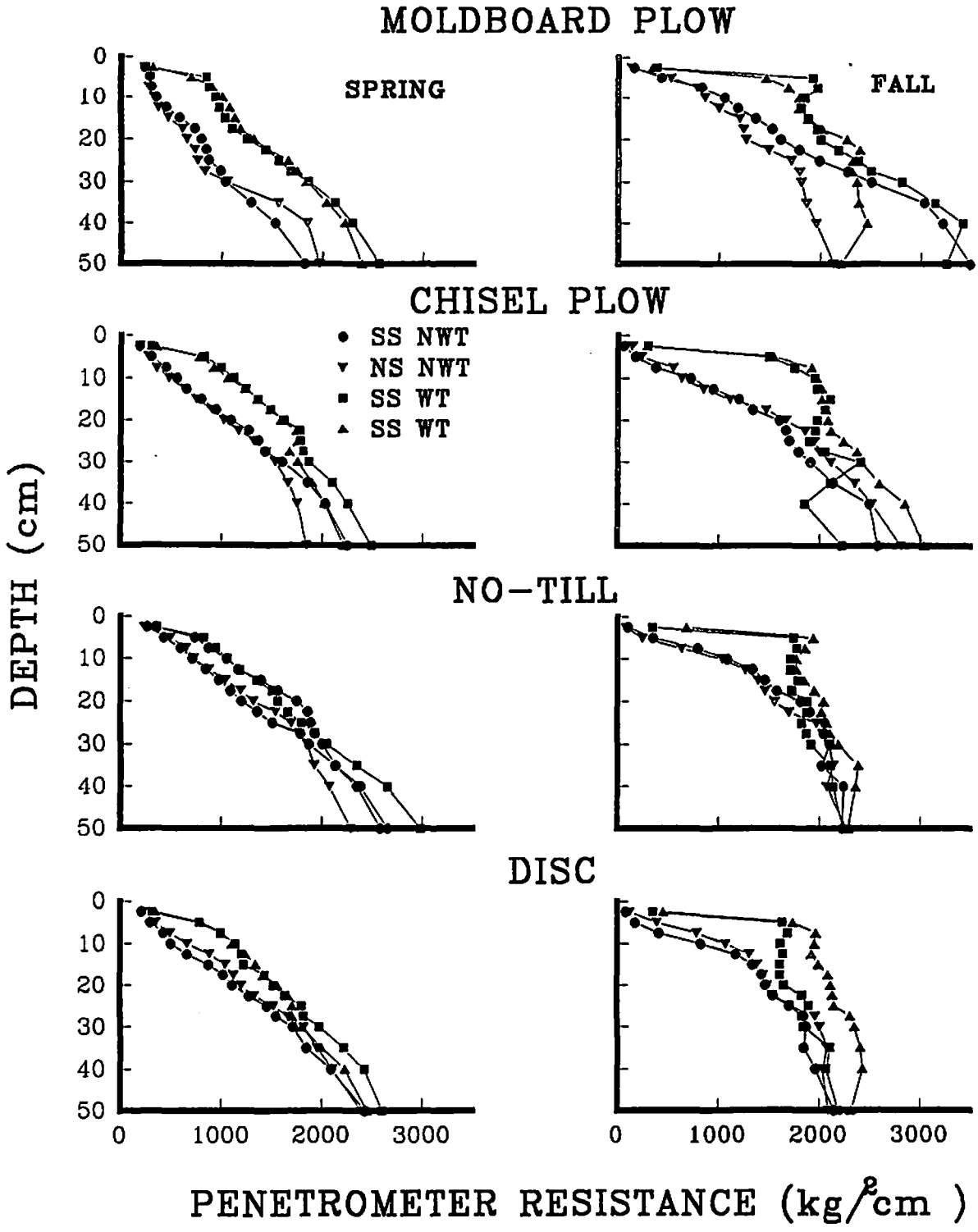

Figure 1. Penetrometer resistance readings for the four tillage systems in the spring and fall for subsoiled (SS), non-subsoiled (NS), wheel track (WT), and non-wheel tracked (NWT) interrows during the 1990 cropping season.

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

Morris, 1990

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

ABSTRACT: This study completed its 20th year in 1990 and will continue. Nitrate movement and yield responses from two initial annual applications of manure have been measured. Results over 20 years show 1986 as the first year the fertilized check yielded significantly better than the manure treatments. This occurred again in 1989 and 1990. In 1987 the fertilized check yielded more than the manure treatments, but not significantly more. Drouth in 1988 limited yields to an average of 50 bu./acre. Soil samples, measuring NO_3-N, were taken to a depth of 4 feet in the fall of 1990. Mineralization of organic N from manure to inorganic N is still providing enough N to maintain all manure treatment yields significantly above the check yields.

This is the 20th year of a continuing study initiated to measure the residual effects of 1970 and 1971 applications of two types of manure on corn yields and soil nitrogen levels. The total manure applications were as follows: Solid Beef Manure-200 tons/acre (wet weight), Liquid Beef Manure-136,000 gal/acre, and Liquid Hog Manure-136,000 gal/acre. The fertilized plots received the same amount of fertilizer annually (120+50+50 of $N+P_2O_5+K_2O$ in lbs./acre, respectively).

Experimental Procedure: The fertilized plots received 120+50+50 ($N+P_2O_5+K_2O$) lbs./acre on October 23, 1989, and the entire experimental area was moldboard plowed the same day. The experimental area was worked with a field cultivator 2 times on April 25, 1990, for seedbed preparation. The study was planted to Pioneer 3906 corn on May 4, 1990, at 26,000 seeds/acre. Furadan 15G was applied at 10 lbs./acre (1.5 lbs./acre a.i.) in the row at seeding. Lasso and Bladex (3.0 lbs./acre a.i. + 2.2 lbs./acre a.i. respectively) were tank mixed and applied broadcast pre-emergence on May 7, 1990. On May 30, 1990, the plot area was sprayed with Atrazine and Crop Oil Concentrate (2.0 lbs./acre a.i. + 2 quarts/acre, respectively) post-emergence for quackgrass control. Plots were cultivated on June 18 and June 27, 1990. Corn heights were measured on June 25, 1990, and whole plant samples were taken on June 26, 1990. Tasseling and silking dates were recorded and ear leaf samples were taken at mid-silk on August 1-3, 1990. Two 10-foot rows were harvested for silage yields on September 17, 1990. Two-100 foot rows were harvested with a plot combine on October 2, 1990, for grain yields. Grain yield, grain moisture, and grain bushel weight were recorded at harvest. Three soil cores were taken from each plot on October 8, 1990, to a depth of 4 feet in 1-foot increments. These cores were combined, subsampled, and submitted for nitrogen analysis.

Results and Discussion: Early plant height, early plant dry weight, grain moisture, grain yields, and silage yields are given in table 1. The fertilizer treatment and all manure treatments had significantly taller plants than the check treatment. The fertilizer treatment had a higher dry weight than the check, solid beef manure, and liquid hog manure treatments. There were no significant differences in height or dry weight between the fertilized treatment and the liquid beef manure treatment. The fertilizer treatment significantly outyielded all other treatments. The yield ranking of the manure treatments was as follows: liquid beef>solid beef>liquid hog. The fertilizer treatment has now yielded more than the manure treatments the last 5 years; significantly so in 1986, 1989, and 1990. In 1986, the fertilizer treatment yielded more than the manure treatments for the first time. The effect of the 1970-71 manure applications on grain yield has decreased to the extent that the fertilizer treatment now has higher grain yields than the manure treatments, but the manure treatments still have higher grain yields and taller and heavier plants than the check treatment. The results of nitrate and ammonium analyses are given in table 2. Nitrate-N levels generally increased with depth while NH_4-N levels decreased with depth. Nitrate-N levels found in the fertilizer treatment were significantly greater than NO_3-N levels found in the manure treatments. Ammonium-N levels in all treatments were essentially the same. Low NO_3-N levels in the manure treatments in 1990 are similar to those found in the fall of 1986.

Over the last 5 years NO_3-N levels in the top 4 feet have varied from year-to-year. In the fall of 1987, 1988, and 1989 the liquid beef treatment had the highest average NO_3-N levels in this soil zone. In the fall of 1990 the solid beef treatment had the highest average NO_3-N value, mostly due to the 8.4 ppm value in the 3-4 foot zone. Nonetheless, enough nitrogen is being released each year from the all old

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

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manure treatments to maintain yields significantly above the check treatment. A considerable amount of nitrogen has leached below the 4-foot level as indicated by the last deep sampling in the fall of 1987. At that time levels of 20 ppm, 27 ppm, and 30 ppm were found in the 6-8 or 8-10 foot zones of the solid beef, liquid beef, and liquid hog manure treatments. Precipitation from October 1987 to October 1990 has been average or below average in most months, so the NO_3-N levels below the root zone of corn have probably not changed much.

Table 1. Summary of plant measurements - 1990.

Treatment	Early Plant Height	Early Plant (10) Dry Weight	Grain: Moisture at Harvest	Grain: Yield at 15.5% Moisture	Silage: Dry Matter at Harvest	Silage: Silage Yield (D.M)	Silage: Ear Wt. as a % of Silage
	- cm -	- grams -	- % -	- bu/ac -	- - % - -	lb/ac	- % - -
Check	36.6	35.0	24.7	40.4	42.7	6,845	47.5
Fertilized	52.6	73.7	21.5	98.5	49.6	10,860	61.6
Solid Beef Manure	49.4	57.3	21.6	66.8	45.4	9,812	47.9
Liquid Beef Manure	51.2	77.7	21.0	75.0	46.2	8,237	53.3
Liquid Hog Manure	47.0	56.7	22.5	52.6	44.1	7,492	51.7
Signif. Level (%)	97	99	98	>99	>99	97	90
LSD (.05)	10.2	22.8	2.2	22.9	3.2	2,642	NS
CV (%)	10.7	19.5	5.0	18.2	3.6	15.2	11.2

Table 2. Nitrate and ammonium nitrogen levels of a Tara soil 20 years (Fall, 1990) after application of high rates of manure.

Depth Incr.	Treatment: Ck	Fert.	Solid Beef Manure	Liquid Beef Manure	Liquid Hog Manure	Mean	Treatment: Ck	Fert.	Solid Beef Manure	Liquid Beef Manure	Liquid Hog Manure	Mean
ft.	- - - - - - - - - ppm NO_3 - N - - - - - - - - -						- - - - - - ppm NH_4 - N - - - - - - - - -					
0-1	2.6	7.3	3.6	3.6	2.3	3.9	4.0	4.9	2.5	4.8	5.2	4.2a
1-2	0.4	13.3	0.4	0.9	0.4	3.1	2.7	2.7	2.2	3.1	2.8	2.7b
2-3	5.2	27.7	1.2	0.6	1.2	7.2	2.2	2.2	2.1	2.1	2.0	2.1c
3-4	2.7	14.9	8.4	4.1	7.3	7.5	2.3	2.3	3.3	2.2	2.2	2.5bc
Mean	2.7b	15.8a	3.4b	2.3b	2.8b	Mean	2.8	3.0	2.5	3.1	3.1	

Signif. Level (%):

Replication	- 86		Replication	- 81	
Treatment	- >99	LSD, (.05) 5.6	Treatment	- 70	
Depth	- 87		Depth	- >99	LSD (.05) 0.4
Trt. x Depth	- 84		Trt x Depth	- >99	

SOYBEAN TILLAGE NITROGEN INOCULUM STUDY[1]
MORRIS, 1990

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

Abstract: This study was designed to measure the effects that previous nitrogen rates and tillage systems from continuous corn have on subsequent soybean yields and what effect inoculation has on soybean yields in these environments. Yields were significantly higher in moldboard plow and chisel plow systems as compared to ridge till and no-till systems. Soybean yields appeared to be positively affected by previous N rates (higher residual N), but not by inoculation. In general, the higher yielding tillage treatments matured earlier while the higher yielding former N rate plots matured later. Inoculation did not overcome any of the tillage or N rate effects.

Objective: The tillage nitrogen inoculation study was designed to measure the effects on soybean growth, maturity, and yield of soybean inoculation following six years of a continuous corn tillage x N rate x hybrid study.

Experimental Procedure: This experiment was on a Tara silt loam (Pachic Udic Haploboroll) soil that was in a continuous tillage x N rate x hybrid study from 1984-1989. The experimental design was split-split plot replicated 4 times. Established tillage treatments were main plots and included 1) fall moldboard plow - (MP), 2) fall chisel plow - (CP), 3) ridge till - (RT), and 4) no till - (NT). Each tillage block was split into 5 N rates, namely, 0, 40, 80, 120, and 160 lbs./acre of fall applied N as anhydrous ammonia. From 1984-89 each N rate plot was split into 2 corn hybrids which were rotated each year. In 1990 one of the hybrid treatments was seeded to inoculated Evans soybeans and the other to non-inoculated Evans soybeans.

Corn stalks were chopped and appropriate plots were moldboard plowed and chisel plowed on October 31, 1989. Fall MP and CP plots were disked for seedbed preparation on May 22, 1990. Evans soybeans were seeded in 30-inch rows on all tillage systems at 9-10 seeds/foot on May 23. Non-inoculated soybeans were seeded first and then inoculated soybeans were seeded, to avoid any planter seed box residual inoculum contamination. Lasso at 3 lbs./acre a.i. was applied broadcast pre-emergence on May 24. Ridge-till plots were cultivated on June 21 and ridged on July 2. The other tillage treatments were not cultivated. Fusilade was applied post-emergence on July 6 at 0.1875 lb./acre a.i. for control of volunteer corn and escaped grasses. On August 28 the plots were sprayed with Sevin at 1 lb./acre a.i. for grasshopper control. Plant height and lodging were recorded on September 13 and soybean maturity was recorded from September 13-18. The plots were harvested with a plot combine on September 25 recording grain yield and grain moisture. The harvest area was 5 feet by 35 feet.

Results and Discussion: Growing conditions were fair during 1990 with adequate moisture through June and a dry July and August. Mean soybean yield for the study was 30.2 bu./acre. A summary of plant measurements is given in Table 1. The results for analysis of variance for grain yield, grain moisture, lodging, plant height, and maturity date are shown in Table 2.

There were significant effects of tillage and N rate on grain yield, lodging, and maturity date and a significant effect of tillage only on plant height. The MP and CP tillage treatments had a higher grain yield than RT and NT. The MP and CP tillage treatments also lodged more, were taller, and matured earlier than RT.

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[1] Funding provided by the West Cent. Expt. Sta., Univ. of Minnesota.

[2] Professor and Junior Scientist, West Cent. Expt. Sta., and Professor, Dept. of Soil Science, respectively, Univ. of Minnesota.

In general, yields were positively correlated with previous N rate with the former 160-lb rate yielding the highest. Lodging was also increased by N rate, but the lodging differences were rather small. It therefore appears that the residual N from previous treatments in some way positively influenced soybean yields. Even though the N rate x inoculum interaction is not significant at the 5% level, it is significant at the 10% level. However, yields (Table 3) show both positive and negative effects of inoculum and no consistent trends.

Grain moisture was significantly affected by tillage, tillage x N rate, inoculum, and the 3-way interaction, but the effects were small. Most of these differences were probably due to the fact that the experiment was harvested about 10 days after maturity and there were significant effects of both tillage and N rate on maturity date. The inoculation by tillage interaction was significant at the 10% level for grain moisture. The data (Table 4) show that inoculation resulted in higher moisture in RT and NT whereas in MP and CP there was no effect of inoculation.

Table. 1 Summary of plant measurements, 1990.

Treatment	Grain Yield	Grain Moisture	Lodging (1-5)	Plant Height	Date of Maturity
	bu/ac	%	1 = erect 5 = flat	inches	from Sept. 1
Tillage					
Moldboard Plow	33.1a	10.3	2.1a	31.6a	15.5b
Chisel Plow	32.2a	10.1	2.1a	33.1ab	15.1b
Ridge Till	26.5b	10.7	1.3b	26.8c	17.2a
No Till	28.9b	10.5	1.8a	29.9b	16.2ab
Signif. Level (%)	>99	99	>99	>99	99
BLSD (.05)	3.2	0.3	0.3	2.2	1.2
CV (%)	11.8	4.9	15.5	10.9	3.9
Previous N Rate (lbs./ac)					
0	28.5c	10.4	1.7b	31.2	15.7b
40	28.6c	10.4	1.7b	29.4	15.8b
80	31.3ab	10.4	1.8ab	29.7	15.9ab
120	30.2bc	10.5	1.9ab	30.3	16.3a
160	32.5a	10.4	2.0a	31.1	16.2ab
Signif. Level (%)	>99	15	97	72	95
BLSD (.05)	1.7	NS	0.3	NS	0.5
CV (%)	11.8	4.9	15.5	10.9	3.9
Inoculation					
Inoculated	29.8	10.5	1.8	30.3	16.0
Non-inoculated	30.6	10.3	1.8	30.4	15.9
Signif. Level (%)	83	99	--	6	69
CV (%)	11.8	4.9	15.5	10.9	3.9

Summary:

1) Soybean yields in various tillage systems were not influenced by inoculation, but were influenced by tillage with MP and CP yielding more than NT and RT.

2) Soybean yields in previous N rate treatments were not influenced by inoculation, but yields were influenced by previous N rate (residual N). Inoculation did not improve soybean yields any more where no N fertilizer had been used as compared to where 160 lbs. N/acre had been used.

3) Grain moisture was the only plant measurement significantly affected by inoculation. However, inoculation increased grain moisture at harvest only from 10.3% to 10.5%. Most of this increase came in the NT and RT systems.

Table 2. Statistical analysis of tillage nitrogen inoculum study, Morris, 1990.

Variable	Grain Yield	Grain Moisture	Lodging (1-5)	Plant Height	Date of Maturity
		Pr > F			
Tillage (T)	.0035	.0098	.0010	.0007	.0108
- - - - - - - - - - - - using Rep * T as an error term -					
N Rate (N)	.0001	.8482	.0319	.2814	.0463
T * N	.3633	.0266	.8148	.4161	.6171
- - - - - - - - - - - - using Rep * T * N as an error term -					
Inoculum (I)	.1711	.0058	1.000	.9430	.3137
T * I	.4251	.0866	.8887	.8996	.2338
N * I	.0953	.8252	.4217	.6251	.7883
T * N * I	.1357	.0525	.5198	.8587	.5928

Table 3. Effect of previous N rate and inoculum on soybean yield.

Previous N Rate (lbs./ac)	Non-Inoculated	Inoculated
	- - - - - - - - bu/ac - - - - - - -	
0	29.3	27.7
40	27.8	29.3
80	31.8	30.8
120	31.8	28.6
160	32.3	32.6

Table 4. Effect of tillage and inoculation on soybean moisture.

Tillage	Non-Inoculated	Inoculated
	- - - - - - % moisture - - - - - -	
Moldboard	10.3	10.2
Chisel plow	10.3	10.3
Ridge-Till	10.4	10.7
No-Till	10.5	11.0

COMPARING BARLEY AND CORN PRODUCTION UNDER IRRIGATED AND DRYLAND CONDITIONS IN NORTH-CENTRAL MINNESOTA

George Rehm, Erv Oelke, Mel Weins, and Dan Schmitz[1/]

ABSTRACT: Production of dryland corn on the sandy soils of North-Central Minnesota is frequently severely restricted by dry weather. Production of barley appears to be a viable alternative. For this study, corn and barley were grown under both irrigated and dryland conditions. Best management practices were used for all inputs. For irrigated conditions, corn production would appear to be more profitable. The data from 1990 would indicate that production of barley would be more profitable for dryland conditions.

Introduction:

The majority of the soils in North-central Minnesota have a sandy texture and are low in native fertility. Because of the sandy texture, storage of available water is low and frequent growing season rains are needed for profitable production. In addition, farming enterprises are dominated by livestock and forage production is essential. Traditionally, corn is grown for both grain and forage. Yet, because of soils and climate, yields are frequently low. Barley can substitute for corn in the livestock ration and may be an alternative to corn production in the region. Therefore, this study was conducted to provide an economic basis for comparing barley and corn production under both irrigated and dryland conditions.

Experimental Procedure:

This study was conducted at two sites at the Irrigation Center at Staples. One site was irrigated, the other was not. A checkbook procedure was used for irrigation scheduling for each crop.

The inputs that were used for barley production are summarized below. The fertilizer rates used were based on a yield goal of 100 bu./acre for irrigated barley and 60 bu./acre for dryland barley.

Input and Practice	Irrigated Barley	Dryland Barley
Planting Date	4/21/90	4/21/90
Variety	Excel	Excel
Planting Rate	90 lb./acre	90 lb./acre
Seedbed Preparation	Field Cultivate (twice)	Field Cultivate (twice)
Fertilizer	100 lb. 21-0-0-24/ acre 120 lb. N/acre as 46-0-0 80 lb. K_2O/acre	100 lb. 21-0-0-24/ acre 50 lb. N/acre as 46-0-0 40 lb. K_2O/acre
Herbicide	1 pint Buctril/acre	1 pint Buctril/acre
Irrigation	2 times	-

The inputs that were used for corn production are summarized below. The fertilizer rates were based on a yield goal of 160 bu./acre for irrigated corn and 60 bu./acre for dryland corn.

[1/] Extension Specialist, Extension Specialist, Research Plot Supervisor, Junior Scientist, respectively.

Input and Practice	Irrigated Corn	Dryland Corn
Seedbed Preparation	Field Cultivate (twice)	Field Cultivate (twice)
Planting Date	5/10/90	5/10/90
Variety	Pioneer 3845	Pioneer 3845
Planted Population	32,000	15,000
Fertilizer	20-5-30-10 (starter) 180 lb. K_2O/acre 180 lb. N/acre as 28-0-0	20-5-30-10 (starter) 180 lb. K_2O/acre 40 lb. N/acre as 28-0-0
Herbicide (preemerge)	Bladex + Dual 1.25 pint + 1.25 pint/acre	Bladex + Dual 1.25 pint + 1.25 pint/acre
Irrigation	9.17 inches	-

The forage yields of barley were measured at head emergence and whole plant samples were collected for protein analysis. Grain yields were measured in late July with samples collected for protein analysis.

Corn grain yields were measured in late October. Forage yields were not recorded.

Results and Discussion:

Results from the barley and corn yield measurements are summarized as follows:

Crop	Irrigated	Forage Yield	Grain Yield
		ton D.M./acre	bu./acre
Barley	yes	1.92	102.2
Barley	no	1.86	61.2
Corn	yes	-	161.2
Corn	no	-	33.1

The forage yield of irrigated and dryland barley was nearly equal but the difference in grain yield was substantial. For corn, irrigated yield was approximately 5 times higher than the dryland yield. This difference is typical of past production on the sandy soils of North-Central Minnesota.

There are always questions about the protein content of barley. For the whole plants harvested at early heading, the protein percentage was 13.8% for dryland and 15.1% for irrigated barley. This difference was probably the result of the higher rate of N applied to the irrigated barley. The protein percentage in the grain was 12.7% for both irrigated and dryland conditions.

Costs of annual inputs were also recorded. For both crops, this included the cost of seed, herbicide, power used for irrigation and fertilizer. Tillage and land charges were the same for each crop and were not included.

Annual input costs for dryland barley were $41.25/acre. This cost for dryland corn was $62.31/acre. For the irrigated situation, the annual costs were $63.65 per acre for barley production and $113.58 per acre for corn production. Net return or profit must take the yield and the value of the commodity into consideration. This was not done in this report.

It would appear that irrigated barley may not be a good alternative to irrigated corn. The situation, however, may be much different for dryland situations. The data collected in 1990 indicate that dryland barley may be a good economic alternative to dryland corn in the area.

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

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

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

This is the first year of a two year study to investigate the effect of tillage on the availability of N to corn from urea and turkey manure. Previous to the introduction of the manure variable (since 1987) urea fertilizer was the sole N source and this field was in alfalfa in 1986. Tillage treatments are shown in table 1 (moldboard plowing, spring discing, and no tillage). A small amount of urea was applied with the planter (17 lbs/acre) and the remainder at about the 4-7 leaf growth stage and moved into the soil with irrigation to prevent volatilization losses. Turkey manure was applied in the spring before tillage.

Also evaluated in this study was the effectiveness of the clearing discs on the planter. In one nitrogen subplot clearing discs were raised on half the plot. All other plots were planted with row cleaners in the down position.

This is the fourth year of corn. The previous three years averaged about a 190 bushel per acre grain yield. This left corn residue levels quite high under no till conditions. Row cleaners reduced soil cover by corn residue from 80 to 69% (table 2). They had less influence with other tillage systems. This amount of cover in the row has a dramatic affect on corn emergence and growth. Emergence was delayed two weeks with corn grown under no till and spring discing treatments. Final stands were reduced 5 thousand plants per acre under no till conditions and not affected by discing. This reflects the negative affect of corn residue in the seed furrow with the no till system. Even though soil cover by residue levels were similar for the no till and disc treatments mixing the residue with soil reduced the likelihood of getting corn residue in the seed furrow with spring discing. This prevented the stand loss. Conservation tillage systems resulted in a delay in early growth of 1.2 to 2.8 leaves per plant.

Nitrogen source did not affect soil cover, emergence, early growth, or stand establishment.

Tillage by N source by N rate

Tillage effects on early growth also showed up in grain moisture (table 3). Due largely to the delayed growth the disc treatment resulted in an average yield reduction of 36 bushels per acre. Reduced N availability also contributed to this yield reduction (grain protein). The tillage induced stand reduction was mainly associated with the no till treatment and is likely responsible for the further decline in grain yield.

Although the estimated available N applied as turkey manure was slightly higher than the urea rates, urea resulted in higher yields, grain protein, and N uptake. The assumption that 30% of the organic N in the turkey manure would be available during the growing season was most likely high due the extremely cool spring and the lack of moisture when turkey manure was shallowly incorporated.

This is illustrated by the tillage by N source interaction shown in the middle of table 3. When turkey manure was followed by moldboard plowing, grain and stover yields were the same for urea and manure sources. As tillage was reduced yield differences become larger between urea and manure sources. A similar trend

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

[2] *J.F. Moncrief and J.J. Kuznia are Associate Professor and Assistant Scientist in the Soil Science Department at the University of Minnesota, St. Paul, MN, 55108. M.J. Wiens is a Senior Plot Coordinator at the Staples Irrigation Center, Staples Area Technical College, Staples, MN.*

occurs with total N uptake.

The tillage and rate response interaction is due to the detrimental effects of residue on corn phenology and stand establishment. This influenced the source and rate interaction also.

Tillage by N source by cultivation

The objective of this study is to evaluate the effect of cultivation with a conservation tillage cultivator on the availability of N from turkey manure and urea (table 4).

Tillage and manure rate main effects are similar to the previous study.

Cultivation on July 2 increased N uptake with turkey manure as an N source.

The tillage by manure rate interaction was similar to the previous study. Turkey manure incorporated with tillage resulted in a higher corn response to an increased rate.

Higher level interactions did not show any consistent trends.

Tillage by N rate (urea)

The effect of tillage on the response by corn on applied urea is shown in table 5.

Tillage main effects are similar to the previous studies.

It is unusual that corn did not respond to urea applied beyond the 137 lb/acre rate.

The tillage by N rate interaction is indicative of the detrimental effects of corn residue on growth and yield with the conservation tillage options. The N response was greater as the tillage intensity increased.

Tillage and row cleaners

This study was designed to evaluate the influence of row cleaners on stand establishment and corn phenology (table 6). All plots had urea as a source of N.

Without row cleaners, the fluted coulter had no influence on the amount of soil cover by corn residue in the row. The clearing discs type row cleaners reduced the soil cover in the row by 12% under no till conditions. There was little influence on soil cover with the other two tillage systems. The clearing discs, although the soil cover was reduced only a small amount, increased plant stands by 6 thousand plants per acre under no till conditions.

Although tillage main effects were similar to other studies, the main effects of row cleaners and cultivation were not significant.

Soil Water Nitrate

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

Figure 1 shows the effect of tillage, N source, and depth on the concentration of nitrate over the growing season. It is difficult to detect treatment influences on soil water nitrate concentrations from June to September. The moldboard treatment had higher concentrations of nitrate in the fall than the no till treatment. Turkey manure also resulted in higher levels of soil water nitrate in the fall. Concentrations were slightly higher at five feet during the fall period.

The interaction with tillage, N source, and depth is shown in figure 2. The moldboard system resulted in lower concentrations of soil water nitrate which is likely due to the increased uptake. Turkey manure resulted in higher soil water nitrate concentrations when moldboard plowed than with urea as an N source.

WADENA COUNTY

Table 1. Cultural practices at Staples Irrigation Center, Wadena County, MN. 1990.

Tillage

No Till
Spring Disc-twice with light finishing disc on May 4, 1990
Spring Moldboard Plow-May 7, 1990 then disced and harrowed
Manure and selected urea plots were split by cultivation on July 2, 1990.

Previous Crop

1984-86 Alfalfa, 1987-89 Corn

1990 Crop

Corn-Pioneer 3790

Planting and Harvest Date

The planter is a 4 row Deutz-Allis Model 385 with 30 inch row spacing, equipped with 2 inch fluted coulters and disc (10 inch diameter) row cleaners mounted on the planter units ahead of the double disc openers. Yetter coulters are mounted on the tool bar supporting the fertilizer hoppers and open the soil for fertilizer.

At planting selected urea plots were split with row cleaners up or down.

A 4 row Hiniker 5000 Econ-O-Till cultivator was used to establish the cultivation split.

	Planting		Harvested	
Crop	Date	Rate	Grain	Stover
Corn	May 7, 1990	33,000 seeds/A	October 8, 1990	October 30, 1990

Fertilizer 1987

Material Analysis	Rate[3]	Actual N	P_2O_5	K_2O	S	Date Applied
		---- lb/A ----				
17-7-23-6[1]	93 lb/A	16	6	21	6	May 11, 1987
46-0-0[2]	0 lb/A	0	0	0	0	June 16, 1987
46-0-0[2]	75 lb/A	35	0	0	0	June 16, 1987
46-0-0[2]	146 lb/A	67	0	0	0	June 16, 1987
46-0-0[2]	221 lb/A	102	0	0	0	June 16, 1987

1. Planter applied 2" below and 2" beside row.
2. Broadcast as urea and irrigated in with 0.75 inch water.
3. The resulting N rates are: 16, 51, 83, and 118 lbs/A.

Fertilizer 1988

Material Analysis	Rate[3]	Actual N	P_2O_5	K_2O	S	Date Applied
		---- lb/A ----				
24-8-15-8[1]	85 lb/A	20	7	13	7	April 27, 1988
46-0-0[2]	0 lb/A	0	0	0	0	June 1, 1988
46-0-0[2]	137 lb/A	63	0	0	0	June 1, 1988
46-0-0[2]	254 lb/A	117	0	0	0	June 1, 1988
46-0-0[2]	400 lb/A	184	0	0	0	June 1, 1988

1. Planter applied 2" below and 2" beside row.
2. Broadcast as urea and irrigated in with 0.75 inch water.
3. The resulting N rates are: 20, 83, 137, and 204 lbs/A.

Fertilizer 1989

Material Analysis	Rate[3]	Actual N	P_2O_5	K_2O	S	Date Applied
		---- lb/A ----				
20-7-20-7[1]	95 lb/A	19	7	19	7	May 10, 1989
46-0-0[2]	0 lb/A	0	0	0	0	June 6, 1989
46-0-0[2]	72 lb/A	33	0	0	0	June 6, 1989
46-0-0[2]	139 lb/A	64	0	0	0	June 6, 1989
46-0-0[2]	207 lb/A	95	0	0	0	June 6, 1989
46-0-0[2]	0 lb/A	0	0	0	0	June 30, 1989
46-0-0[2]	70 lb/A	32	0	0	0	June 30, 1989
46-0-0[2]	139 lb/A	64	0	0	0	June 30, 1989
46-0-0[2]	200 lb/A	92	0	0	0	June 30, 1989

1. Planter applied 2" below and 2" beside row.
2. Broadcast as urea and irrigated in with 0.70 inch water on June 6 and 0.50 inch water on June 30.
3. The resulting N rates are: 19, 84, 147, and 206 lb/A.

Soil

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

1990 Fertilizer and Manure Analysis

Material Analysis	Rate[3]	Actual N	P_2O_5	K_2O	S	Date Applied
		---- lb/A ----				
20-5-30-10[1]	87 lb/A	17	4	26	9	May 7, 1990
46-0-0[2]	0 lb/A	0	0	0	0	June 29, 1990
46-0-0[2]	113 lb/A	52	0	0	0	June 29, 1990
46-0-0[2]	261 lb/A	120	0	0	0	June 29, 1990
46-0-0[2]	457 lb/A	210	0	0	0	June 29, 1990

1. Planter applied 2" below and 2" beside row on all plots.
2. Broadcast as urea and irrigated in with 0.58 inch water.
3. The resulting N rates are: 17, 69, 137, and 227 lb/A.

Analysis and rate of application of manure (average of 12 samples).

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

1. Collected in fall and stored near the study until application at Staples Irrigation Center. Source:Turkey finishing operation with wood shavings as a source of litter.

Rate of applied, estimated available N[2], and value[1] of nitrogen, phosphorus, and potassium.

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

1. It is assumed that fertilizer cost .13, .2065, and .1148 per pound of N, P_2O_5, and K_2O respectively.
2. It is assumed that all of the mineral N and 30% of the organic N will be available during the year of application.

Weed Control

1.5 qt/A (1.125 lb/A) Roundup spot sprayed on April 27, 1990.
1.5 pt/A (1.5 lb/A) Bladex + 1 qt/A (1.0 lb/A) 2,4-D Amine on May 11, 1990.
2 pt/A (2.0 lb/A) Dual on May 16, 1990.
1.5 pt/A (0.375 lb/A) Buctril applied to no till and disc treatments to control dandelions on May 30, 1990.
1 qt/A (1.0 lb/A) 2,4-D Amine spot sprayed on thistles on June 5, 1990.

Table 2. Effect of tillage on soil cover by corn and litter residue, corn growth stage and plant stands from 5-21-90 to 6-18-90 at Wadena Co[1].

Tillage	5-20 Residue[2] In Row	Bet Row	6-18 Growth Stage	Date 5-21	5-23	5-25	5-29	5-31	6-4	6-6	6-12	6-18
	------ %	------	leaves	----------	----------	----------	plants/acre x 10^{-3}	----------	----------	----------	----------	----------
No Till	68.5a	79.7a	3.0c	0.07b	0.36b	2.98c	12.78c	20.11b	23.96b	24.18b	25.34b	25.99b
Disk	52.7b	48.6b	4.4b	0.51b	2.40b	13.14b	24.76b	28.39a	29.26a	29.26a	30.06a	30.20a
Moldboard	16.7c	18.3c	5.8a	13.29a	22.36a	28.97a	30.71a	29.98a	30.86a	31.07a	30.93a	31.15a
Sig.	.001	.001	.002	.001	.001	.001	.001	.006	.013	.007	.009	.028
N-Source												
Urea 227lb/A	44.0a	46.0a	4.4a	4.79a	8.28a	16.41a	24.25a	26.57a	29.19a	29.33a	29.98a	29.91a
Low T.M.	47.8a	48.7a	4.4a	4.43a	8.57a	14.88a	21.13a	24.83a	27.59a	27.30b	28.39a	28.97a
High T.M.	46.0a	52.0a	4.5a	4.65a	8.28a	13.79a	22.87a	27.08a	27.30a	27.89ab	27.95a	28.46a
Sig.	.623	.371	.960	.963	.963	.288	.292	.399	.245	.200	.238	.437

1. Means within the same column with the same letter are not significantly different (α=.10).
2. "In row" is defined as a 4 inch area centered over the row. "Between row" is the remainder.

Table 3. Effect of tillage, nitrogen source, and nitrogen rate on various corn plant characteristics at Wadena Co., 1990[1].

Treatment	Grain Moisture	Grain Yield	Final Stand	Stover Moisture	Stover Yield	Total D.M.	Harvest Index	Grain Protein	Grain N	Stover N	Total N
	--%--	bu/A	Plant Ax10^{-3}	--%--	--T/A-	-T/A-		--%--	-------lb/A---------		
Tillage (n=16)											
No Till	34.6a	60.0c	23.7c	33.7a	1.37b	2.79c	.509b	6.53b	30.2c	7.5b	37.9c
Disk	29.6b	96.1b	27.1b	32.1ab	1.74ab	4.01b	.562a	6.70b	50.2b	8.9ab	59.1b
Moldboard	26.5c	131.8a	29.8a	26.4b	2.18a	5.29a	.583a	7.27a	74.5a	10.5a	85.0a
Sig. (Pr > F)	.001	.002	.006	.144	.003	.001	.072	.096	.005	.054	.005
N-Source (n=24)											
Urea	31.3a	106.5a	27.0a	28.5b	1.97a	4.49a	.549a	7.20a	60.3a	10.5a	70.8a
Turkey Manure	29.2b	85.4b	26.7a	33.0a	1.55b	3.57b	.554a	6.47b	42.9b	7.5b	50.4b
Sig. (Pr > F)	.009	.002	.645	.011	.001	.001	.682	.001	.002	.001	.001
N Rate (n=24)											
Low[1]	30.6a	85.3a	27.7a	33.7a	1.64b	3.67b	.542a	6.37b	41.7b	7.5b	49.1b
High[2]	29.8a	106.5b	26.8a	27.8b	1.88a	4.40a	.560a	7.30a	61.5a	10.5a	72.1a
Sig. (Pr > F)	.335	.001	.787	.022	.032	.003	.105	.001	.001	.001	.001

1. Means within the same column with the same letter are not significantly different (α=.10).

Interactions

Tillage X N Source (n=8)											
No Till Urea	36.1	70.6	24.7	34.2	1.65	3.32	.500	6.83	37.2	8.9	46.1
No Till T.M.	33.2	49.3	22.7	33.2	1.09	2.26	.518	6.23	23.3	6.1	29.4
Disk Urea	29.8	118.1	27.1	30.7	2.04	4.83	.577	7.08	64.8	10.9	75.7
Disk T.M.	29.3	74.0	27.2	33.6	1.44	3.19	.547	6.32	35.6	7.0	42.5
Mldbd Urea	27.8	130.7	29.3	20.5	2.23	5.33	.570	7.69	79.0	11.6	90.6
Mldbd T.M.	25.1	132.9	30.3	32.3	2.11	5.26	.596	6.85	70.0	9.4	79.4
Sig. (Pr > F)	.287	.011	.190	.014	.001	.004	.155	.817	.143	.313	.133
Till x N Rate lb N/A (n=8)											
No Till Low	34.0	57.9	24.8	37.4	1.24	2.61	.523	6.21	27.3	5.7	33.0
No Till High	35.3	62.1	22.6	30.0	1.50	2.94	.495	6.85	33.2	9.2	42.4
Disk Low	30.3	82.3	26.5	33.7	1.66	3.61	.537	6.24	39.2	7.8	47.1
Disk High	28.8	109.8	27.8	30.6	1.81	4.41	.588	7.16	61.1	10.0	71.1
Mldbd Low	27.5	115.8	29.7	29.9	2.04	4.77	.568	6.66	58.6	8.7	67.4
Mldbd High	25.4	147.7	30.0	22.9	2.32	5.81	.598	7.89	90.3	12.2	102.6
Sig. (Pr > F)	.209	.116	.203	.707	.852	.430	.018	.216	.035	.686	.076
N Source x N Rate lb N/A (n=12)											
Urea Low	31.6	90.8	26.6	34.7	1.80	3.94	.536	6.47	45.1	8.1	53.2
Urea High	30.9	122.2	27.5	22.2	2.15	5.04	.562	7.93	75.5	12.9	88.4
T.M. Low	29.7	79.9	27.4	32.6	1.50	3.39	.549	6.26	38.3	6.8	45.1
T.M. High	28.7	90.9	26.1	33.4	1.60	3.75	.559	6.67	47.6	8.1	55.7
Sig. (Pr > F)	.818	.082	.161	.011	.225	.105	.462	.001	.011	.035	.011

1. Low signifies available nitrogen rate for turkey manure of 114 lb/A (includes 17 lb N/acre as starter fertilizer) of and a nitrogen rate of 69 lb/A for urea.
2. High signifies available nitrogen rate for turkey manure of 180 lb/A (includes 17 lb N/acre as starter fertilizer) of and a nitrogen rate of 137 lb/A for urea.

Table 4. Effect of tillage, N rate as manure, and cultivation on various corn plant characteristics at Wadena Co., 1990[1].

Treatment	Grain Moisture	Grain Yield	Final Stand	Stover Moisture	Stover Yield	Total D.M.	Harvest Index	Grain Protein	Grain N	Stover N	Total N
	--%--	bu/A	Plant Ax10^{-3}	--%--	--T/A-	-T/A-		---%---	--------lb/A--------		
Tillage											
No Till	33.2a	49.2c	23.2c	32.7a	1.14c	2.30c	.499c	6.19b	22.9c	5.8b	28.7c
Disk	29.0b	72.2b	26.3b	24.9a	1.39b	3.10b	.543b	6.31b	34.9b	6.1b	41.0b
Mldbd	24.7c	127.4a	30.2a	32.8a	2.01a	5.02a	.598a	6.72a	65.7a	8.9a	74.6a
Sig. (Pr > F)	.001	.001	.001	.431	.001	.001	.003	.037	.001	.001	.001
N Rate (n=24)											
114 lb N/A	29.7a	74.7b	26.5a	33.6a	1.43a	3.20b	.537b	6.25b	35.6b	6.4b	42.0b
180 lb N/A	28.2b	91.5a	26.6a	33.4a	1.50a	3.76a	.556a	6.56a	47.0a	7.5a	54.5a
Sig. (Pr > F)	.045	.002	.894	.946	.101	.008	.081	.004	.001	.062	.001
Cultivation											
W/ Cult	29.3a	85.4a	26.7a	33.0a	1.55a	3.57a	.550a	6.47a	43.0a	7.5a	50.5a
W/O Cult	28.6a	80.6a	26.4a	34.0a	1.48b	3.38b	.543a	6.34a	39.4a	6.4b	45.8b
Sig. (Pr > F)	.115	.275	.584	.357	.111	.169	.579	.267	.197	.001	.110

1. Means within the same column with the same letter are not significantly different (α=.10).

Interactions											
Tillage X N Rate (n=8)											
Notill 114lb/A	33.4	46.2	23.1	32.3	1.04	2.13	.507	6.30	22.0	5.2	27.2
Notill 180lb/A	32.9	52.2	23.5	33.2	1.24	2.47	.491	6.07	23.9	6.3	30.2
Disk 114lb/A	30.2	59.9	26.0	34.1	1.35	2.77	.510	6.03	27.4	6.3	33.6
Disk 180lb/A	27.7	85.3	26.7	35.8	1.43	3.45	.578	6.60	43.0	6.0	48.9
Mldbd 114lb/A	25.5	118.1	30.5	34.3	1.91	4.70	.594	6.42	57.5	7.7	65.2
Mldbd 180lb/A	24.0	136.7	30.0	31.4	2.11	5.34	.602	7.02	73.8	10.1	84.0
Sig. (Pr > F)	.510	.169	.756	.701	.889	.627	.023	.004	.067	.149	.091
Tillage X Cultivation (n=16)											
No Till W/	33.4	49.3	22.7	33.2	1.09	2.28	.512	6.23	23.3	6.1	29.4
No Till W/O	32.9	49.0	23.6	32.3	1.19	2.35	.485	6.15	22.6	5.4	28.1
Disk W/	29.4	74.0	27.2	33.6	1.44	3.19	.541	6.32	35.7	7.0	42.6
Disk W/O	28.5	70.3	25.4	36.3	1.34	3.00	.543	6.29	34.1	5.3	39.3
Mldbd W/	25.1	132.9	30.3	32.3	2.12	5.26	.595	6.85	70.1	9.4	79.5
Mldbd W/O	24.4	121.9	30.1	33.4	1.90	4.78	.601	6.58	61.2	8.5	69.7
Sig. (Pr > F)	.953	.491	.190	.388	.010	.162	.365	.494	.301	.314	.364
N Rate X Cultivation (n=24)											
114lb/A W/Cult	29.8	79.9	27.4	32.6	1.50	3.39	.546	6.26	38.3	6.8	45.1
114lb/A W/O Cult	29.6	69.6	25.7	34.5	1.37	3.01	.528	6.24	32.9	6.0	38.9
180lb/A W/Cult	28.9	90.9	26.1	33.4	1.60	3.75	.553	6.67	47.7	8.1	55.9
180lb/A W/O Cult	27.5	92.1	27.2	33.4	1.59	3.77	.559	6.45	46.2	6.8	53.0
Sig. (Pr > F)	.203	.137	.014	.391	.143	.102	.263	.357	.414	.366	.498
Till X N Rate X Cultivation (n=8)											
NT 114lb/A W/	31.9	50.0	23.9	35.1	0.98	2.16	.538	6.16	23.3	4.9	28.2
NT 114lb/A W/O	34.9	42.3	22.3	29.5	1.10	2.10	.475	6.45	20.6	5.6	26.2
NT 180lb/A W/	34.9	48.6	21.6	31.3	1.20	2.35	.486	6.30	23.2	7.3	30.5
NT 180lb/A W/O	30.8	55.7	24.9	35.2	1.27	2.59	.495	5.85	24.6	5.3	29.9
Disk 114lb/A W/	31.4	62.8	27.1	30.6	1.45	2.94	.504	6.13	29.1	7.6	36.7
Disk 114lb/A W/O	29.0	57.1	24.9	37.6	1.24	2.59	.515	5.94	25.7	5.0	30.6
Disk 180lb/A W/	27.5	85.2	27.2	36.6	1.42	3.43	.579	6.51	42.3	6.3	48.6
Disk 180lb/A W/O	27.9	85.3	26.0	34.8	1.44	3.46	.576	6.70	43.5	5.6	49.3
Mb 114lb/A W/	26.0	126.8	31.3	32.2	2.05	5.06	.595	6.50	62.5	8.0	70.5
Mb 114lb/A W/O	24.9	109.3	29.7	36.3	1.76	4.35	.594	6.33	52.5	7.5	60.0
Mb 180lb/A W/	24.2	138.9	29.4	32.3	2.18	5.47	.596	7.20	77.7	10.8	88.5
Mb 180lb/A W/O	23.9	134.5	30.5	30.5	2.03	5.21	.609	6.83	70.0	9.5	79.5
Sig. (Pr > F)	.001	.933	.389	.001	.287	.958	.244	.060	.951	.002	.840

Table 5. Effect of tillage and urea nitrogen rate on various corn plant characteristics at Wadena Co., 1990[1].

Treatment	Grain Moisture	Grain Yield	Final Stand	Stover Moisture	Stover Yield	Total D.M.	Harvest Index	Grain Protein	Grain N	Stover N	Total N
	--%--	bu/A	Plant Ax10^{-3}	--%--	--T/A-	-T/A-		---%---	--------lb/A--------		
Tillage (n=16)											
No Till	35.7a	64.8b	23.3b	33.5a	1.63b	3.16b	.488b	7.22a	37.0b	11.3a	48.3b
Disk	30.4b	105.7a	27.9a	29.7b	1.90ab	4.40a	.566a	7.12a	59.3a	11.6a	70.9a
Moldboard	27.6c	120.0a	29.8a	17.0c	2.05b	4.89a	.570a	7.52a	72.1a	12.0a	84.1a
Sig. (Pr > F)	.001	.006	.005	.001	.118	.014	.006	.481	.014	.953	.031
N Rate (n=12)											
17 lb N/A	28.7c	56.8c	26.2a	27.1b	1.21c	2.55c	.523a	5.87d	25.1c	5.4c	30.5d
69 lb N/A	31.6b	90.8b	26.6a	34.7a	1.80b	3.94b	.536a	6.47c	45.1b	8.1c	53.2c
137 lb N/A	30.9b	122.2a	27.5a	22.2b	2.15a	5.04a	.562a	7.93b	75.5a	12.9b	88.4b
227 lb N/A	33.7a	117.6a	27.7a	22.9b	2.27a	5.06a	.543a	8.87a	78.8a	20.1a	99.0a
Sig. (Pr > F)	.001	.001	.535	.001	.001	.001	.437	.001	.001	.001	.001

1. Means within the same column with the same letter are not significantly different (α=.10).

Interactions											
Tillage X N Rate (n=8)											
No Till 17lb/A	31.8	38.5	22.1	34.5	0.97	1.88	.485	5.99	17.4	5.0	22.4
No Till 69lb/A	36.2	65.8	25.7	39.8	1.50	3.06	.504	6.25	31.3	6.6	37.8
No Till 137lb/A	36.0	75.5	23.7	28.7	1.79	3.58	.497	7.40	43.1	11.2	54.3
No Till 227lb/A	39.0	79.4	21.6	31.1	2.24	4.12	.467	9.22	56.2	22.3	38.5
Disk 17lb/A	28.1	65.9	28.1	34.0	1.33	2.89	.543	5.63	28.2	5.4	33.6
Disk 69lb/A	29.5	101.8	25.9	36.8	1.87	4.28	.564	6.35	49.3	8.2	57.5
Disk 137lb/A	30.2	134.4	28.3	24.6	2.21	5.39	.590	7.80	80.2	13.7	93.9
Disk 227lb/A	33.7	120.7	29.5	23.3	2.17	5.03	.565	8.71	79.7	19.2	98.8
Mldbd 17lb/A	26.2	65.9	28.3	12.7	1.34	2.90	.541	5.99	29.6	5.8	35.4
Mldbd 69lb/A	29.0	104.7	28.2	27.6	2.02	4.49	.540	6.81	54.8	9.5	63.2
Mldbd 137lb/A	26.7	156.6	30.5	13.4	2.45	6.16	.599	8.57	103.2	13.8	117.0
Mldbd 227lb/A	28.4	152.6	32.1	14.3	2.41	6.02	.599	8.70	106.7	19.0	119.6
Sig. (Pr > F)	.194	.031	.160	.626	.836	.188	.747	.092	.017	.856	.038

Table 6. Effect of tillage and row cleaners on residue relative to the row, growth stage and plant stands at Wadena Co[1].

Treatment	5-20 Residue In Row	5-20 Residue Between Row	6-18 Growth Stage	Plant Stand 6-4	Plant Stand 6-12	Plant Stand 6-18
	-------- % --------		--------	------ plants/A x 10^{-3} -----		
Tillage (n=8)						
No Till	73.3a	79.5a	2.94c	21.13b	23.52b	23.63c
Disk	59.5b	55.5b	3.88b	28.53a	29.19a	29.40b
Moldboard	14.0c	18.5c	4.63a	31.47a	32.56a	33.21a
Signif. (Pr > F)	.001	.001	.003	.009	.009	.005
Row Cleaners (n=12)						
W/ Row Cleaners	44.0	46.0	4.38	29.19	29.98	29.91
W/O Row Cleaners	53.8	56.3	3.25	24.90	26.86	27.59
Signif. (Pr > F)	.001	.073	.001	.001	.005	.046
Tillage X Row Cleaners						
No Till w/	66.5	79.0	3.38	24.39	25.92	26.57
No Till w/o	80.0	80.0	2.50	17.86	21.13	20.69
Disk w/	51.0	48.0	4.25	30.27	31.36	30.71
Disk w/o	68.0	63.0	3.50	26.79	27.01	28.10
Mldbd w/	14.5	11.0	5.50	32.89	32.67	32.45
Mldbd w/o	13.5	26.0	3.75	30.06	32.45	33.98
Signif. (Pr > F)	.028	.462	.232	.420	.147	.037

1. Means within the same column with the same letter are not significantly different (α=.10).

Table 7. Effect of tillage, row cleaners and cultivation on various plant characteristics of corn at Wadena Co. 1990[1].

Treatment		Grain Moisture	Grain Yield	Final Stand	Grain Protein	Grain N
Tillage		---%----	bu/A	plants/acre x 10^{-3}	---%---	--%--
No Till	(n=32)	36.5a	61.6c	21.5c	7.40b	35.2c
Disk	(n=30)	32.7b	118.6b	28.0b	8.01ab	72.6b
Moldboard	(n=32)	27.9c	152.4a	31.8a	8.59a	99.7a
Signif. (Pr > F)		.001	.001	.002	.091	.001
Row Cleaners						
W/ Row Cleaners	(n=46)	31.9a	110.9a	27.3a	7.97a	69.4a
W/O Row Cleaners	(n=48)	32.8a	110.5a	26.9a	8.03a	68.9a
Signif. (Pr > F)		.200	.845	.690	.954	.713
Cultivation						
W/ Cultivation	(n=47)	32.8a	111.9a	27.4a	8.05a	70.1a
W/O Cultivation	(n=47)	31.7b	109.5a	26.8a	7.95a	68.2a
Signif. (Pr > F)		.005	.542	.488	.588	.591

1. Means within the same column with the same letter are not significantly different (α=.10).

FIGURE-1
SOIL WATER NITRATE IN CORN
FOLLOWING CORN AT STAPLES 1990

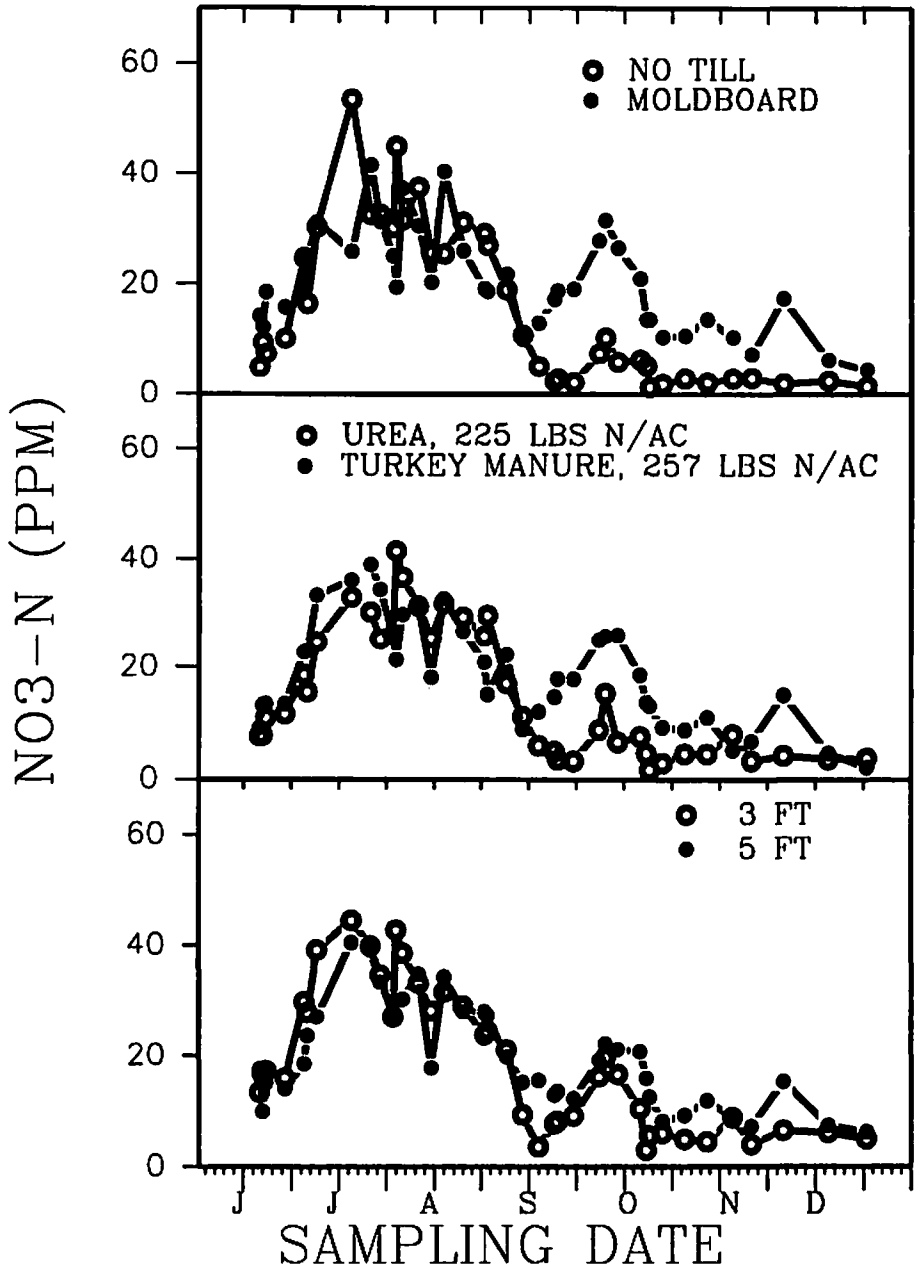
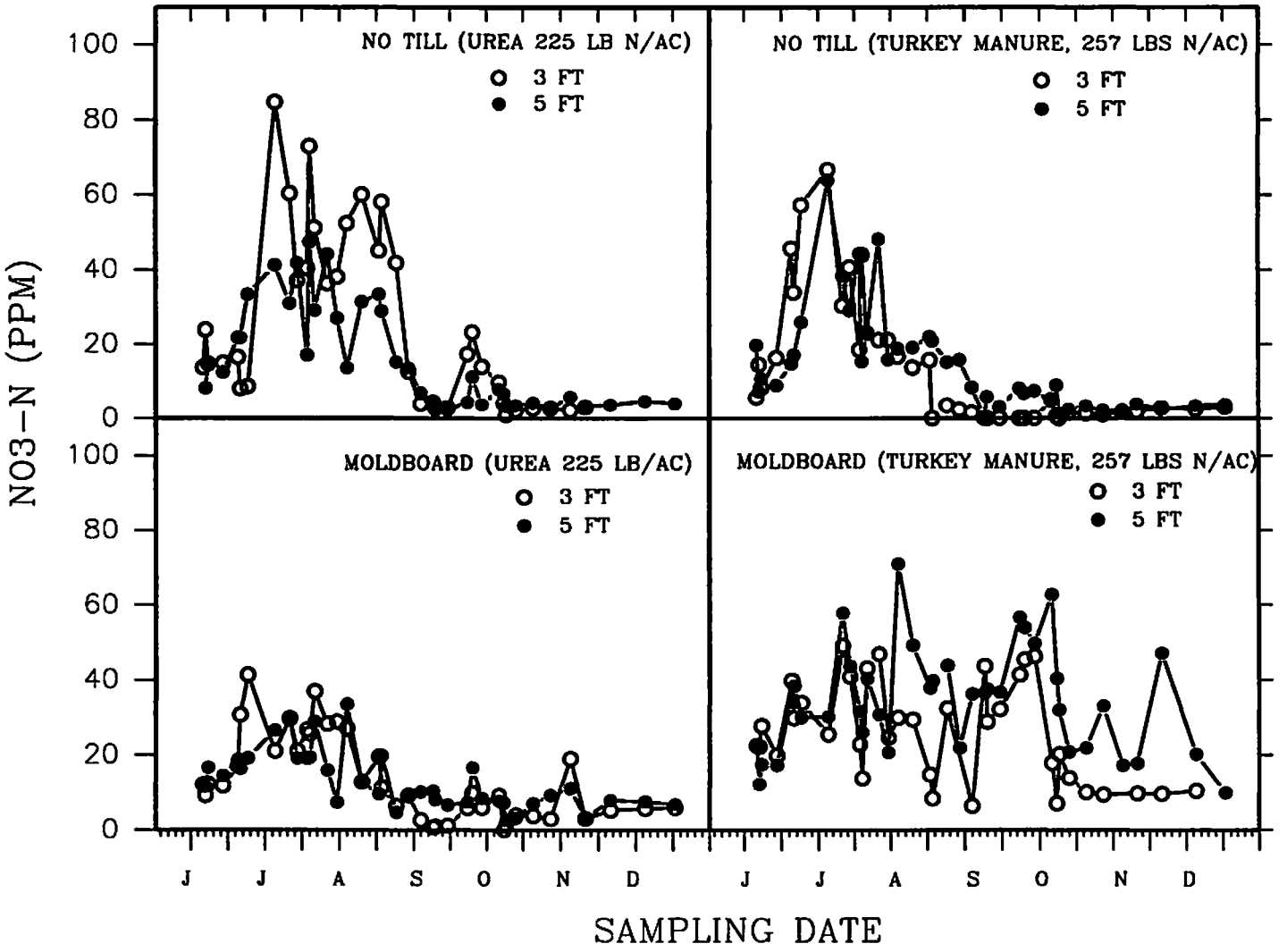
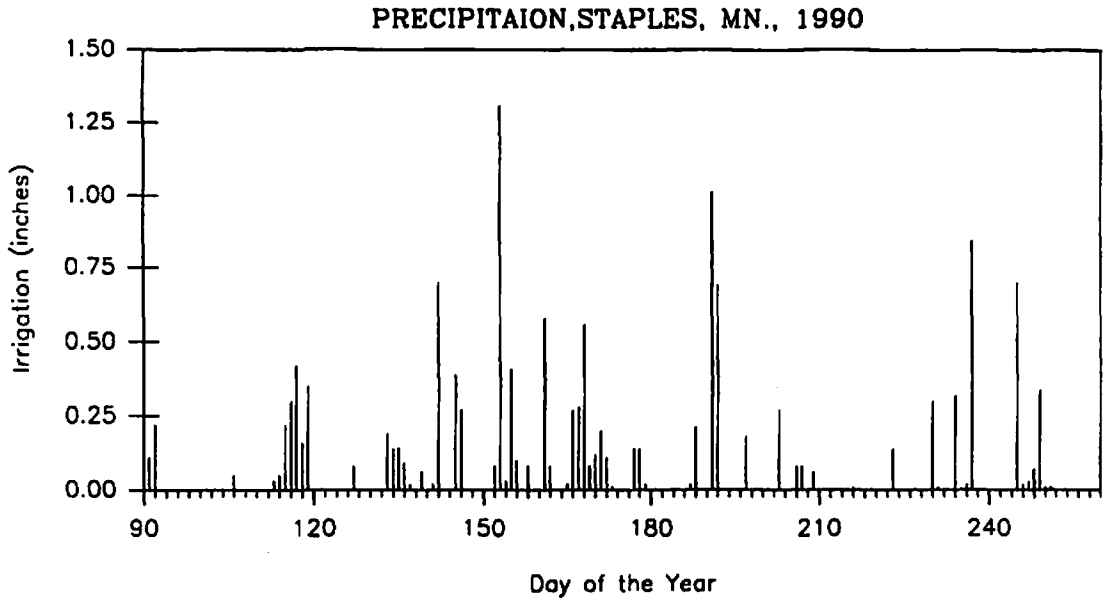


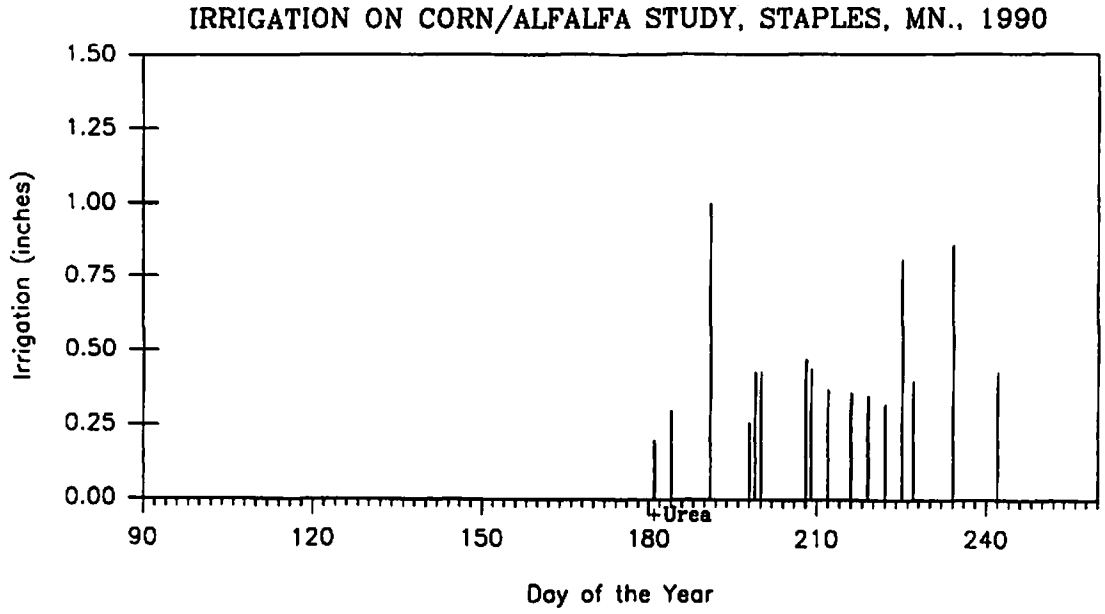
FIGURE-2

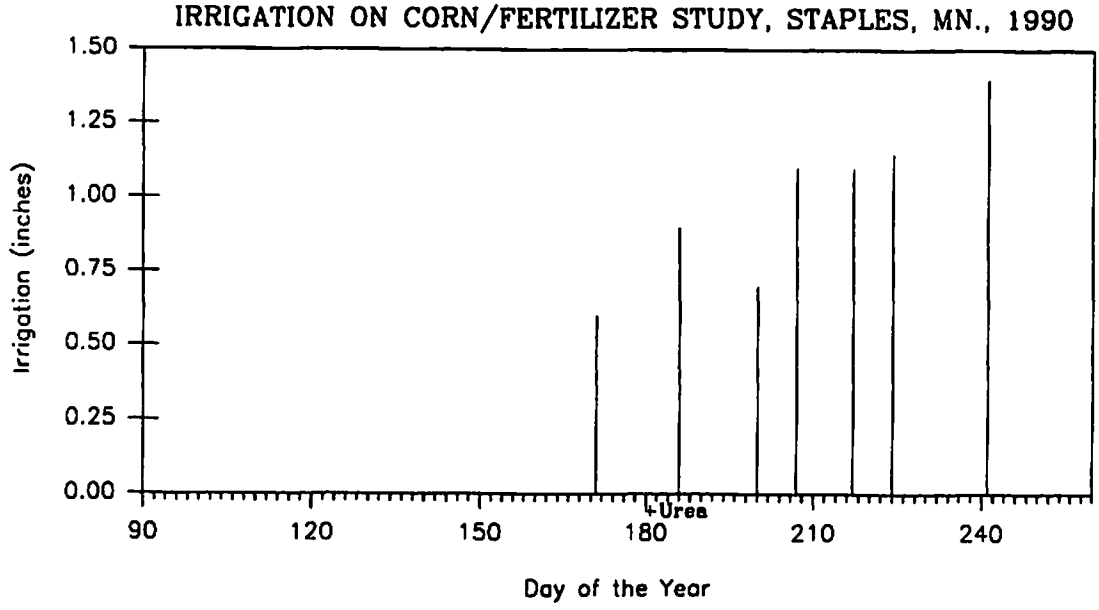
SOIL WATER NITRATE BY DEPTH IN CORN FOLLOWING CORN

STAPLES 1990




PRECIPITAION,STAPLES, MN., 1990
Irrigation (inches)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
90
120
150
180
210
240
Day of the Year


IRRIGATION ON CORN/ALFALFA STUDY, STAPLES, MN., 1990
Irrigation (inches)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Urea
90
120
150
180
210
240
Day of the Year


IRRIGATION ON CORN/FERTILIZER STUDY, STAPLES, MN., 1990
Irrigation (inches)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Urea
90
120
150
180
210
240
Day of the Year

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

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

This study is designed to evaluate full width tillage and row cultivation on the N available to corn after alfalfa. Tillage did not affect stand establishment and had only slight influence emergence rate. Conservation tillage systems reduced the amount of N available to corn from alfalfa. At the 83 lb/acre rate all tillage systems had equal yields but slightly lower total N uptake.

The objective of this study is to evaluate the effect of full width tillage and row cultivation in June on the amount of nitrogen available to corn from alfalfa. Alfalfa was killed with herbicide in the spring (table 1). The alfalfa stand was about 8 plants per square foot (table 2).

The soil cover by alfalfa residue after planting is shown in table 3. The planter equipped clearing discs were much more effective at reducing soil cover by alfalfa residue in the row area than with corn residue (see companion paper). Emergence was only delayed by 2 days with the no till treatment and not at all with the spring disc treatment. Final stands were not affected by tillage.

Tillage affected grain moisture, but only slightly. Although tillage affected grain yield and N uptake there was an interaction with rate of urea. At the high N rate grain yields were similar between tillage systems. Although this interaction was similar for nitrogen uptake, it was slightly higher as tillage increased.

Cultivation did not show any consistent trend on growth, N uptake or yield.

Figure 1. shows the soil water nitrate at 3 and 5 feet under moldboard and no till conditions. The moldboard system appeared to have higher levels of nitrate through out the season. Figure 2 shows the individual sampler duplicates within the plots. The variability within plots makes it difficult to identify any treatment trends.

WADENA COUNTY

Table 1. Cultural practices at Staples Irrigation Center, Wadena County, MN. 1990.

Tillage

No Till
Spring Disc-twice with light finishing disc on May 4, 1990
Spring Moldboard Plow-May 4, 1990 then disced and harrowed
Plot were split by cultivation on June 26, 1990.

Previous Crop

Alfalfa 1987-89

1990 Crop

Corn-Pioneer 3790

Planting and Harvest Date

The planter is a 4 row Deutz-Allis Model 385 with 30 inch row spacing, equipped with 2 inch fluted coulters and disc (10 inch diameter) row cleaners mounted on the planter units ahead of the double disc openers. Yetter coulters are mounted on the tool bar supporting the fertilizer hoppers and open the soil for fertilizer.

A 4 row Hiniker 5000 Econ-O-Till cultivator was used to establish the cultivation split.

	Planting		Harvested	
Crop	Date	Rate	Grain	Stover
Corn	May 7, 1990	33,000 seeds/A	October 8, 1990	October 30, 1990

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

[2] *J.F. Moncrief and J.J. Kuznia are Associate Professor and Assistant Scientist in the Soil Science Department at the University of Minnesota, St. Paul, MN, 55108. M.J. Wiens is a Senior Plot Coordinator at the Staples Irrigation Center, Staples Area Technical College, Staples, MN.*

Fertilizer 1990

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

1. Planter applied 2" below and 2" beside row.
2. Broadcast as urea and irrigated in with 0.29 inch water.
3. The resulting N rates are: 17, 29, 56, and 83 lb/A.

Soil

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

Weed Control

1 qt/A (0.75 lb/A) Roundup + 1 qt/A (1.0 lb/A) 2,4-D Amine on April 27, 1990.
1.5 pt/A (1.5 lb/A) Bladex + 1 qt/A (0.75 lb/A) Roundup on May 11, 1990.
2 pt/A (2.0 lb/A) Dual on May 16, 1990.

Table 2. Alfalfa crown counts[1] at Wadena Co. on April 25, 1990[2].

Nitrogen Rate	Tillage: No Till	Tillage: Disk	Tillage: Chisel	Average
	----- plants/foot^2 -----			
17 lb/acre	8.8	8.3	8.0	8.4a
29 lb/acre	7.8	7.9	7.4	7.7a
56 lb/acre	8.3	8.2	5.8	7.4a
83 lb/acre	9.3	8.8	7.2	8.4a
Average	8.5a	8.3ab	7.1b	

1. Crown counts were taken when the plot was flagged out and before establishment of tillage and N treatments.
2. The p value for tillage, nitrogen rate, and tillage by nitrogen rate interaction for alfalfa crown counts are 0.163 (n=32), 0.293 (n=24), and 0.710 (n=8) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 3. Effect of tillage on soil cover by alfalfa residue, and corn plant stands from 5-21-90 to 6-12-90 at Wadena Co[1].

Tillage	Date 5-20 Residue: In Row	Date 5-20 Residue: Bet Row	Date: 5-21	5-23	5-25	5-29	5-31	6-4	6-7	6-12
			---------- plants/acre x 10^{-3} ----------							
No Till	26.0a	72.0a	8.49b	20.04b	28.75a	30.71a	31.36a	31.15a	31.36a	30.49a
Disk	15.5b	14.0b	6.32b	16.77b	28.75a	31.36a	31.58a	30.49a	31.36a	30.71a
Moldboard	3.0c	7.0b	16.99a	28.97a	30.49a	31.36a	31.36a	30.93a	30.93a	31.15a
Signif. (Pr > F)	.001	.001	.001	.001	.533	.879	.981	.832	.918	.892

1. Means within the same column with the same mean are not significantly different (α=.10).

Table 4. Effect of tillage, nitrogen rate, and cultivation on various corn plant characteristics at Wadena Co., 1990[1].

Treatment	Stover Moisture	Stover Yield	Grain Moisture	Grain Yield	Total D.M.	Harvest Index	Final Stand	Grain Protein	Grain N	Stover N	Total N
	--%--	-T/A-	--%--	-bu/A-	-T/A-		Plants Ax10^{-3}	---%---	--------lb/A---------		
Tillage (n=32)											
No Till	29.1a	3.23a	27.2ab	153.1b	6.85a	.530a	29.78a	6.72b	78.9b	24.3a	103.2b
Disk	24.7a	3.46a	27.5a	160.9ab	7.26a	.525a	30.00a	7.56a	92.8a	25.7a	118.5a
Moldboard	26.1a	3.37a	26.4b	165.8a	6.85a	.538a	30.00a	7.17ab	91.0a	27.8a	118.8a
Sig. (Pr > F)	.276	.646	.135	.081	.393	.570	.846	.034	.027	.651	.104
N Rate (n=24)											
17 lb/A	34.7a	3.03b	27.5a	138.0d	6.30a	.519b	29.65a	6.55c	69.1d	20.6c	89.7d
29 lb/A	28.4b	3.36a	27.1ab	151.0c	6.94b	.516b	29.62a	6.94cb	78.8c	23.2c	103.0c
56 lb/A	25.0b	3.43a	27.1ab	169.2b	7.43c	.542a	30.37a	7.45ab	95.7b	27.5b	123.3b
83 lb/A	18.4c	3.57a	26.5b	181.5a	7.86d	.547a	30.08a	7.66a	105.5a	32.3a	137.9a
Sig. (Pr > F)	.001	.002	.250	.001	.001	.001	.344	.005	.001	.001	.001
Cultivation (n=48)											
Cultivation	26.9a	3.33a	26.8b	160.9a	7.13a	.534a	30.00a	7.30a	89.6a	24.7a	114.3a
No Cultivation	26.3a	3.37a	27.3a	159.0a	7.13a	.527a	29.86a	7.00a	85.6a	27.1a	112.7a
Sig. (Pr > F)	.686	.516	.044	.238	.980	.260	.688	.173	.130	.108	.597
Interactions											
Tillage X N Rate (n=8)											
No till 17 lb/A	37.8	2.79	27.7	123.3	5.71	.514	29.04	6.08	56.6	17.5	74.1
No till 29 lb/A	31.5	3.27	27.5	141.9	6.63	.510	28.97	6.31	68.1	24.2	92.3
No till 56 lb/A	29.1	3.13	27.0	166.5	7.07	.560	30.27	7.33	92.8	23.9	116.8
No till 83 lb/A	18.1	3.72	26.5	180.8	7.99	.536	30.86	7.17	98.2	31.4	129.6
Chisel 17 lb/A	32.9	3.03	27.8	136.8	6.27	.516	29.55	6.66	69.3	18.0	87.3
Chisel 29 lb/A	25.2	3.49	28.1	153.7	7.13	.510	29.91	7.92	92.1	23.3	115.4
Chisel 56 lb/A	20.4	3.78	26.9	173.3	7.88	.523	30.49	7.78	102.5	29.1	131.6
Chisel 83 lb/A	20.1	3.52	27.0	180.0	7.78	.548	30.06	7.87	107.5	32.2	139.7
Mldbd 17 lb/A	33.4	3.28	26.9	154.0	6.92	.526	30.35	6.91	81.5	26.4	107.8
Mldbd 29 lb/A	28.3	3.33	25.8	157.6	7.05	.528	29.98	6.59	79.3	22.2	101.4
Mldbd 56 lb/A	25.4	3.39	27.3	167.7	7.36	.541	30.35	7.23	92.3	29.3	121.6
Mldbd 83 lb/A	17.0	3.47	25.8	183.8	7.82	.557	29.33	7.93	110.8	33.4	144.2
Sig. (Pr > F)	.462	.103	.135	.081	.027	.227	.309	.359	.095	.453	.141

1. Means within the same column with the same mean are not significantly different (α=.10).

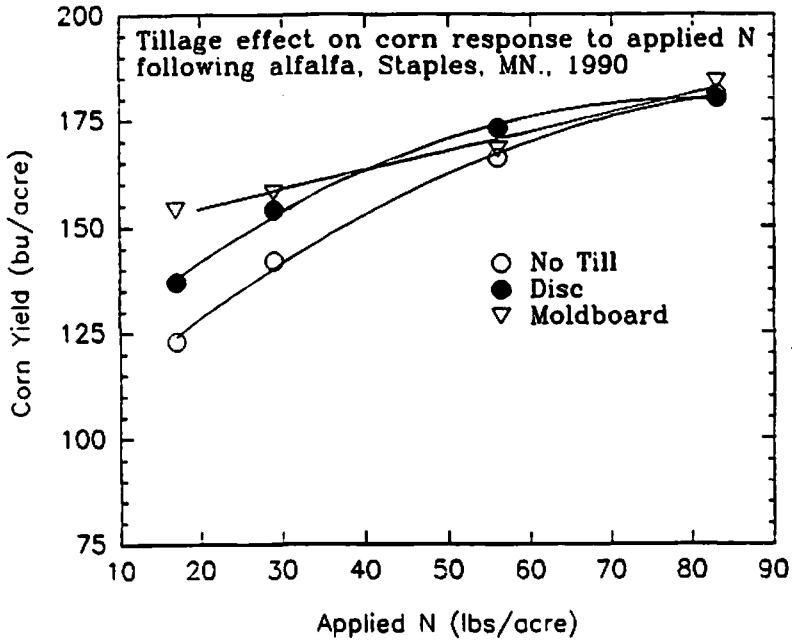


FIGURE -1

SOIL WATER NITRATE BY DEPTH IN CORN FOLLOWING ALFALFA

STAPLES 1990

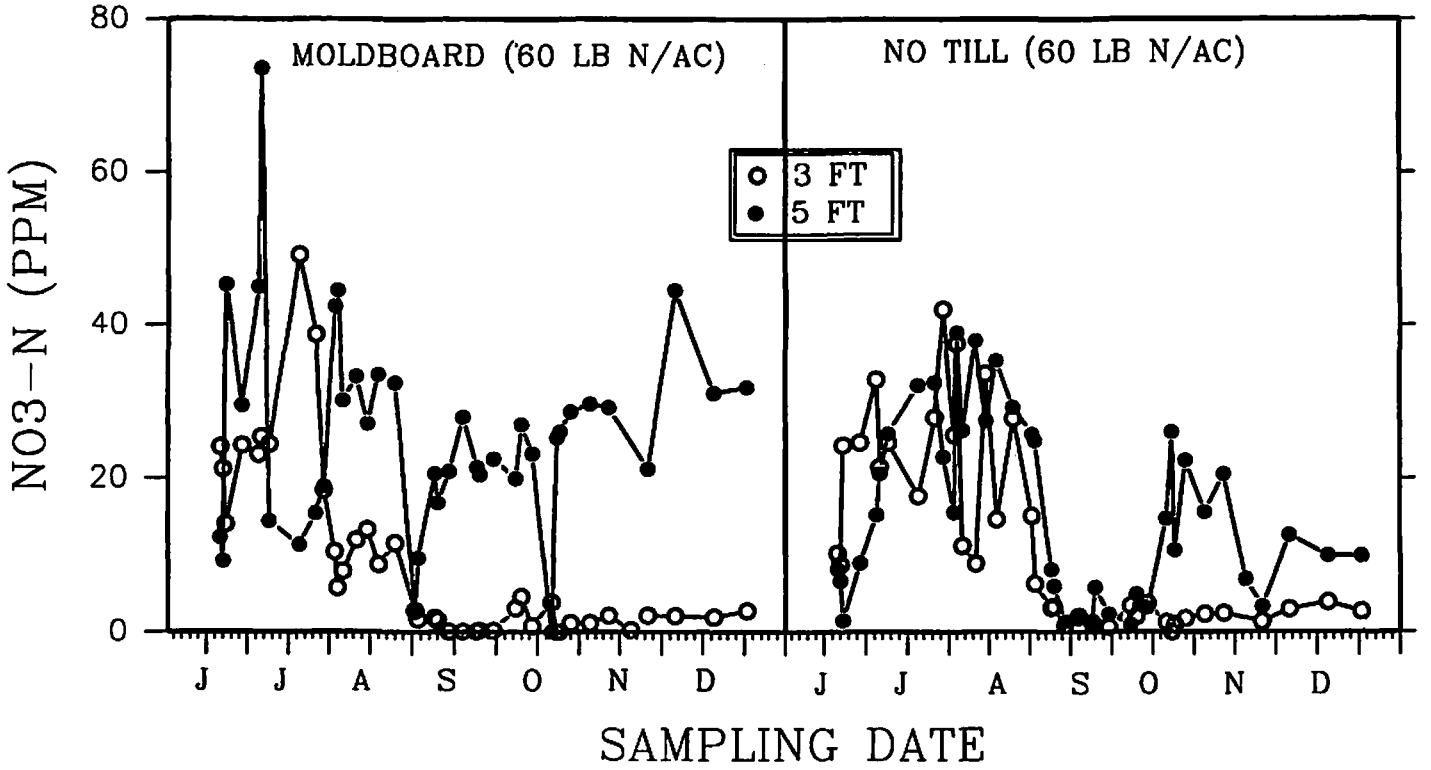
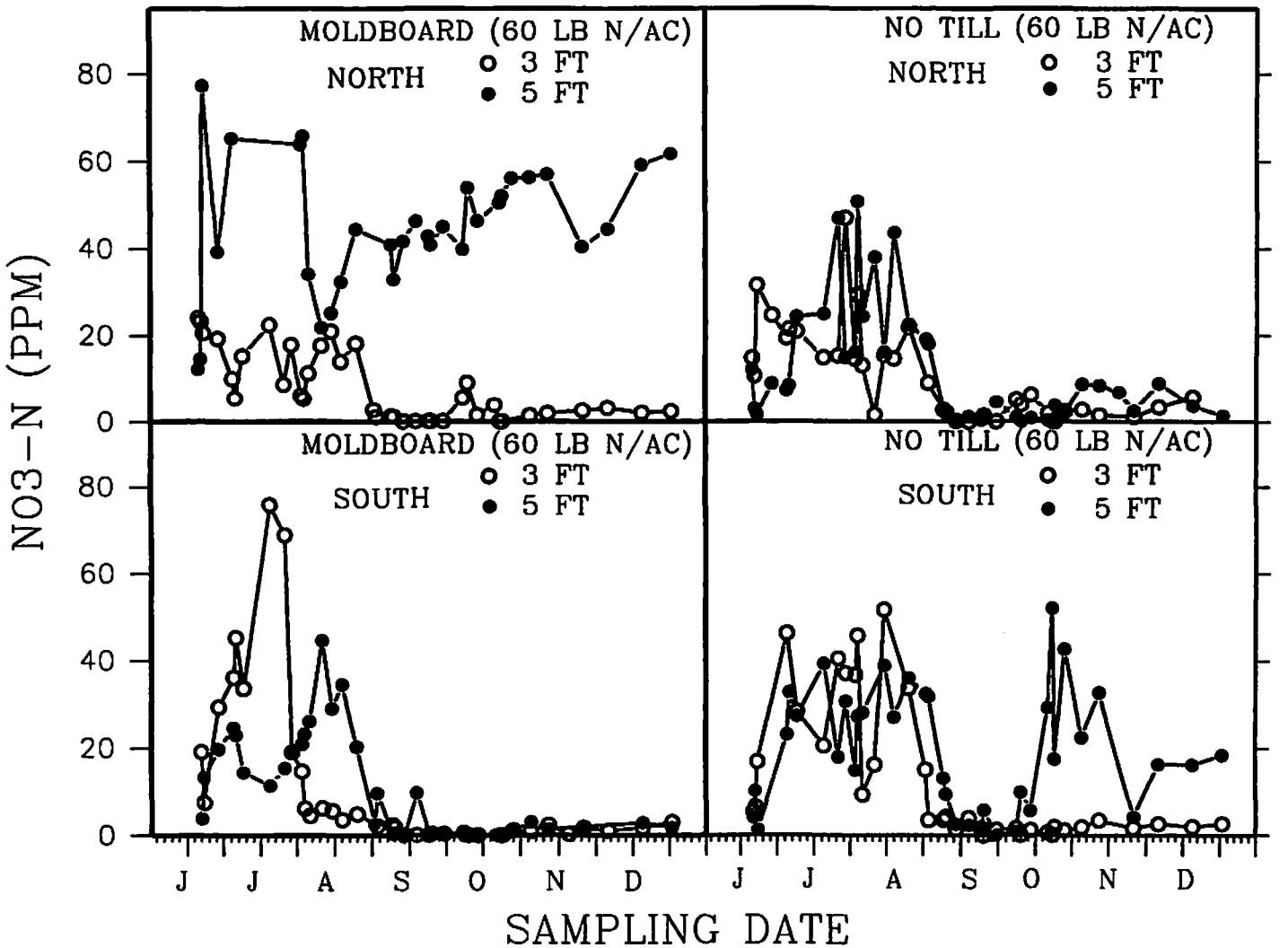


FIGURE -2

SOIL WATER NITRATE BY DEPTH IN CORN FOLLOWING ALFALFA

STAPLES 1990



NITROGEN VALUE OF RED CLOVER GROWN ON A SANDY SOIL

George Rehm, Dan Schmitz, and Andy Scobbie[1/]

ABSTRACT: The severe winter of 1989-90 killed existing stands of red clover at the Staples Irrigation Center. This provided an opportunity for evaluation of nitrogen credits for red clover preceeding a corn crop. Seven rates of N, supplied as 28-0-0, were applied to corn following: 1) a one-year old stand of red clover, 2) a three-year old stand of red clover, and 3) oats. Corn following oats responded to fertilizer N in the same manner as corn following the one-year old stand. The three-year old stand supplied substantial N to the corn. It would appear that current N credits assigned to an established stand of red clover are correct.

Introduction:

It's widely recognized that legumes supply nitrogen to grain crops grown in rotation. Considerable research has focused on the amount of N supplied by soybeans and alfalfa. There is less information about the amount of nitrogen supplied by red cover.

Experimental Procedure:

This study was conducted at the Irrigation Center at Staples. The severe winter of 1989-90 killed red clover at the Center. This was true for stands that were both 1 year old and 3 years old. This provided an opportunity to evaluate the amount of N supplied by red clover stands of two different ages (1 year, 3 years).

Corn was planted on May 10 on 3 areas that were adjacent to each other. In one area, the red clover was one year old before winter kill. In the second area, the red clover was three years old before winter kill. Oats was grown on the third area in 1989. Tillage consisted of 2 passes with a field cultivator. The planted population was 32,000 plants per acre. Potash (300 lb. 0-0-60/acre) was broadcast and incorporated before planting. The preemergence herbicide was a combination of Bladex (1.25 pint/acre) and Dual (1.25 pint/acre).

Six rates of nitrogen (30, 60, 90, 120, 150, 180 lb./acre) were applied to each of the three areas. Each treatment as well as the control (no N) was replicated 4 times. The nitrogen was applied as a sidedress treatment on July 5 and incorporated with the irrigation water. The nitrogen source was 28-0-0.

Irrigation was applied throughout the season as needed. A total of 9.17 inches of irrigation water was applied.

Results and Discussion;

Corn yields are summarized in the following table. All yields are corrected to 15.5% moisture.

N Applied	Previous Crop 1 year old Red Clover	 3 year old Red Clover	Oats
lb./acre		bu./acre	
0	141.2	139.0	101.7
30	155.3	157.4	119.4
60	165.3	155.2	150.7
90	179.7	167.9	162.0
120	171.5	149.9	165.0
150	173.3	154.9	159.3
180	177.0	169.6	162.2

[1/] Extension Specialist, Junior Scientist, Assistant Scientist, respectively.

There was a response to the use of nitrogen fertilizers on all three areas. In general, the optimum nitrogen rate was 120 lb./acre when corn followed oats. When corn followed the 3 year old stand of red clover, the optimum N rate was approximately 60 lb. of nitrogen per acre. The 1 year old stand of red clover supplied little or no nitrogen. For this crop sequence, the optimum nitrogen rate was 120 lb./acre.

Current University of Minnesota fertilizer recommendations suggest using a nitrogen credit for red clover of 75 lb./acre. Results from this one site suggest that this credit is appropriate and should not be changed.

CORN NITROGEN RATE STUDY

H. Meredith and Mel Wiens[1/]

ABSTRACT: A nitrogen rate study was initiated in 1990 on an irrigated sandy loam soil on the research area at the Stapes Irrigation Center. The study is to be multi year with N rates of 20, 60, 100, 140, 180 and 220. A 95-day relative maturity hybrid was used as the test crop. The objective of the study is to establish optimum N rates for production of corn under intensive management.

Table 1. N Rates, Corn Yields and Percent Moisture in Grain at Harvest of 95-day Relative Maturity Hybrid, Staples Irrigation Center.

Treatment	Yield	Moisture
lbs N/A	bu/A	%
20	73.2	21.0
60	91.8	23.4
100	124.0	19.3
140	135.7	17.9
180	142.2	18.4
220	134.1	18.4

[1/] Regional Director, TVA; Research Plot Supervisor, Staples Irrigation Center, University of Minnesota, respectively.

LUPIN BEAN FERTILITY STUDY

H. Meredith, Mel Weins, and Andy Scobbie[1/]

ABSTRACT: A fertility study initiated in 1984 to determine the nutrient requirements of the lupin bean (Lupinus albus) was continued in 1990. Excellent yields resulted due to wee and insect control, excellent seed quality, and ideal climatic conditions for germination and emergence. The diseases, which plagued the crop and reduced yield in 1989, were again evident on the continuous lupin plot but yields were not reduced as drastically as the previous year. As in past years, no yield increases were noted with any of the nutrient additions.

Table 1. Summary of "Good" Lupin Yields 1985 - 1990, Staples MN.

		Yield, bu/A[2/]				
No	Treatment	1985	1987	1988	1990	
1	Check	71.4	61.8	61.9	61.9[3/]	68.7[4/]
2	S	71.2	62.8	67.2	61.2	64.0
3	S+K	63.8	61.9	61.1	57.1	59.8
4	S+K+P	68.8	61.8	57.2	61.2	67.0
5	S+K+P+Zn	64.1	56.3	58.0	60.3	67.2
6	S+K+P+Zn+B	64.9	60.8	52.3	56.2	67.2

[2/] Yields based on 13.5% moisture and 60 lb/bu
[3/] Continuous lupin site
[4/] 1st year lupin site

Summary and Conclusions:

The 1990 growing season was quite conducive for lupins and satisfactory yields were achieved. It is reassuring that the highest yield was attained on the zero fertility plots. The range in yield of the four replications was 66.7 to 70.5 with a four rep average of 68.7. A yield reduction on the potassium and phosphate treatments was observed in 1990 as some years previously. Lupins are sensitive to soluble salt whether from the native soil, irrigation water or fertilizer salts.

The lupin plant has great potential for use as a nitrogen builder and as a crop to mobilize sparingly soluble soil nutrients for utilization by succeeding crops. to date, a yield increases has been attained only from applied sulfur in one year, 1988. No response from other applied nutrients has been measured.

The continuous lupin plot will be discontinued after 1990 due to buildup of pathogens, primarily Ascochyta and to a lesser extent from Pleiochaita and Fusarium. Future lupin research plots will follow cereal crops.

[1/] Regional director, TVA; Research Plot Supervisor, Staples Irrigation Center; Assistant Scientist, University of Minnesota, respectively.

TRITICALE PRODUCTION

H. Meredith, Mel Wiens, and Andy Scobbie[1/]

ABSTRACT: Winter and spring Triticale varieties are evaluated under irrigation at the Staples Irrigation Center. Winter varieties unprotected with snow cover do not have the hardiness of rye and as a result, disappointing yields result. Spring triticale varieties are far more promising although yields were not as high as expected.

Table 1. Spring Triticale Trials at the Staples Irrigation Center.

Variety	Straw Yield Tons/A	Grain Yield bu/A	Test Weight lbs/bu
Wapati	2.67	43.4	56.0
Florico	2.53	40.8	57.0
Companion	2.63	39.6	53.9
Plains	2.63	46.5	54.3
Norico	2.66	45.0	58.7
Norita	2.31	39.2	54.1

Table 2. Winter Triticale Trials at the Staples Irrigation Center.

Variety	Straw Yield Tons/A	Grain Yield bu/A	Test Weight lbs/bu
Winteri	1.37	9.2	44.8
81 DED 1015	1.30	11.1	50.3
81 DED 1012	1.45	7.5	49.4
Ind 5-3-3	1.48	11.2	47.9
Ind 3-2-2	1.28	11.0	45.6

[1/] Regional Director, TVA; Research Plot Supervisor, Staples Irrigation Center; Assistant Scientist, University of Minnesota, respectively.

WATER QUALITY STUDIES

H. Meredith and Mel Wiens[1/]

ABSTRACT: Each year a limited quantity of water samples are collected and analyzed. The purpose of this study is to monitor, on a limited basis, the quality of water applied to agricultural crops in central Minnesota. The data are represented in the tables follows, 1990.

Table 1. Analysis of Irrigation Well Water in the Perham, MN Area.

	Parts Per Million (PPM)									
Sample #	N	Ca	Mg	Na	P	K	S	Fe	Mn	Zn
1	4.1	81.5	20.3	4.2	.17	3.2	8.2	.79	.14	.27
2	T	33.6	28.4	11.8	.10	2.3	.08	.20	.01	.01
3	0.5	46.7	17.5	2.6	.11	1.2	5.5	.11	.16	T*
4	T	41.6	21.3	2.2	.07	1.5	1.6	.17	.08	T
5	0.7	39.3	20.0	2.2	.07	1.4	1.6	.02	.28	.01
6	13.2	116.2	27.9	2.5	.09	2.4	20.0	.20	.24	.13
7	3.7	64.9	21.0	3.5	.08	1.4	5.9	.02	.28	.02
8	3.5	31.9	18.4	5.1	.07	2.3	5.0	.06	.08	T
9	1.0	73.2	19.4	3.1	.18	1.1	3.5	3.4	.18	T

* T = trace

The following elements were present in concentrations below measurement: aluminum, boron, copper, cadmium, chromium, nickel and lead.

Table 2. Analyses of Irrigation Well Water from Wells in the Perham, MN Area, 1990.

	Pounds of Nutrients Per Acre-Inch Water							
Sample #	N	Ca	Mg	K	S	Calcium Equivalent	$CaCO_3$ Equivalent (Lime)	Lbs N Required to Neutralize Lime in IW Water
1	.90	17.9	4.5	.70	1.8	25.5	63	17.8
2	T	7.4	6.2	.51	.02	17.9	44	12.5
3	.11	10.3	3.8	.26	1.2	16.8	42	11.8
4	T	9.2	4.7	.33	0.4	17.2	44	13.4
5	.15	8.6	4.4	.31	0.4	16.1	40	11.3
6	2.9	25.6	6.1	.53	4.4	36.0	90	25.2
7	.81	14.3	4.6	.31	1.3	22.1	55	15.5
8	.77	7.0	4.0	.51	1.1	13.8	34	9.6
9	.22	16.1	4.3	.24	0.8	23.4	58	16.4

1/ Regional Director, TVA; Research Plot Supervisor, Staples Irrigation Center, respectively.

Table 3. Analyses of Irrigation Water at the Staples Station, 1990.

	Parts Per Million (PPM)										
Location	N	Ca	Mg	Na	P	K	S	Fe	Mn	Zn	Sample Date
SW Pit	T	30.3	9.1	1.2	.07	4.8	2.0	.42	.18	.02	7/18
NW Pit	21.7	58.2	24.2	1.1	T	4.8	6.5	.04	.07	T	7/18
SE Pit	0.8	34.6	12.3	2.8	T	1.1	2.5	.13	.11	.02	7/10
Center Pivot	5.4	32.3	20.1	1.6	T	1.0	3.7	.03	.03	.02	6/29
Plot Well C	13.7	40.5	22.2	7.1	T	1.2	2.1	.27	.15	T	6/29
Plot Well A	14.4	59.5	23.6	2.0	.04	1.0	3.3	.23	.36	.01	7/2
Plot Well D	9.1	38.8	20.4	2.6	.05	1.1	2.7	.42	.12	T	6/29
Plot Well B	3.5	50.9	26.5	2.1	.05	1.3	1.8	.65	.21	T	7/3
Plot Well B	4.2	48.1	23.0	2.6	T	1.2	1.8	.28	.19	.03	7/18
Plot Well C	8.1	36.6	20.8	2.0	T	1.2	2.1	.23	.10	T	7/18
NW Pit	20.3	25.8	22.7	2.7	T	1.0	6.7	.04	.02	.02	7/3
SW Pit	T	26.5	9.2	1.3	.04	6.8	2.2	.35	.04	T	7/3
Energy Well	1.0	13.9	19.9	9.7	T	2.1	7.7	.06	.04	T	7/3

Table 4. Analyses of Irrigation Well Water from the Staples Station, 1990.

	Pounds of Nutrients Per Acre-Inch Water							
Location	N	Ca	Mg	K	S	Calcium Equivalent	$CaCO_3$ Equivalent (Lime)	Lbs N Required to Neutralize $CaCO_3$ eq.
SW Pit	T	6.7	2.0	1.1	.4	10.1	25.2	7.0
NW Pit	4.8	12.8	5.3	1.1	1.4	21.8	54.5	15.3
SE Pit	.2	7.6	2.7	.2	.6	12.1	30.2	8.4
Center Pivot	1.2	7.1	4.4	1.0	1.5	14.6	36.5	10.2
Farm Well	T	6.6	4.1	.3	1.1	13.6	34.0	9.5
Center Pivot	1.5	4.2	3.7	.2	.8	10.5	26.2	7.3
Plot Well C	3.0	8.9	4.9	.3	.5	17.2	43.0	12.0
Plot Well A	3.2	13.1	5.2	.2	.7	21.9	54.8	15.3
Plot Well D	2.0	8.5	4.5	.2	.6	14.1	35.2	9.8
Plot Well B	.8	11.2	5.8	.2	.4	21.1	52.8	14.8
Plot Well B	.9	10.6	5.1	.2	.4	19.3	48.2	13.5
Plot Well C	1.8	8.0	4.6	.2	.5	15.8	39.5	11.1
NW Pit	4.5	5.7	5.0	.2	1.5	14.2	35.5	9.9
SW Pit	T	5.8	2.0	1.5	.5	8.2	20.5	5.7
Energy Well	.2	3.0	4.4	.5	1.7	10.5	26.2	7.3

Table 5. Analyses of Irrigation Water at the Staples Station, 1990.

	Parts Per Million (PPM)										
Location	N	Ca	Mg	Na	P	K	S	Fe	Mn	Zn	Sample Date
Center Pivot	8.9	53.8	23.6	4.0	T	.91	10.4	.05	.04	.02	8/29
Farm Well	T	26.7	22.9	6.0	T	.91	3.2	.09	.07	.02	7/25
Two Towers	8.7	78.7	16.7	2.5	.06	1.2	8.8	.32	.34	.01	8/29
SE Pit	T	40.3	22.3	1.7	.05	2.5	3.6	.27	.31	.01	7/25
Energy Well	2.7	47.2	21.8	6.7	.06	2.8	10.5	.32	.20	.01	7/25
Center Pivot	3.0	43.7	19.3	5.1	.04	1.2	8.7	.07	.03	.02	7/25
Plot Well D	4.5	38.7	22.7	1.9	.06	1.1	2.8	.94	.14	T	6/29
NW Pit	52.7*	76.7	20.2	2.4	.05	.93	6.4	.15	.23	T	8/9
Plot Well C	3.6	75.1	20.0	2.0	.12	.97	2.8	2.2	.34	.05	7/25
Farm Well	T	47.2	21.3	3.9	.06	.95	3.5	.21	.14	.01	8/9
SW Pit	T	69.4	24.8	2.4	.06	4.7	7.5	.31	.38	.03	8/10
Center Pivot	7.8	68.2	8.9	5.0	.05	1.2	10.4	.16	.13	.01	8/9
Well drilling Well	T	34.5	19.9	12.0	.14	1.0	.19	.69	.01	.01	8/10
Plot Well D	T	81.0	19.8	2.0	.09	1.1	3.4	1.4	.36	T	8/9
Plot Well D	4.4	67.1	19.8	2.0	.08	1.2	3.3	1.3	.29	.01	8/9
SE Pit	2.4	77.1	22.0	2.4	.06	4.0	7.6	.62	.37	.03	8/9
Energy Well	1.6	73.0	22.8	2.4	.06	3.1	11.3	.43	.39	.01	8/10
SW Pit	T	53.6	12.2	6.5	.31	2.8	8.4	.40	.50	T	8/10
NW Pit	5.4	82.6	23.9	1.6	.30	1.3	6.7	.10	.25	.02	7/25
NW Pit	3.9	76.3	25.2	2.6	.07	1.1	6.7	.13	.43	T	8/2
Plot Well B	1.9	80.4	22.0	2.1	.11	1.0	2.3	2.9	.43	.01	7/25
Energy Well	6.1	74.6	22.8	6.6	.07	3.1	11.4	.43	.40	.03	8/2
Energy Well	28.6	55.5	21.1	6.0	.07	2.9	10.2	.41	.28	.02	8/9
SE Pit	1.7	77.0	14.8	1.6	.10	1.7	3.9	.57	.54	.01	8/2
SW Pit	T	37.0	11.8	1.8	.17	4.9	7.2	1.6	.37	.04	8/2

* This value needs to be compared with the two other samples from the same pit.

Table 6. Analyses of Irrigation Water from the Staples Station, 1990.

	Pounds of Nutrients Per Acre-Inch Water						
Location	N	Ca	Mg	S	Calcium Equivalent	$CaCO_3$ Equivalent (Lime)	Lbs N Required to Neutralize $CaCO_3$ eq.
Center Pivot	2.0	11.8	5.2	2.3	20.6	52	15
Farm Well	T	5.9	5.0	.7	14.4	36	10
Two Towers	1.9	17.3	3.7	1.9	23.6	59	16
SE Pit	T	8.9	4.9	.8	17.2	43	12
Energy Well	.6	10.4	4.8	2.3	16.6	42	12
Center Pivot	.7	9.6	4.2	1.9	16.7	42	12
Plot Well D	1.0	8.5	5.0	.6	17.0	42	12
NW Pit	11.6*	16.9	4.4	1.4	24.4	61	17
Plot Well C	.8	16.5	4.4		24.0	61	17
Farm Well	T	16.5	4.4	.6	24.0	61	17
SW Pit	T	10.4	4.7	.8	18.4	46	13
Center Pivot	1.7	15.3	5.4	1.6	24.5	61	17
Well Drilling Well	T	15.0	2.0	2.3	18.4	46	13
Plot Well D	T	7.6	4.4	T	15.1	38	11
Plot Well D	1.0	17.8	4.4	.7	25.3	63	17
SE Pit	.5	14.8	4.4	.7	22.3	56	16
Energy Well	.4	16.1	4.8	1.7	24.3	61	17
SW Pit	T	11.8	4.8	2.5	20.0	50	14
NW Pit	1.2	18.2	2.7	1.8	22.8	57	16
NW Pit	.8	16.8	5.2	1.5	25.6	64	18
Plot Well B	.4	17.7	5.5	.5	17.1	43	12
Energy Well	1.3	16.4	4.8	2.5	24.6	62	17
Energy Well	6.3	12.2	5.0	2.2	20.7	52	15
SE Pit	.4	16.9	4.6	.8	24.7	62	18
SW Pit	T	8.1	2.6	1.6	12.5	31	9

* This value needs to be compared with the two other samples from the same pit.

Irrigation water quality is increasingly becoming of greater concern. The nutrients contained in irrigation water have economic implications to the user. Additionally, routine sampling permits monitoring of selected elements dissolved in irrigation water.

The nutrients of greatest value to the grower are the calcium, magnesium and sulfur contained in irrigation water. Tables 2, 4, and 6 indicate the pounds of the dominate nutrients contained in irrigation water expressed in pounds per acre inch. Calcium carbonate equivalent (lime) is the calcium plus magnesium expressed as calcium carbonate. The column pounds of nitrogen required to neutralize the pounds calcium carbonate equivalent delivered in irrigation water is on a per acre inch basis. If a nitrogen fertilized crop is included in the rotation, this figure is a guide as to the potential neutralization of the lime equivalent contained in irrigation water.

SOUTHERN EXPERIMENT STATION

WASECA, MINNESOTA

WEATHER DATA - 1990

Month	Period	Precipitation 1990	Precipitation Normal[1]	Avg. Air Temp. 1990	Avg. Air Temp. Normal[1]	Growing Degree Days 1990	Growing Degree Days Normal[1]
		- - - inches - - -		- - - - ° F - - - -			
January	1-31	0.26	0.84	25.9	10.0		
February	1-28	1.03	0.99	22.6	16.4		
March	1-31	4.02	1.99	35.5	27.6		
April	1-30	2.80	2.64	45.9	44.7		
May	1-10	1.88		53.8		87.5	
	11-20	2.54		52.1		58.0	
	21-31	.89		60.1		119.0	
	Total	5.31	3.76	55.4	57.7	264.5	334
June	1-10	1.37		62.2		133.5	
	11-20	4.32		73.3		231.0	
	21-30	.99		72.9		220.5	
	Total	6.68	4.48	69.5	67.1	585.0	518
July	1-10	2.23		74.5		235.0	
	11-20	2.21		69.2		190.5	
	21-31	1.70		69.8		218.0	
	Total	6.14	4.02	71.1	71.2	643.5	641
August	1-10	0.91		66.9		170.0	
	11-20	4.60		71.1		209.0	
	21-31	0.94		72.6		246.0	
	Total	6.45	3.99	70.3	68.8	625.0	579
September	1-30	1.50	3.36	64.6	59.8	476.5	311
October	1-31	1.36	2.08	47.7	48.9		38
November	1-30	0.53	1.43	37.5	32.5		
December	1-31	1.63	1.02	15.1	18.0		
Year	Jan-Dec	37.71	30.60	46.9	43.6	2594.5[2]	2421
Growing Season	May-Sep	26.08	19.61	66.2	64.9	2594.5	2383

[1] 30-year normal from 1951 -- 1980.
[2] 50 to 86 ° F base, May 1 until first fall frost.

Notes:
1) Highest temperature on July 4 - - - 102 °.
2) Only 8 days of ≥90 ° F.
3) Highest 24-hour precipitation on August 20 - - - 4.02".
4) Last spring frost - - - May 2.
5) First fall frost - - - October 1.

NITROGEN LOSS TO TILE LINES AS AFFECTED BY TILLAGE[1]

Waseca, 1990

G. W. Randall and B. W. Anderson[2]

ABSTRACT: No tillage (NT) is thought to increase infiltration and, therefore, should increase the amount of water percolating through the soil compared to conventional tillage. This long-term study is being conducted to determine if greater amounts of NO_3-N and pesticides are being lost to tile drainage water with NT compared to moldboard plow (MP) tillage. Rainfall during 1990 was 7.1" above normal and tile flow was plentiful. The slightly higher tile drainage with NT was offset by slightly higher NO_3-N concentrations with the MP system. Nitrate-N losses were not different between the two tillage systems. Corn yields, N uptake, and N removal in the grain were all significantly higher for MP compared to NT. Grain yield was 29% less with NT. Substantially higher amounts of NO_3 remained in the 8-foot soil profile in October with the MP system compared to NT.

Nitrogen losses to tile lines have been documented in a number of research studies including some conducted at Lamberton and Waseca, Minnesota. These studies primarily showed that N losses were a function of the N application rate and amount of precipitation. To some degree the time of application and crop grown have been shown to influence NO_3-N loss to tile lines. The purpose of this long-term study is to determine if tillage has an effect on N utilization, accumulation of NO_3-N in the soil profile, and the subsequent loss of NO_3-N to tile lines.

EXPERIMENTAL PROCEDURES

A study was initiated in 1975 on a Webster clay loam at Waseca to monitor the movement of N into a tile line installed in each of 12 plots measuring 45' x 50'. Each plot is enclosed with plastic sheeting to a 6' depth. Annual N rates of 0, 100, 200, and 300 lb N/A were applied from 1975-1979. No N was applied for the 1980 and 1981 crops. Residual N from N applied over the 5-year period (75-79) was utilized by the 1980 and 1981 corn crops. Soil samples to 10' and tile water samples taken in late 1981 showed little remaining evidence of the previous treatments.

In the fall of 1981, eight plots with the most uniform tile flow rates over the 1975-81 period were selected. Two tillage treatments (fall moldboard plow and no tillage) were replicated four times and randomized over the previous plot histories. Corn was grown on these plots in 1982 through 1989. The stalks were chopped in October, 1989 and moldboard plots plowed.

On May 20, 180 lb N/A as ammonium nitrate was broadcast applied to the surface of all plots. The moldboard treatment was then field cultivated. Corn (Dekalb 547) was planted on May 8 at a population of 27700 plants/A with a John Deere Max-Emerge planter equipped with ripple coulters. Starter fertilizer was not used because of the high soil tests. Counter was applied at 1 lb (ai)/A to control rootworms. Weeds were controlled with a preemergence application of Lasso (3-1/2 lb/A) and Bladex (3 lb/A) applied May 11. Weed and insect control were excellent. Percent surface residue was measured on April 2 and averaged 7 and 98% for the MP and NT systems, respectively.

The leaf opposite and below the ear was taken from 10 randomly selected plants per plot at silking (MP = July 30 and NT = August 7) and was analyzed for N. Silage yields were taken at physiological maturity by hand harvesting 40' of row from each plot.

Grain yields were taken by combine from 2 - 45' rows. Tile lines flowed from March 27 to September 8. When tile lines were flowing, flow rates were measured daily and samples taken on a daily basis for the first week and then on a M-W-F basis thereafter for NO_3 analysis. All analyses were done by the Research Analytical Lab.

Soil NO_3-N in the 0-8' profile was determined from two cores/plot taken in 1-foot increments on October 26, 1990.

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[1] Funding provided by the North Central Regional Research Committee (NC-98) and the Southern Experiment Station.

[2] Professor and Asst. Scientist, Southern Experiment Station, Univ. of Minnesota.

RESULTS

Yields, N uptake by the whole plant (silage), and N removal in the grain were all significantly higher for the moldboard plow (MP) system compared to no tillage (NT) (Table 1). This was the fifth year of nine where MP yields were significantly higher. Neither leaf N nor grain N concentration was affected by tillage, however.

Precipitation during the growing season was 6.5" above normal. Consequently, tile flow was substantially higher than in previous years and averaged about 8% higher with NT compared to MP tillage (Table 2). Flow-weighted NO_3-N concentration for the season averaged 10% higher with MP tillage. Thus, NO_3-N losses via the drainage water were not different for the two tillage systems. On an annual basis these NO_3-N losses were the equivalent of 55% of the fertilizer N added. This figure is erroneous, however, because much of the NO_3 lost, especially early in the season, would have come from the residual NO_3 remaining in the soil after the 1989 crop. Much of that residual NO_3 was probably due to carryover of unused fertilizer N in the drier years and soil mineralization especially with MP tillage.

Table 1. Influence of tillage system on corn production and N utilization at Waseca in 1990.

Tillage system	Final population	Leaf N	Silage Yield	Silage N uptake	Grain Yield	Grain N	Grain N removal
	$x10^{-3}$	%	T DM/A	lb N/A	bu/A	%	lb N/A
Moldboard Plow	25.8	2.75	8.61	143.6	146.7	1.45	100.8
No Tillage	25.9	2.62	6.66	92.8	104.8	1.28	63.5
Signif. Level (%):[1]	5	83	99	99	99	82	96
CV (%) :	4.5	3.0	2.5	1.4	4.8	7.5	11.

[1] Probability level of significance.

Table 2. Influence of tillage system on tile flow, flow-weighted NO_3-N concentration and NO_3-N loss in 1990.

Month	Tile Flow	NO_3-N Concentration[1]	NO_3-N Loss
	acre-in	ppm	lb/A
		Moldboard plow	
March	0.01	10.0	0.01
April	0.02	17.4	0.10
May	5.94	28.8	35.71
June	6.70	21.4	30.95
July	2.45	25.3	9.04
August	3.86	30.2	22.35
September	0.17	25.8	1.58
Total	19.14	23.0	99.74
		No tillage	
March	0.06	10.7	0.13
April	0.37	13.0	1.03
May	5.74	20.3	25.65
June	7.83	21.2	36.21
July	2.83	25.6	15.60
August	3.59	22.1	17.50
September	0.24	18.3	1.33
Total	20.66	20.9	97.45

Residual NO_3-N in the soil profile at the end of the 1990 growing season showed about 100 lb/A more N remaining with the MP system (Table 3). The largest differences between the two tillage systems occurred in the 2 to 5' zone where substantially more NO_3 accumulated with MP. These results are similar to previous years except that the greatest difference between the two systems usually occurred in the top 1 to 2 feet.

Table 3. Influence of tillage systems on residual NO_3-N in the soil profile in Oct., 1990.

Profile depth	Tillage System	
	Mb. Plow	No Tillage
feet	- - - - NO_3-N (lb/A)	- - - -
0-1	18.3	13.5
1-2	8.1	6.1
2-3	34.1	8.4
3-4	46.5	23.9
4-5	42.9	29.2
5-6	30.7	21.2
6-7	22.7	16.4
7-8	21.2	15.7
Total (lb NO_3-N/A 0-8')	224.5	134.4

NINE-YEAR SUMMARY

The cumulative totals for the 9-year period (1982-1990) are shown in Table 4. Corn yields over this period have averaged 14.5 bu/A better with moldboard plow tillage. Approximately 16% more N has been removed in the grain with moldboard plow tillage. This has been due to both higher yields and slightly higher grain N concentrations with the moldboard tillage system some years. As a result an equivalent of 51 and 44% of the applied N has been removed in the grain by the MP and NT systems, respectively. Even though total water flow and NO_3-N lost through the tile lines was 9% and 5% higher, respectively, with NT compared to MP tillage, this small difference is considered to be insignificant when considering tile flow variability among the eight plots. The equivalent of 15 to 16% of the fertilizer N applied to these plots has been lost to tile drainage over this 9-year period.

Table 4. Cumulative effects of the two tillage systems over the 9-year period.

Parameter	Tillage System	
	Mb. plow	No tillage
Fert. N applied (lb/A)	1620	1620
Corn grain removed (bu/A)	1232	1102
N removed in grain (lb/A)	825	708
N removed in grain as a percent of applied N (%)	51	44
Tile flow (acre inches)	80.4	87.5
Nitrate-N lost in tile (lb/A)	248.8	260.0
N lost via tile lines as a percent of applied N (%)	15	16

Soil samples were taken in 3- and 6-inch increments to 24" in early November, 1990 and analyzed for total Kjeldahl N. Results shown in Table 5 indicate higher N levels in the top 6 inches with NT, slightly higher N levels in the 6 to 18" layer with MP, and no difference between the tillage systems within the 18 to 24-inch depth. Assuming a bulk density of 1.2 g/cc in the 0-6" depth, 1.25 g/cc in the 6-12" depth, and 1.35 g/cc in the 12-18" depth, we found 178 pounds more soil N in the NT system than in the MP system. This amount accounts for most of the difference shown between the two tillage systems in Table 4.

Table 5. Total N in the 0-24" soil layer as affected by tillage systems.

Depth	Tillage	
	MP	NT
inches	- - - - - - %	- - - - - - - -
0-3	.242	.288
3-6	.248	.258
6-12	.222	.212
12-18	.148	.142
18-24	.082	.082

NITRATE LOSSES TO TILE DRAINAGE AS AFFECTED BY NITROGEN FERTILIZATION OF CORN IN A CORN-SOYBEAN ROTATION[1]

Waseca, 1990

Gyles W. Randall, Gary L. Malzer and Brian W. Anderson[2]

ABSTRACT: A study to determine the influence of time of N application and N-Serve on the uptake of N by corn and the loss of NO_3 to tile drainage was continued in 1990. Results from this fourth year showed significant yield improvement over the control with all N treatments, but no significant differences among the four primary application time/method treatments. Tile lines flowed from late April through late August. Tile flow averaged 11.45" for corn and 14.73" for soybeans. Nitrate-N concentrations and losses were higher for corn than for soybeans. Highest NO_3-N losses in the corn plots occurred with the fall application of N without N-Serve while the highest losses under soybeans occurred with spring application to the previous corn crop. Nitrate-N concentrations and losses from continuous fallow plots that had received neither fertilizer N nor a planted crop for four years were twice that from the fertilized corn. This was due to high levels of NO_3 throughout the 8-foot profile as a result of soil mineralization and no crop uptake.

Nitrogen (N) losses to tile drainage water have been directly linked to N additions, crop grown, and soil organic matter level. Research has been conducted on NO_3 losses to tile water in Minnesota since 1972. This research has focused primarily on the effects of rates and timing of fertilizer N application and tillage in a continuous corn system. The purpose of this study is to determine the influence of time of N application and the use of a nitrification inhibitor on NO_3 movement and accumulation in the soil, NO_3 losses via tile drainage, and yield and N uptake by corn grown in a rotation with soybeans.

EXPERIMENTAL PROCEDURES

Thirty-six individual tile line plots were installed on a poorly drained Webster clay loam at the Southern Experiment Station in 1976. Each 20 x 30' plot is completely surrounded by plastic sheeting to a depth of 6' to prevent lateral flow and contains a tile line (4' deep) 5 feet from one end. All tiles drain to collection pits where flow rates can be measured and water samples collected for analyses. After completing a research project in 1983 using this tile facility, the plots were cropped to corn with a blanket N rate in 1984 and 1985 to establish uniformity.

Beginning in 1986 corn was planted on one-half of the experimental site while soybeans were planted on the other half. Thirty two plots (16 with corn and 16 with soybeans) with the most uniform drainage were selected from the 36 for the primary study. The experimental design consists of a 4 x 4 Latin square where the rows and columns were based on the previous (1977-83) tile flow rates from each plot. The four basic N treatments (see Table 1) are applied to the corn phase each year with the residual effects measured in the soybean phase. Three additional N treatments were replicated four times around the edge of the core 16-tile-plot area and were planted to corn. These three treatments were analyzed along with the other four as a completely randomized design.

Anhydrous ammonia was applied at a rate of 135 lb/A for all N treatments while N-Serve was applied at 0.5 lb/A. Fall treatments were applied on October 25. Average soil temperature at the 4" depth on that date was 60°F with an average of 49°F over the following 10-day period. Spring preplant treatments were applied on May 4. The sidedress portion (60%) of the split treatments was applied at the V-9 stage on July 2.

The soybean area that was planted to corn in 1990 was field cultivated once before planting. The corn area, however, was fall chiseled and field cultivated once prior to planting soybeans. Surface residue accumulation estimated by the line-transect method on April 2 showed an average of 40 and 69% for the areas that were planted to corn and soybeans, respectively, in 1989. Because of high soil P and K tests, no broadcast nor starter fertilizer was used.

Corn (Pioneer 3737) was planted at 30,200 plants/acre on May 18 with a JD Max-Emerge planter equipped with waffle coulters. A corn rootworm insecticide was not used. Weeds were chemically controlled with a preemergence application of Lasso (3.5 lb/A) plus Bladex (3 lb/A).

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[1]. Partial funding provided by Dow Chemical U.S.A., Minnesota Agric. Exp. Stn., and Center for Agric. Impacts on Water Quality.

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Soybeans (Hardin) were planted in 30" rows at 9 beans per foot of row on May 31. Weeds were chemically controlled with a preemergence application of Lasso (3-1/2 lb/A) plus Amiben (3 lb/A). Pursuit (imazethapyr) was applied on June 18 at 0.06 lb/A plus 0.25% v/v X-77 to plots 1, 5, 6, 11, 12, 13, 15, & 16.

Two plots within each of the corn and soybean areas were not planted and were fallowed all summer. These four fallow plot areas were located on those tile plots that showed greatest water flow variability (1977-83). The purposes of these plots were to simply check the NO_3-N concentrations in the tile water in a fallow system and to utilize all 36 of the tiled plots, even though these four historically showed the highest flow variability.

Stand counts were taken at the V-5 stage and plots were thinned to a uniform population. Eight randomly selected plants were removed from the center rows at silk initiation (July 30) and were chopped, dried, weighed and ground for total dry matter accumulation and analyzed for total N concentration. Stover and grain samples were taken at physiological maturity by hand harvesting 30' of row for stover yields and 60' of row for grain yields and moisture. Chemical analyses of whole plant, stover and grain samples were performed by the Research Analytical Laboratory, University of Minnesota. Tile line flow rates were determined daily and were recorded when flow exceeded 10 ml/minute (0.01"/day). Samples were collected for NO_3-N analysis on an every-other-day basis. Periodic samples were collected for alachlor (Lasso), cyanazine (Bladex), and imazethapyr (Pursuit) analyses.

Soil samples for NO_3-N analysis were taken in 1-foot increments to a depth of 8 feet from the fallow plots and selected corn and soybean plots on April 18. The same technique was used to sample all fallow and corn plots and selected soybean plots on October 26.

RESULTS AND DISCUSSION

Plant

Whole plant N concentration at the silking stage was not affected by any of the N treatments (Table 1). This is in contrast to 1989 probably because of very favorable conditions for mineralization that released adequate amounts of soil N to the control plots in 1990. Dry matter accumulation was unaffected by time/method of N treatment. Although stover N concentration of the control was lowest, the 135-lb N treatments did not result in significantly (P = 90% level) higher concentrations at physiological maturity (PM). Stover yield at PM was higher than the control for all N treatments with no difference among the four primary time/method treatments. Final population was not significantly different among the N treatments.

Table 1. Influence of time of N application and N-Serve on whole plant N, stover yield, and final population of corn following soybeans.

N application		Whole Plant Silk stage		Stover		Final
Time	N-Serve	N %	DM g/plt	N %	Yield TDM/A	Population ppA x 10^{-3}
Primary trts						
Fall (Oct.)	No	1.76	90	.50	2.36	28.8
Fall (Oct.)	Yes	1.74	103	.51	2.54	28.0
Spr. (April)	No	1.78	86	.48	2.44	28.2
Split[1]	No	1.75	99	.52	2.49	28.0
Additional trts						
Check	-	1.64	79	.44	1.83	28.6
Spr. (April)	Yes	1.69	104	.56	2.55	28.3
Split[1]	Yes	1.82	94	.56	2.47	28.7
		Statistical Analysis				
Latin square (Primary Trts)						
Signif. Level (%):		6	45	12	15	36
CV (%) :		6.4	19.	12.	13.	3.1
Completely randomized (7 trts)						
Signif. Level (%):		17	74	83	96	17
BLSD (.05) :		-	-	-	.52	-
CV (%) :		10.	16.	13.	13.	3.3

[1] 40% preplant + 60% sidedress.

Grain and silage yields were increased significantly over the check (0 lb N/A) by all of the N treatments (Table 2). The 9.0 bu/A difference among the four primary time/method treatments was not significant at the P = 90% level. Grain moisture at harvest was significantly higher (P = 94% level) for the check compared to the N treatments with no difference among the four primary time/method treatments. Grain N concentration and N removal in the grain were increased over the 0-lb N check by all of the N treatments but was not different among the four primary treatments. Total N uptake was increased almost two-fold over the 0-lb N check by all of the N treatments. Although not statistically significant (P = 90% level), a consistent trend of lower N efficiency was noted with the fall N application without N-Serve.

Total N removal in the grain ranged from 92.1 to 101.8 lb/A for the six N treatments (Table 2). Based on these removal amounts, N efficiency (N removed by a treatment - N removed in the check ÷ 135 lb N/A) ranged from 31 to 38% for the six N treatments. Nitrogen efficiency based on total plant uptake ranged from 36 to 48% for the six N treatments. These efficiency values are slightly less than in 1989.

Total N uptake by the plants receiving fertilizer N prior to silking (Fodder N yield at silking) divided by total N uptake at PM shows that from 75 to 86% of the N was accumulated by the plants prior to silking (Table 3). NEW N in the grain (assumed to be taken up by the plant after silking and translocated to the grain) ranged from -31% in the check treatment to between 14 and 25% for all treatments receiving fertilizer N. Under the 1990 conditions there was no affect of time/method of N application on post-silk (NEW N) N uptake into the grain.

Table 2. Corn grain and silage production as influenced by time of N application and N-Serve.

N application		Grain					Total N
Time	N-Serve	Yield	H_2O	N	N removal	Silage	uptake
		bu/A	%	%	lb/A	TDM/A	lb/A
Primary trts							
Fall (Oct.)	No	146.1	29.2	1.33	92.1	6.33	115.7
Fall (Oct.)	Yes	146.0	29.6	1.44	99.0	6.51	124.9
Spr. (April)	No	142.2	26.6	1.44	96.5	6.31	120.0
Split[1]	No	151.2	28.2	1.42	101.3	6.59	127.1
Additional trts							
Check	-	107.5	32.4	.98	50.3	4.76	66.4
Spr. (April)	Yes	158.0	27.8	1.36	101.8	6.84	130.9
Split[1]	Yes	147.5	27.7	1.40	97.9	6.47	125.3
Statistical Analysis							
Latin square (Primary trts)							
Signif. Level (%) :		52	56	80	88	21	71
CV (%) :		5.2	9.4	5.0	4.8	7.2	6.6
Completely randomized (7 trts)							
Signif. Level (%):		99	94	99	99	99	99
BLSD (.05) :		13.3	-	.12	10.6	.75	15.8
CV (%) :		6.7	8.3	6.6	8.5	8.2	9.9

[1] 40% preplant + 60% sidedress

Water

Weather conditions during the 1990 growing season were slightly warmer than normal but were 6.5" wetter than normal. Rainfall during May through August totaled 8.33" above normal. This resulted in tile flow from April 27 through August 30. Tile drainage volumes shown in Table 4 indicate highest flows in May and June. Drainage from the 16 corn plots averaged 11.45 with a 4.03" range among the four time/method treatments. Soybeans showed greater tile drainage compared to corn with an average of 14.73" from the 16 plots but only a range of 1.71" among the four time/methods. Ideally, drainage should be uniform among the time/method treatments because crop growth was not different; however, normal soil and drainage variability exists in these plots and results in these unfortunate differences.

Monthly flow-weighted NO_3-N concentrations were markedly higher for corn compared to soybeans throughout the year (Table 5).

Table 3. Influence of time of N application and N-Serve on time of N uptake.

N application		Fodder N Yield at[1]		Grain N Yield at PM			
Time	N-Serve	Silk	PM	Total	OLD[2]	NEW[3]	NEW[3]
		- - - - - - - - - -		-lb N/A	- - - - - - - - - - - -		%
Primary trts							
Fall (Oct)	No	99.5	23.6	92.1	75.9	16.2	18
Fall (Oct)	Yes	110.9	25.8	99.0	85.0	14.0	14
Spr (April)	No	95.2	23.5	96.5	71.8	24.7	25
Split[4]	No	107.0	25.8	101.3	81.2	20.1	20
Additional trts							
Check	-	82.8	16.1	50.3	66.7	-16.4	-31
Spr (April)	Yes	110.5	29.0	101.8	81.5	20.3	19
Split[4]	Yes	109.4	27.4	97.9	82.0	15.9	17
			Statistical Analysis				
Latin square (Primary trts)							
Signif. Level (%):		27	22	88	19	11	12
CV (%)	:	21.	18.	4.8	26.	112.	109.
Completely randomized (7 trts)							
Signif. Level (%):		44	97	99	11	85	98
BLSD (.05)	:	-	8.3	10.6	-	-	35
CV (%)	:	22.	20.	8.5	28.	151.	182.

[1] Silk = Silk stage, PM = physiological maturity.
[2] OLD N = N in stover at silk -- N in stover at PM; the difference is assumed to be translocated to the grain.
[3] NEW N = Total N in grain -- Old N; the difference is assumed to be absorbed from the soil and/or translocated from the roots after silking.
[4] 40% preplant + 60% sidedress.

Fall application of N without N-Serve to corn resulted in consistently higher NO_3-N concentrations compared to the inclusion of N-Serve. However, both fall treatments gave higher NO_3-N concentrations than the spring or split treatments. An opposite trend occurred under soybeans where N had been applied in either October, 1988 or spring 1989 for the 1989 corn crop. In this case, lowest and highest NO_3-N concentrations were associated with the fall and spring treatments, respectively. Nitrate-N concentrations under a 4-yr continuous fallow system (no fertilizer N applied) were approximately 2X and 3X higher than for corn and soybeans, respectively.

Under corn, substantially higher NO_3-N losses occurred with the fall treatment without N-Serve (Table 6). This was due to both higher tile flow and NO_3-N concentration. Little difference was observed among the NO_3-N losses from the fall + N-Serve, spring, and split treatments. Interestingly, NO_3-N losses under soybeans were lowest for the fall N treatments that were applied for the 1989 corn crop compared to the spring-applied treatments. Very high NO_3-N losses occurred under the fallow system where the mineralization of the soil organic matter was the nitrate source. This emphasizes the importance of growing a crop to absorb N released from these high organic matter soils.

Table 4. Tile water discharge from the corn, soybean, and fallow plots in 1990.

N application		Month					Year
Time	N-Serve	April	May	June	July	August	Total
		acre-inches					
		CORN					
Fall (Oct.)	No	0.00	4.61	5.66	0.73	2.93	13.93
Fall (Oct.)	Yes	0.03	3.51	3.71	0.58	2.47	10.30
Spr. (April)	No	0.00	3.48	3.48	0.60	2.34	9.90
Split	No	0.08	3.90	4.68	0.85	2.16	11.67
		SOYBEANS					
Fall (Oct.)[1]	No	0.05	5.44	5.78	1.37	2.45	15.09
Fall (Oct.)[1]	Yes	0.00	4.72	6.15	1.23	2.27	14.37
Spr. (April)[1]	No	0.01	4.33	6.18	1.26	2.10	13.88
Split[1]	No	0.00	4.92	6.22	1.62	2.83	15.59
		FALLOW					
NONE		0.05	4.26	4.34	1.23	1.81	11.69

[1] N applied for the 1989 corn crop.

Table 5. Flow-weighted NO_3-N concentrations for each month from the corn, soybean, and fallow plots in 1990.

N application		Month					Year
Time	N-Serve	April	May	June	July	August	Total
		mg NO_3-N/L					
		CORN					
Fall (Oct.)	No	-	36.3	38.4	40.6	25.0	34.7
Fall (Oct.)	Yes	38.3	29.9	33.8	37.5	18.8	29.5
Spr. (April)	No	-	28.7	29.6	32.1	19.8	26.9
Split	No	25.0	28.0	29.0	28.1	23.2	27.8
		SOYBEANS					
Fall (Oct.)[1]	No	21.9	15.4	17.1	19.2	12.3	15.1
Fall (Oct.)[1]	Yes	-	17.6	19.5	29.4	13.1	19.0
Spr. (April)[1]	No	16.2	21.3	23.4	28.3	15.3	22.3
Split[1]	No	-	18.8	21.3	21.7	14.2	18.4
		FALLOW					
NONE		42.8	69.8	62.6	57.6	47.4	56.6

[1] N applied for the 1989 corn crop.

Table 6. Nitrate-N loss for each month from the corn, soybean and fallow plots in 1990.

N application		Month					Year
Time	N-Serve	April	May	June	July	August	Total
		lb NO_3-N/A					
		CORN					
Fall (Oct.)	No	0.00	37.68	48.54	6.86	16.25	109.33
Fall (Oct.)	Yes	0.26	23.55	29.70	4.84	10.41	68.76
Spr. (April)	No	0.00	23.40	22.12	4.29	10.53	60.34
Split	No	0.44	25.24	31.02	5.36	11.45	73.51
		SOYBEANS					
Fall (Oct.)[1]	No	0.30	18.58	21.29	5.12	6.40	51.69
Fall (Oct.)[1]	Yes	0.00	18.65	28.05	7.90	7.08	61.68
Spr. (April)[1]	No	0.03	21.66	32.97	7.68	7.78	70.12
Split[1]	No	0.00	20.50	28.91	6.87	8.76	65.04
		FALLOW					
NONE		0.50	61.94	54.66	14.74	18.12	149.96

[1] N applied for the 1989 corn crop.

Nitrate-N losses to the tile drainage water were normalized to tile water flow to minimize the influence of water flow volume among the N treatments on the interpretation of the data (Table 7). Normalized values show highest losses for fall-applied N without N-Serve to corn. Spring applications showed slightly less loss than fall N + N-Serve. On the other hand, fall applications without N-Serve to corn in the year ahead of the soybeans resulted in lower NO_3-N losses compared to the spring and fall with N-Serve applications. Nitrate-N losses for the corn-soybean system were highest for the fall application without N-Serve and lowest for the split application. Additional years with adequate drainage losses are necessary to determine if these findings are consistent over time.

Table 7. "Flow-normalized" NO_3-N losses to tile drainage in a corn-soybean sequence in 1990.

Crop[1] System	Time/Method of N Application: Fall No N-Serve	Fall N-Serve	Spring No N-Serve	Split No N-Serve
	NO_3-N Lost (lb/A/inch of drainage)			
Corn	7.85	6.67	6.09	6.35
Soybean	3.41	4.29	5.06	4.17
C-Sb System	5.54	5.28	5.49	5.10

[1] Continuous fallow (4 years without fertilizer N) = 12.8

Soil

Nitrate-N remaining in the 0-8′ soil profile in mid-April was very high in the fallow plots (429 lb/A) compared to those where either soybeans or corn were grown in 1989 (Table 8). Soybeans that had not received fall-applied N averaged 98 lb/A with 69 lb/A remaining in the top 5′. Very low amounts of residual NO_3-N remained in the 0-8′ profile when corn receiving no N fertilizer was the previous crop (54 lb/A). Residual NO_3-N remaining from the 1989 crop was increased by 30 to 60 lb/A with the previous fall, spring preplant, and split applications. Distribution of NO_3 within the profile was consistently very high to 8′ with the fallow system compared to high levels only in the top one foot following soybeans and unfertilized corn. Corn receiving N showed increased levels of NO_3 down to the 4′ depth.

Table 8. Nitrate-N in the soil profile in April, 1990 as influenced by previous crop and N treatment for corn in 1989.

Profile depth	1989 Crop					
			Corn[1]			
	Fallow	Soybean	0 lb N	Fall	Preplant	Split
	lb/A[2]					
0-1	77.1	25.8	20.5	22.3	25.4	25.6
1-2	74.2	9.5	5.4	16.3	23.6	12.3
2-3	67.2	12.6	4.7	10.4	15.6	12.3
3-4	59.8	10.6	4.7	9.3	13.8	13.5
4-5	55.8	10.3	4.0	7.3	13.5	8.4
5-6	39.0	11.2	4.8	6.8	8.7	7.3
6-7	31.4	10.3	5.0	6.3	7.2	6.9
7-8	24.2	8.0	5.1	7.7	6.0	5.6
Total in						
0-5′ profile	334.1	68.8	39.3	65.8	91.9	72.1
0-8′ profile	428.7	98.3	54.2	86.6	113.8	91.9

[1] These fall, spring preplant and split treatments all received N-Serve.
[2] Average of 4 replications

A comparison of the residual NO_3 amounts found in April, 1990 (Table 8) with those amounts found in the same plots in October, 1989, shows the spring NO_3 levels to be approximately the same as in the previous fall for the plots that did not receive fertilizer N (fallow and 0-lb rate). Results from the plots that received N were mixed with the fall and spring preplant applications showing 41 and 22% less soil NO_3 (0-8′), respectively, while 27% more was found in the spring with the split treatment.

Residual NO_3-N remaining in the 0 to 5′ profile after the 1990 season shows approximately the same amount of nitrate as after the 1989 season except in the fallow treatment (Table 9). Approximately 25% less nitrate remained in the fallow plots compared to 1989. However, more nitrate was found in the 5 to 8′ zone for all treatments in 1990. Higher amounts of nitrate were found consistently in the top 5′ with the N-Serve treatments. The reason for these differences is not clear but may be highly related to the excessive amount of precipitation in 1990. Differences among the time of N application were not shown. A comparison between the amount of NO_3-N in the 0 to 5′ profile of the fallow plots this fall with that in the spring (Table 8) shows 69 lb less NO_3N in the fall. Nitrate-N losses through the tile totaled 150 lb/A (Table 6). Thus at least 80 lb of NO_3-N was added to the 0 to 5′ system due to soil mineralization during the growing season.

Table 9. Residual NO-N remaining in the 0-8′ soil profile after harvest as influenced by time of N application and N-Serve.

Profile depth			Application Time					
			N-Serve			No N-Serve		
	Fallow	Check	Fall	Preplant	Split	Fall	Preplant	Split
	lbs NO_3-N/A[1]							
0-1	62.8	27.3	29.7	39.2	38.0	31.2	28.8	33.2
1-2	30.3	5.7	7.3	6.8	9.3	9.8	5.1	11.3
2-3	47.3	3.9	4.7	6.9	9.2	2.6	3.9	9.6
3-4	69.0	4.3	20.2	16.1	17.2	11.4	9.8	10.6
4-5	55.4	6.0	26.7	20.2	19.6	18.4	14.6	11.6
5-6	46.5	7.5	18.2	16.1	17.1	32.5	16.4	33.3
6-7	36.1	7.3	13.7	12.1	13.0	18.3	11.8	14.0
7-8	29.8	6.0	13.1	12.3	10.0	16.4	11.5	10.4
Total in								
0-5′ profile	265	47	89	89	93	73	62	76
0-8′ profile	377	68	134	130	133	141	102	134

[1] Avg. of 4 replications

CONCLUSIONS

The warm and wet conditions resulted in good corn production and excellent tile drainage. Corn production was greatly improved by the various N treatments over the control. However, differences among the time/methods of N application were not generally significant. Tile flow was higher for soybeans while NO_3-N concentrations and NO_3-N losses were higher for corn compared to soybeans. Fall application of N without N-Serve to corn showed highest NO_3 losses while losses in the "residual year" when soybeans were grown were highest for the spring application. Continuous fallowing (no N for four years) resulted in NO_3-N losses 2X to 3X as high as when either corn or soybeans were grown. These data indicate the importance of growing a crop to utilize the N mineralized from these high organic matter soils.

IMPACT OF NITROGEN AND TILLAGE MANAGEMENT PRACTICES ON CORN YIELD AND POTENTIAL GROUNDWATER CONTAMINATION IN SOUTHEASTERN MINNESOTA[1]

Center for Agricultural Impacts on Water Quality
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ABSTRACT: Studies are being conducted on the silt loam soils of southeastern Minnesota to evaluate specific N and tillage practices for their role in providing profitability (BENEFIT) while minimizing NO_3 occurrences in the water below the root zone (RISK). In general, continuous corn yields were optimized at N rates from 100 to 150 lb N/A. Corn yields were not improved with split or sidedress N applications. No tillage resulted in lower yields at two sites and lower nitrate-N concentrations in the soil water at all three sites. Yields from the residual manure treatments (manure applied in 1987 and 1988) were significantly lower than the fertilized plots due to plant use of N in 1989 and leaching of nitrate out of the root zone in 1990. High rainfall amounts leached nitrate that had accumulated in the top five feet in the last 3 years to the 7.5′ depth at two sites. When profitability was highest, NO_3-N concentrations in the lysimeter water at 5′ averaged between 25 and 30 mg/L.

Current agricultural production systems are being linked closely to the occurrence of agricultural chemicals in the groundwater. This concern is especially prevalent in southeastern Minnesota where agriculture is quite intensive and the soils are rather shallow over a fractured limestone and sandstone bedrock geology (karst). The purposes of these studies are to: (1) determine the cause and effect relationship of specific N and tillage management practices on corn production and NO_3 and pesticide accumulation/movement through the soil and (2) identify best management practices that minimize groundwater contamination while maintaining economic profitability.

EXPERIMENTAL PROCEDURES

Three sites were continued for the 1990 studies. The primary site with the most intensive investigation is being conducted in Olmsted Co. on the Lawler Farm. The other sites are in Goodhue Co. on the Foss Farm and in Winona Co. on the Kalmes Farm.

Olmsted County - Lawler Farm

In April of 1986 a 6.5 acre site of Port Byron soil was identified on the Richard Lawler and Sons Farm approximately 6 miles east of Rochester. A very comprehensive field history for the last 7 years was provided. Corn was grown in 1986. No herbicides and no nitrogen (N) fertilizer were applied to the corn which was cultivated three times.

Nitrogen Study

A randomized, complete-block with four replications was established in the fall of 1986 and was continued in 1990. Ten N treatments including both anhydrous ammonia and manure were established for a total of 40 plots (Table 1). Each plot was 30′ wide and 65′ long. The fall N treatments were applied on November 13, 1989. Spring N fertilizer treatments were applied on May 2 and again on July 5, 1990. Liquid hog manure was not applied in 1989 or 1990. All plots except the no-till treatment were disked on May 3.

Corn (Pioneer 3751) was planted on May 24 at 30,200 plants/A. Lasso (3 lb/A) and Bladex (2.5 lb/A) were applied preemergence. Force was applied in the furrow at a rate of 8 oz/1000′ of row to control rootworms. All chisel plow plots were cultivated on July 6.

Whole plants were harvested from selected rows at silking, were weighed, dried, ground and analyzed for total N to determine pre-silk N uptake. Stover yields were taken from 20′ of row at physiological maturity (Oct. 10). Grain yields and moisture were determined by combine harvesting two rows, each 60′ long on Oct. 19. All samples were weighed, dried, ground and analyzed for total N.

Soil samples were obtained from each plot on April 20 and Nov. 6 by taking two 2-inch cores in 1-foot increments to the bedrock and then compositing the cores from each increment. The samples were forced-air, oven-dried at 120°F, ground and analyzed for inorganic N (NH_4-N and NO_3-N).

[1] Funding provided by the Legislative Commission on Minnesota Resources, Center for Agricultural Impacts on Water Quality, and the Minnesota Agricultural Experiment Station.

Suction lysimeters installed in 1987 at the 5 and 7.5-foot depths in each plot were used to extract soil water from these depths to measure NO_3 concentrations in the soil water. Samples were collected on May 3, June 6, July 5, August 2, and September 5.

Pesticide Study

An area adjacent to the N study was established in the fall of 1986 to accommodate a study to evaluate the movement of Lasso, atrazine, Banvel, and Counter through the soil profile as influenced by four tillage systems. The four tillage treatments (moldboard plow, chisel plow, ridge tillage, and no tillage) were initiated in November, 1986. Nitrogen was applied on May 2 at a rate of 180 lb N/A as anhydrous ammonia. All other planting operations were the same as in the N study. The herbicides were applied using specialized plot equipment. Potassium bromide was broadcast-applied to a 15-foot section of each plot. The Br serves as a tracer to which pesticide movement can be compared. The corn was cultivated on July 6 with the ridge plots being ridged at that time.

Each plot was intensively soil sampled throughout the season to monitor herbicide movement. Stainless steel suction lysimeters installed at 5' and 7.5' depths were used to extract soil water. Grain and stover yields were taken at physiological maturity (PM).

Goodhue County - Foss Farm

In May of 1986 an area of 5.1 acres of Port Byron soil was identified on the Selmer Foss and Sons (James Foss) farm in Goodhue County. A good field history was provided for the past 6 years. Corn was grown in 1986 and received a minimal amount of N (75 lb N/A) because it was in continuous corn. Weeds were controlled with 4 lb atrazine/A. Due to wet conditions no primary tillage was performed in the fall of 1986.

A randomized, complete-block design with 4 replications was established at this site in April, 1987 and was continued in 1990. Sixteen N treatments all consisting of anhydrous ammonia applied to chiseled and no-till plots were established. Each of the 64 plots measures 30' wide and 65' long. Chisel plowing was done with a John Deere Mulch Tiller on November 14, 1989. Anhydrous ammonia was applied preplant on May 29. All chisel plots were disked on May 29.

Corn (Pioneer 3751) was planted at 30,200 plants/A on May 30. Prowl (1.5 lb/A) and Bladex (2.5 lb/A) was applied at 2 leaf stage (June 6). Force (8 oz/1000 ft) was applied to control corn rootworms. The chisel plowed plots were cultivated to remove weeds and volunteer corn. Sidedress applications of N as anhydrous ammonia were applied at the 5-leaf stage (June 27) and 7 to 8-leaf stage (July 5).

Plant sampling procedures at silking and at PM were essentially the same as at the Olmsted Co. site. Soil sampling to the 8-foot depth on May 2 and November 14 was accomplished using the same procedures as in Olmsted Co. Suction lysimeters installed in six treatments (24 plots) to a 5' depth in 1987 were sampled on May 8, June 8, July 5, Aug. 2, Aug. 31 and Nov. 1 to determine the NO_3 and pesticide concentrations in the extracted soil water.

Winona County - Kalmes Farm

A 3.0 acre contour strip of Seaton soil was identified in early April, 1987. This farm is owned by Eugene Kalmes and son, Robert Kalmes. A field history was provided for the last 4 years. Corn was grown in 1986 and received 70 lb N/A and 2 lb atrazine/A. Alfalfa was grown in 1983-85 and received manure in the fall of 1985.

A randomized, complete-block design with 4 replications was established at this site in mid-April, 1987 and was continued in 1990. Twelve N treatments were established for a total of 48 plots. Each plot measures 20' wide by 65' long.

Fall chiseling was conducted on November 13, 1989. The preplant anhydrous ammonia treatments were applied on May 7. A field cultivator was used as secondary tillage just prior to planting.

Corn (Pioneer 3751) was planted at 30,200 plants/A on May 24. Lasso (3 lb/A) and Bladex (2.5 lb/A) were applied preemergence. Force (8 oz/1000') was used to control corn rootworms. The chisel plowed plots were cultivated to remove weeds. Sidedress applications of N as anhydrous ammonia were applied at the 6-leaf stage (June 27) and the 8 to 9-leaf stage (July 5).

Whole plant and soil sampling procedures were identical to those used in Olmsted Co. Grain yields were taken by hand harvesting two rows each 40' long at physiological maturity (October 9). Stainless steel and PVC suction lysimeters were installed in 1987 at the 5' depth in six treatments (24 plots). PVC suction lysimeters were installed in 1988 at the 5' depth in three additional treatments and at the 7.5' depth in

six treatments. These were sampled on May 7, June 6, July 5, Aug. 2, Sept. 5 and Nov. 15 to determine NO_3 and pesticide concentrations in the extracted soil water.

RESULTS AND DISCUSSION

Olmsted County

Corn grain yields in 1990 were increased significantly by the fertilizer N treatments (Table 1). The addition of 75 lb N/A increased yield by 69 bu/A resulting in very high fertilizer N efficiency. The 150-lb N rate applied preplant (PP) gave the optimum yield among the fertilizer treatments. Although the yields for the fall-applied treatments were not statistically lower (P=95% level) than the spring preplant 150-lb treatment, the 7 to 10 bu/A depression put the fall treatments at an economic disadvantage. Split application of N resulted in the same yield as the single preplant application. This was the first year in four where the no tillage plots yielded less than chisel tillage. Yields from the two manure treatments were significantly less than the fertilizer treatments because no manure had been applied since April, 1988. Under the high rainfall conditions in 1990, the corn suffered from N deficiency early in the season because the residual NO_3 from the manure had been leached below the top three feet. The corn recovered somewhat in August when the roots moved down into a higher zone of nitrate accumulation; hence yields that were 30 to 45 bu better than the control. Average 4-year yields showed greatest economic return to the 150-lb PP application with no advantage to higher rates, fall application, or split treatments.

Nitrate-N concentrations in the soil water extracted from the 5-foot depth were correlated linearly with the spring-N rate (Table 1). Concentrations below 15 mg/L were found only with the 0 and 75-lb N rates, but economical return was also considerably less with the treatments. Contrary to 1989, fall applications of N, regardless of the inclusion of N-Serve, showed much higher NO_3-N concentrations than the spring preplant applications. For the first time in four years no tillage had nitrate-N concentrations about 30% lower than the similar 150-lb rate applied to chisel tillage. Perhaps the no tillage system had reached an equilibrium and mineralization was reduced compared to annual chiseling. Due to no manure applied in 1989 or 1990 and the high precipitation in May-July, nitrate-N concentrations at the 5' depth were greatly reduced for the two manure treatments. However, leaching from the 5-foot depth caused the concentrations to escalate markedly at the 7.5-foot depth. It should be cautioned that these 5 and 7.5-foot NO_3-N concentrations may not represent the concentrations entering the aquifer because of dilution; however, they do provide an indication as to the potential environmental contribution and ranking of the treatments.

Table 1. Effect of N treatments on the 1990 corn yields and NO_3-N concentrations in the water at 5' in Olmsted Co.

Treatment				Grain Yield		Nitrate-N[3] Conc. in Water	
No.	Tillage	N rate	Time/Method	1990	1987-90	5'	7.5'
		lb N/A		bu/A		mg/L	
1	Chisel	0	—	76.0	83.6	1	2
2	Chisel	75	Spr., preplant	144.8	155.5	11	8
3	Chisel	150	Spr., preplant	154.9	172.5	29	18
4	Chisel	225	Spr., preplant	156.4	167.1	43	42
5	Chisel	150	Fall, post tillage	145.0	169.4	43	-
6	Chisel	150+NI[1]	Fall, post tillage	147.6	169.1	50	-
7	Chisel	150-Split	50% Spr., preplant 50% SD, 8-leaf	154.2	168.4	47	-
8	No Tillage	150	Spr., preplant	139.6	168.0	20	-
9	Chisel	315[2]	Spr., disked in	108.0	165.9	15	23
10	Chisel	490[2]	Spr., disked in	122.0	168.4	25	49
Significance level (%):				99			
BLSD (.05) :				14.3			
CV (%) :				8.0			

[1] N-Serve
[2] Liquid swine manure was applied annually at an average rate of 6050 and 9200 gal/A, respectively, in 1987 and 1988. No manure was applied in 1989 or 1990. Total N rates were 315 and 490 lb N/A/yr or approximately 175 and 265 lb "available" N/A/yr.
[3] September 5, 1990.

Corn yields in the pesticide study were quite variable and thus statistical differences among treatments were not found (Table 2). However, similar to the 4-year average, yields were highest with the moldboard and chisel treatments and lowest with no tillage.

Table 2. Effect of tillage treatments on the 1990 corn yields in Olmsted Co.

Tillage	Grain Yield 1990	1987-90 Avg.
	bu/A	
Moldboard plow	150.7	168.2
Chisel plow	147.2	164.4
Ridge till	140.6	155.7
No tillage	136.2	152.1
Significance level (%):	57	
BLSD (.05) :	-	
CV (%) :	9.0	

Goodhue Co.

Grain yields were increased significantly over the control (both chisel and no tillage) by all of the N treatments (Table 3). Yields were optimized with the 150-lb spring PP treatment. The highest yield, although not statistically speaking, was obtained with the split 100 + 50-lb treatment. Yields with no tillage were consistently less, and at some N rates were significantly less than with chisel tillage. None of the split and sidedress treatments enhanced yields over the spring PP anhydrous applications. Benefits were not obtained by including N-Serve with the anhydrous ammonia.

Four-year average grain yields also show: (1) optimum N rate to be between 100 and 150 lb/A, (2) no improvement in yield with either split or sidedress N application, and (3) slightly lower yields at all N rates with no tillage compared to chiseling.

Nitrate-N concentrations in the soil water extracted from the 5-foot depth on Aug. 31 related closely to N rate applied (Table 3). Similar to Olmsted Co., NO_3-N concentrations were consistently less with no tillage. Highest nitrate-N concentrations occurred with the 150-lb rate sidedress applied at the 6-leaf stage.

Table 3. Corn yield and NO_3-N concentration in the soil water at 5' as affected by N treatments in Goodhue Co. in 1990.

Treatment				Grain Yield		Nitrate-N[3] Conc. in Water at 5'
No.	Tillage[1]	N rate	Time/Method	1990	1987-90	
		lb N/A		------- bu/A -----		mg/L
1	Chisel	0	-------	96.4	89.4	6
2	Chisel	50	Spr., preplant (PP)	125.2	128.6	-
3	Chisel	100	Spr., preplant (PP)	134.6	143.4	22
4	Chisel	150	Spr., preplant (PP)	142.4	146.9	39
5	Chisel	200	Spr., preplant (PP)	144.1	147.5	-
6	No tillage	0	-------	88.1	77.4	-
7	No tillage	100	Spr., preplant (PP)	120.2	137.2	17
8	No tillage	150	Spr., preplant (PP)	121.0	141.4	28
9	No tillage	200	Spr., preplant (PP)	126.4	140.0	-
10	Chisel	50+50	Spr. PP + SD 9-lf	142.6	142.4	-
11	Chisel	50+100	Spr. PP + SD 9-lf	141.4	145.6	-
12	Chisel	100+50	Spr. PP + SD 9-lf	146.6	148.2	-
13	Chisel	100	SD 6-lf	134.8	140.0	-
14	Chisel	150	SD 6-lf	143.7	146.2	62
15	Chisel	150+NI[2]	Spr. PP	144.9	150.3	-
16	Chisel	150+NI	SD 6-lf	137.3	145.3	-
Significance level (%):				99		
BLSD (.05) :				17.4		
CV (%) :				9.8		

[1] Chiseling was done in Nov., 1989
[2] NI = N-Serve
[3] Aug. 31, 1990

Winona Co.

Corn grain yields were improved over the 0-lb control by over 55 bu/A with all of the N treatments (Table 4). Yields were optimized by the 100-lb N rate applied preplant. Higher rates of N and split or sidedress applications showed no additional yield advantage. No difference was observed between the two tillage systems.

Four-year average yields show: (1) no difference between the two tillage systems, (2) no advantage for the split and sidedress applications, and (3) a very slight but inconsistent response to fertilizer N at rates greater than 50 lb/A at this site which was in alfalfa from 1983-85. Nitrate-N concentrations in the soil water at 5' after four years of experimentation still are at 13 mg/L where no N has been used. Concentrations ranged between 22 and 64 mg NO_3-N/L for the treatments that received fertilizer N, with a positive relationship to N rate. Nitrate-N concentrations were slightly lower with no tillage. The very high nitrate-N concentration with the split-applied treatment is similar to the results found in Olmsted and Goodhue Counties. Leaching conditions early in the summer apparently contributed to the nitrate-N concentrations at 7.5' being markedly higher than in 1989. These high values throughout the profile must be a result of the previous alfalfa crop which received manure in 1985 and the very dry conditions in 1988 that severely limited yields and N uptake by the crop.

Table 4. Effect of N treatments on the corn grain yield and NO_3-N concentrations in the soil water at 5' and 7.5' in Winona County in 1990.

Treatment				Grain Yield		Nitrate-N[2] Conc. in Water	
No.	Tillage[1]	N rate	Time/Method	1990	1987-90	5'	7.5'
		lb N/A		------- bu/A ------		---- mg/L ---	
1	Chisel	0	--------	117.2	126.7	13*	-
2	Chisel	50	Spr., preplant	173.7	153.1		-
3	Chisel	100	Spr., preplant	178.1	155.7	30	40*
4	Chisel	150	Spr., preplant	181.9	157.8	34*	36*
5	Chisel	200	Spr., preplant	187.6	163.0	63	74*
6	No tillage	0	--------	116.9	128.0	-	-
7	No tillage	100	Spr., preplant	178.6	155.8	22	-
8	No tillage	150	Spr., preplant	182.0	151.8	-	32
9	No tillage	200	Spr., preplant	184.7	155.8	49	40
10	Chisel	50+50	Spr. PP + SD 9-lf	179.1	156.7	-	-
11	Chisel	50+100	Spr. PP + SD 9-lf	184.9	160.2	64	59
12	Chisel	150	SD 6-lf	180.8	152.0	-	-
	Significance level (%):			99			
	BLSD (.05) :			12.8			
	CV (%) :			5.8			

[1] Chiseling was done in November, 1989
[2] Sept. 5, 1990
* - Average of only two samples

SUMMARY

The following summarizes the yield results from the fourth year of these studies:

1) N rates for continuous corn were optimized at between 100 and 150 lb/A at all three sites.
2) No apparent yield advantages were found with split or sidedress applications of N at any of the three sites. Yet, nitrate-N concentrations in the soil water were consistently higher.
3) Yields at two of the sites were lower with no tillage. However, nitrate-N concentrations in the soil water were also lower at all three sites with no tillage.
4) High precipitation and leaching conditions from May-July resulted in lower nitrate-N concentrations in the soil water at the 5-foot depth but increased concentrations at the 7.5-foot depth at the two locations where suction lysimeters are at both depths. Nitrate-N concentrations related very closely to rate of N application.
5) Previous crop and manure history apparently still impacts corn yield and N management at the Winona Co. site.
6) The role of alfalfa and manure contributions to available N for succeeding corn crops needs to be carefully examined and understood before improved N management is a reality on these soils.
7) Nitrate-N concentrations in the soil water at 5' (below the root zone) provide a good basis upon which to compare the environmental risks associated with various N management systems.

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This interdisciplinary investigation would not have been possible without the fine cooperation and dedication of the farmer-cooperators and the participation of the Soil Conservation Service and the Minnesota Extension Service. Sincere appreciation is also extended to the Minnesota Valley Testing Lab who graciously conducted the manure analysis in previous years.

SUPPLEMENTAL APPLICATION OF N TO CORN AFTER HEAVY SPRING RAINFALL[1]

1990

G. W. Randall and B. W. Anderson[2]

ABSTRACT: This was a one-year study conducted because of the high amounts of rainfall that occurred during May and June. The purpose was to determine if a supplemental, sidedress application of N was beneficial to continuous corn where various N rates had already been preplant-applied. Highest grain and silage yields, grain N concentration, N removal and recovery in the grain, and profit were obtained with the 150-lb rate of preplant-applied N. Sidedress application of 50 lb N/A enhanced yields, N concentrations, and profit when the preplant N rates were insufficient (0 and 75 lb/A) but not at the 150-lb rate on this somewhat poorly drained soil. This is not to say that sidedress N applications did not enhance yields and profitability under soil conditions where N losses due to either leaching or denitrification were more severe.

Split and sidedress applications of N are often recommended to maximize N efficiency under high-loss conditions such as irrigated, coarse-textured, sandy soils. These applications are also often suggested on medium and fine-textured soils even though most Minnesota research does not support these "advantages". Because of very high rainfall amounts in May and June in 1990 (11.99 inches, 3.75" above normal), a study was conducted to determine if a sidedress application of 50 lb N/A as anhydrous ammonia (AA) would be beneficial to continuous corn where preplant applications of AA had been preplant-applied.

Experimental Procedures

A factorial design consisting of three preplant N rates (0, 75 and 150 lb N/A) and two sidedress N rates (0 and 50 lb/A) was replicated four times on a Nicollet clay loam (Aquic Hapludoll). The previous crop was corn which had been moldboard plowed in October, 1989. Anhydrous ammonia was preplant applied on May 4 just prior to field cultivation. Corn (Pioneer 3737) was planted on May 8 at 28,420 plants/acre. Lasso (3.5 lb/A) plus Bladex (3.0 lb/A) was applied preemergence on May 11. All plots were cultivated once in mid June. Weed control was excellent.

Supplemental N was applied at 50 lb/A as AA to one half of the plots when corn was in the V7-V8 stage (July 2). Earleaf samples were taken on July 30. Silage yields were taken by hand-harvesting 15' of row on Sept. 27. Grain yield and moisture were obtained on October 4 by combine harvesting the center two rows of each 4-row plot.

Results and Discussion

Main factor analyses showed that leaf N concentration was increased significantly (P=99% level) by both the preplant N rate and the sidedress N treatment (Table 1). However, the preplant x sidedress interaction was highly significant, which indicates that the sidedress N treatment increased leaf N concentration only at the two lower preplant N rates. Sufficient N was available with the 150-lb preplant rate so that sidedressing an additional 50 lb did not increase leaf N. It is noteworthy that leaf N responded this quickly to sidedress N applications made only 28 days before sampling.

Grain yield was increased by both the preplant N treatments and the sidedress treatment (Table 1). The highly significant interaction between preplant and sidedress treatments, however, indicates that yields were only increased by the sidedress treatment when insufficient amounts of N (0 and 75 lb/A) had been preplant applied. Adding an additional 50 lb N/A to the 150-lb preplant AA treatment did not increase yield on this somewhat poorly drained soil even under these high soil moisture conditions. Perhaps a yield increase would have been obtained <u>if</u>: 1) the N had been fall-applied or applied earlier in the spring, 2) a source of N had been used that was more susceptible to N loss under these moist conditions, or 3) the soil would have been very well drained (to promote leaching) or very poorly drained where more denitrification would have been expected.

Grain moisture at harvest was reduced by both the preplant and supplemental N additions. Grain N concentration was increased significantly by the preplant rates but not by the supplemental N.

Fodder N yield was increased by the sidedress N treatment applied to the 0-lb preplant treatment but not to the 75 and 150-lb preplant treatments (Table 1). On the other hand, fodder N concentration was reduced by

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[1] Funding supported by the Southern Experiment Station.

[2] Professor and Assistant Scientist at the Southern Experiment Station.

the sidedress application of N to the 0 and 75-lb preplant N rates. This was probably due to greater translocation of N from the stalk to the grain in these treatments where the combined total rate of N was limiting. Similar to grain yield, silage yields were not increased with the supplemental N addition when the preplant N rate was sufficient (150 lb N/A).

Table 1. Grain yield, silage yield, and N concentrations in the plant as affected by N rate and time of application at Waseca in 1990.

N rate/time	Earleaf	Grain			Fodder		Silage
	N	H_2O	Yield	N	Yield	N	Yield
lb/A	%	%	bu/A	%	T DM/A	%	T DM/A
0 PP + 0 SD	1.88	26.7	94.4	1.18	2.07	0.40	5.14
0 PP + 50 SD	2.70	23.9	115.4	1.19	2.46	0.36	6.29
75 PP + 0 SD	2.60	22.5	136.0	1.23	2.93	0.50	7.13
75 PP + 50 SD	2.82	20.5	153.9	1.33	2.67	0.42	7.29
150 PP + 0 SD	2.86	21.2	162.6	1.40	3.16	0.50	8.23
150 PP + 50 SD	2.90	21.1	161.0	1.40	3.08	0.55	7.90
Preplant N rate (lb/A)							
0	2.29	25.3	104.9	1.18	2.27	0.38	5.71
75	2.71	21.5	145.0	1.28	2.81	0.46	7.21
150	2.88	21.1	161.8	1.40	3.12	0.52	8.06
Signif. Level (%):	99	99	99	99	99	99	99
BLSD (.05) :	0.08	1.1	6.5	0.05	0.18	0.05	0.38
Sidedress N rate (lb/A)							
0	2.45	23.4	131.0	1.27	2.72	0.46	6.83
50	2.81	21.8	143.4	1.31	2.75	0.44	7.16
Signif. Level (%):	99	99	99	89	27	73	94
PP rate x SD rate Interaction							
Signif. Level (%):	99	93	99	86	99	96	99
CV (%) :	3.3	4.8	4.9	4.0	6.6	10	5.6

Table 2. N removal in the grain, total N uptake, apparent N recovery, and production economics as influenced by N rate and time of application.

N rate/time	N removal in grain	Total N uptake	N recovery in[1] grain	N recovery in[1] silage	Cost of[2] treatment	Return to[3] fertilizer	
lb/A	lb/A	lb/A	%	%	$/A	$/A	$/lb of N
0 PP + 0 SD	52.7	69.2	--	--	0	-	-
0 PP + 50 SD	65.0	82.9	25	27	10.50	36.75	0.74
75 PP + 0 SD	79.3	108.6	35	52	9.00	84.60	1.13
75 PP + 50 SD	97.0	119.5	35	40	13.50	120.38	0.96
150 PP + 0 SD	108.0	139.5	37	47	18.00	135.45	0.90
150 PP + 50 SD	106.9	140.5	27	36	22.50	127.35	0.64
Preplant N rate (lb/A)							
0	58.9	76.0					
75	88.2	114.1					
150	107.4	140.0					
Signif. Level (%):	99	99					
BLSD (.05) :	6.1	6.3					
Sidedress N rate (lb/A)							
0	80.0	105.8					
50	89.6	114.3					
Signif. Level (%):	99	99					
PP x SD rate interaction							
Signif. Level (%):	98	84					
CV (%) :	7.4	5.9					

[1] (N removed in grain or taken up in silage - N removed or taken up by the check treatment) : N application rate
[2] Based on N = 12¢/lb and $4.50 for SD application
[3] Based on corn at $2.25/bu.

Nitrogen removal in the grain and total N uptake (silage) were both increased significantly by the preplant and sidedress treatments (Table 2). However, N removal in the grain was not increased when the supplemental N was applied to the 150-lb N treatment. Nitrogen recovery as a percent of the N applied was highest for the 150-lb preplant N treatment. Sidedress application of N did not enhance N recovery either in the grain or in the total above-ground plant (silage).

Economic return was highest with the 150-lb preplant N rate (Table 2). Sidedress application of 50-lb N increased economic return when the preplant N rates were insufficient (0 & 75 lb/A) but not when the 150-lb preplant rate was applied. Highest return per pound of fertilizer N applied was at the 75-lb preplant rate.

N CREDITS FOR MANURE AND ALFALFA

J. A. Lory, G. W. Randall and M. P. Russelle[1]

ABSTRACT: Applications of fertilizer-N to corn can be reduced the first year following a manure application or when the corn crop follows alfalfa in rotation. The objective of this study is to determine first and second year N credits for these two sources of organic-N. In this first year there was no yield response of corn following alfalfa to applications of fertilizer-N or manure at Rosemount and Waseca, MN. Continuous corn yield at the highest fertilizer-N rate was equivalent to the yield of first year corn in rotation with alfalfa. Manure-N availability was predicted based on 25% of the organic-N in the manure being available in the first year after application. The manure N credit for continuous corn closely matched the predicted manure-N availability at Rosemount, whereas the manure N credit at Waseca was 55% of that predicted.

Many dairy farmers apply manure to alfalfa in the spring before they plow down an old stand. This practice is not recommended because it causes an oversupply of N, but the prevalence of the practice requires that we investigate the fate of the excess N. The first objective of this study is to assess the impact of manure on the alfalfa N-credit. Portions of the manure and alfalfa N will not be available to a corn crop until the second and third year after incorporation. Consequently, this study will determine N credits for first and second year corn grown after: (i) previous alfalfa, (ii) spring-applied dairy manure on previous corn, and (iii) spring-applied dairy manure on previous alfalfa. The second objective is to compare the impact of over-application of fertilizer-N and manure-N on soil inorganic-N levels in both continuous corn and alfalfa-corn rotations.

Materials and Methods

Experimental plots were located on a Webster clay loam at the Southern Experiment Station, Waseca, MN and on a Port Byron silt loam at Agronomy Hill, Rosemount Experiment Station, Rosemount, MN.

Plot history

The plots were established in spring of 1988 in a randomized, split-block design with 4 replicates at Waseca and 3 replicates at Rosemount. At both Waseca and Rosemount, portions of established stands of alfalfa were moldboard plowed to establish the corn portion of a alfalfa-corn rotation. The alfalfa was maintained in other blocks. Blazer alfalfa had been seeded in April, 1984 at Waseca and Pioneer 532 alfalfa had been seeded in fall 1985 after oats at Rosemount. Alfalfa was managed for hay production on a 3-cut system, and corn was managed for grain production. Corn plots were chisel plowed at Waseca in fall 1988 and 1989 and plots were chisel plowed in spring 1989 at Rosemount. Fertility levels of P and K, and pH were maintained at or above Minnesota soil test recommendations. At Waseca 0 and 100 lb N/A were applied in spring 1988 and 1989, respectively; at Rosemount, 0 and 30 lb N/A were applied in spring 1988 and 1989, respectively.

Procedures

In spring 1990, before planting corn on all plots, 8 treatments were applied randomly to each previous crop block. Treatments in previous corn were 0 N (control); 60, 100, 140 and 180 lb N/A as urea; and 3000, 7000 and 11,000 gal dairy manure per acre. First year corn following alfalfa treatments were: 0 N (control); 30, 60, 100, and 140 lb N/A as urea; and 3000, 5000, and 7000 gal/A dairy manure per acre. Liquid dairy manure was obtained from the Southern Experiment Station dairy and the Richard Fox farm near Rosemount, MN. These manure sources provided about 18 lb available N/1000 gal at Waseca, and 11 lb available N/1000 gal at Rosemount, based on 25% of the organic N being available the first year. Manure was surface-applied on April 26 at Waseca and April 23 at Rosemount. All plot areas were moldboard plowed, incorporating the manure within 45 min. of application. Urea was surface-applied preplant and disk incorporated.

At Waseca Pioneer 3751 was planted May 29 at 28,400 seeds/A and the stand was thinned to 26,300 plants/A on July 9. To control corn rootworms, Force insecticide (8.7 lb/A actual rate) was applied over the row at planting. Weeds were controlled with a preemergence application of Lasso (3.5 lb/A) and Bladex (3 lb/A). At Rosemount Pioneer 3751 was planted on May 3 at 26,000 seeds/A. To control corn rootworm, Counter (10 lb/A actual rate) was applied over the row at planting. Lasso and Bladex (2 lb/A each) were applied preemergence to control weeds. Atrazine (2 lb/A) was applied May 15 to reduce quackgrass growth.

Plots were harvested October 2 at Waseca and September 29 at Rosemount. Grain and stover dry matter samples were harvested from 40 and 20 ft. of row, respectively. Plant samples were dried at 60°C and ground in preparation for total-N analysis.

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Soil samples were taken from each main plot (previous crop) in the spring before applying treatments, and from all treatments in the fall after corn harvest. At Waseca, two 2" dia. cores were taken per plot to a minimum depth of 4 ft and maximum depth of 8 ft, divided into 1 ft increments and combined by depth. At Rosemount, three 2" dia. cores were taken per plot to a depth of 8 ft, divided into 1 ft increments and combined by depth. The 2" cores were not taken within 10 ft of other sampling points. At Rosemount 1" dia. soil cores to a depth of 3 ft were also taken from selected plots on June 21. All soil samples were dried at 40°C, ground to pass through a 2-mm screen, and analyzed for NO_3 and NH_4.

Results and Discussion

First year corn grain and silage yields following alfalfa did not respond to applications of fertilizer-N or dairy manure at Rosemount and Waseca (Tables 1 and 2). Application of manure or urea significantly increased N uptake of corn following alfalfa at both sites. Continuous corn dry matter yield and N-uptake responded to both manure and fertilizer-N applications.

Dairy manure N credits for continuous corn, based on continuous corn grain yield response to fertilizer-N, are presented in Table 3. Continuous corn may have responded to higher rates of manure at both sites. Manure N was 55% less available than predicted at Waseca. The manure at Rosemount had a relatively low N content.

These results emphasize that first-year corn following alfalfa typically does not respond to N applications in the southeast region of Minnesota.

Table 1. Effect of previous crop, dairy manure, and urea-N on corn yield and N uptake at Rosemount, MN in 1990.

Previous crop	N source	Rate	Grain Yield	Grain N uptake	Silage Yield	Silage N uptake
			bu/A	lb/A	T DM/A	lb/A
Alfalfa	Urea	0 lb/A	214	141	9.49	190
		30	211	150	9.49	206
		60	223	155	9.70	213
		100	218	164	9.70	230
		140	223	167	9.75	234
	Manure	3000 gal/A	210	147	9.31	200
		5000	221	163	9.80	226
		7000	216	153	9.50	216
P>F			0.5	0.04	0.6	0.01
CV(%)			4.3	5.9	3.4	5.3
Corn	Urea	0 lb/A	172	99	7.32	131
		60	190	116	8.32	151
		100	203	138	9.18	187
		140	209	153	9.44	206
		180	218	162	9.80	221
	Manure	3000 gal/A	186	112	8.28	149
		7000	194	127	8.82	169
		11000	197	133	8.66	172
P>F			0.01	0.01	0.01	0.01
CV (%)			3.4	4.9	2.8	6.4