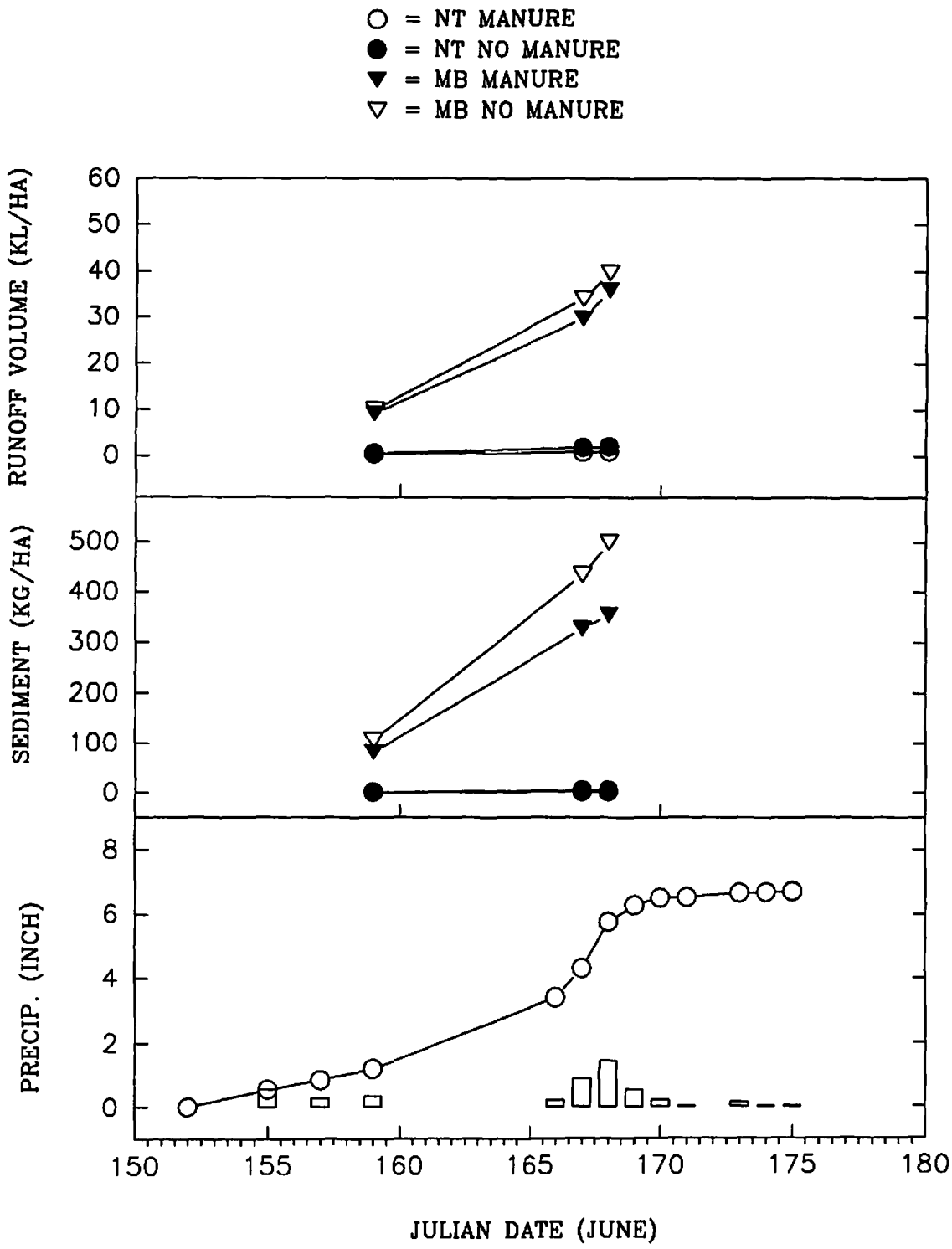


FIG. 2. CUMULATIVE SEDIMENT AND RUNOFF VOLUME AND PRECIPITATION OVER TIME AT MORRIS EXPERIMENTAL STATION, MORRIS, MN (JUNE, 1992).

THE IMPACT OF POTASH FERTILIZATION, TILLAGE SYSTEM AND CORN HYBRID ON CORN YIELD IN WEST-CENTRAL MINNESOTA

George Rehm, Sam Evans, and George Nelson[1/]

ABSTRACT: This study was conducted at the West-Central Experiment Station at Morris to further evaluate the interactions among tillage system, corn hybrid, and potash fertilization on corn yield. Yields were significantly affected by all variables. There were significant interactions between tillage system and hybrid as well as between tillage system and placement of potash fertilization. Yield was not affected by hybrid when the chisel plow and moldboard plow planting systems were used. The highest yield was associated with the Pioneer 3737 hybrid when the ridge-till and no-till planting systems were used. The placement of potash fertilizer had a significant effect on yield when corn was planted with the no-till and ridge-till planting systems.

The problem of potassium (K) deficiencies in corn planted with ridge-till and no-till planting systems was recognized in 1989. Since that time, several studies have been conducted to evaluate the impact of rate of applied potash and hybrid selection on this problem. There was also a continuing need to further evaluate the effect of potash placement on corn response to applied potash.

Objective:

Recognizing the questions cited above, this study was conducted to evaluate the effect of potash fertilization tillage system, and hybrid selection on corn production in West-Central Minnesota.

Experimental Procedure:

This study was conducted at the West-Central Experiment Station at Morris. The experimental area had been used for a number of years to compare the impact of four tillage systems on the yield of continuous corn. The tillage systems were retained for this study. Four potash treatments (control, 200 lb. 7-21-7/acre, 40 lb. K_2O banded to a depth of 3-4 inches into the old row, 80 lb. K_2O/acre broadcast in the fall) were applied to two corn hybrids (Pioneer 3737, Pioneer 3732). A split plot arrangement was used with four replications. The tillage systems were the main plots. The potash treatments and corn hybrids were the split plots.

The banded and broadcast treatments were applied in late October in 1991. The fall plow and chisel plow tillage operations were completed immediately after the fall fertilizer application. Corn was planted in early May. A starter (10-34-0) was used for the treatments where potash was not applied in the starter at planting. Other management practices conducive to optimum corn production in the region were used. Grain yields were measured in October and corrected to 15.5% moisture.

Results and Discussion:

Grain yields are summarized in Table 1. Yield was significantly affected by tillage, potassium treatment and hybrid. The interaction between tillage system and hybrid was also highly significant. Yields of both hybrids were nearly equal in the moldboard plow and chisel plow systems. However, yields were significantly higher for Pioneer 3737 when the ridge-till and no-till planting systems were used.

There was also a highly significant interaction between tillage system and the potassium treatment. The response to applied potash was much greater when the ridge-till and no-till planting systems were used.

When averaged over both hybrids and all potassium treatments, highest yields were produced by the moldboard plow system. The use of the no-till system produced the lowest yield. Yields from the other two systems were intermediate.

When averaged over tillage system and hybrid, the banded application of potash in the fall of 1991 produced the highest yield. Yields from other potash placements were lower and nearly equal. The lowest yield was associated with the control treatment.

[1/] Extension Soil Scientist, St. Paul; Professor, and Junior Scientist, West-Central Experiment Station, respectively.

Table 1. Corn yield in West-Central Minnesota as affected by tillage system, potash fertilization and hybrid.

Tillage System	K_2O Treatment	Hybrid: Pioneer 3732	Hybrid: Pioneer 3737
		- - - - - bu./acre	- - - - - -
Fall Chisel	control	86.8	91.3
	200 lb. 7-21-7/A starter	92.1	80.2
	40 lb. K_2O/A fall band	91.2	89.5
	80 lb. K_2O/A fall bdcst	89.8	85.5
	starter + fall band	98.3	89.4
Ridge-Till	control	63.7	91.5
	200 lb. 7-21-7/A starter	85.0	84.7
	40 lb. K_2O/A fall band	92.3	97.5
	80 lb. K_2O/A fall bdcst	85.1	94.3
	starter + fall band	87.3	91.5
Fall Plow	control	104.4	101.4
	200 lb. 7-21-7/A starter	111.6	106.6
	40 lb. K_2O/A fall band	112.8	104.8
	80 lb. K_2O/A fall bdcst	112.3	107.6
	starter + fall band	108.6	106.0
No-Till	control	76.4	62.8
	200 lb. 7-21-7/A starter	69.5	63.1
	40 lb. K_2O/A fall band	80.0	76.4
	80 lb. K_2O/A fall bdcst	72.1	67.5
	starter + band	78.5	60.5

POTASSIUM FERTILIZATION OF ALFALFA GROWN ON AN IRRIGATED SANDY SOIL

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

ABSTRACT: There was a need to evaluate potassium requirements for alfalfa grown on an irrigated sandy soil. Five rates of plowdown K_2O (0, 80, 160, 240, 320 lb./acre) were combined with 5 rates of annual K_2O (0, 60, 120, 180, 240 lb./acre) in a complete factorial design. Three cuttings were harvested in 1992. Neither plowdown nor annual rate of K_2O had a significant effect on alfalfa yield in 1992. The soil test value for K is low (63 ppm). The yield data does not provide an explanation for the lack of response. This study will be continued in 1993.

In recent years, some have questioned the potash recommendation for alfalfa currently used by the University of Minnesota. Alfalfa is a heavy user of potassium (K) and removal rates are high. High yielding alfalfa can remove over 300 lb. K per acre. Stand longevity is also important for alfalfa production in north-central Minnesota. So, adequate potash fertilization is necessary for optimum production as well as stand longevity.

Objective:

This study was established to evaluate the effect of both plowdown and annual applications of potash applied at several rates on alfalfa yield and stand longevity.

Experimental Procedure:

This study was initiated at the Irrigation Center at Staples in late summer of 1990. Soil samples were collected prior to seeding and the results are summarized in Table 1.

Table 1. Relevant soil test properties for the experimental site.

pH	6.5
P (Bray & Kurtz) #1, ppm	43
K, ppm	63

Plowdown rates of K_2O (0, 80, 160, 240, 320 lb. K_2O/acre) were combined with annual rates (0, 60, 120, 180, 240 lb. K_2O/acre) in a complete factorial design with four replications. A split-plot arrangement of treatments was used. The plowdown rates of K_2O were the main plots. The annual rates of K_2O were the split plots. The K_2O was supplied as 0-0-60 in all cases.

The research site was planted to oats in the spring of 1990. The oats stubble was disced following grain harvest and lime as well as the plowdown rates of K_2O were applied at this time. Sulfur applied at a rate of 50 lb. S/acre as granular gypsum was also incorporated over the entire plot area at this time.

Alfalfa (Profit variety) was seeded at a rate of 16 lb. per acre on August 9, 1990. Irrigation water was applied as needed to insure a good stand and adequate growth before winter. The established stand was excellent.

The annual rates of K_2O were topdressed to the established stand in early spring of 1991 and 1992. Each year, the alfalfa in all plots was topdressed with 50 lb. S/acre supplied as granular gypsum. Three cuttings were harvested each year. Whole plant samples were collected from each plot at each harvest and analyzed for K. Soil samples (0-6 inches) were taken from each plot in the fall of both 1991 and 1992. These samples were analyzed for K.

Results and Discussion:

The total dry matter yields for the 1992 growing season are summarized in Table 2. Plant uptake and soil test data are not summarized at this time. Statistical analysis of the data shows that neither rate of plowdown K_2O nor rate of K_2O applied on an annual basis had a significant effect on alfalfa yield in 1992.

[1/] Extension Soil Scientist, Junior Scientist, and Assistant Scientist, respectively.

These results are consistent with the results obtained in 1991, the first year of production. With the low soil test for K (63 ppm), a response to potash fertilizer would be expected. There is no easy explanation for the lack of response. It is possible that some K is applied with the irrigation and some is probably supplied from the subsoil. The data available do not provide an explanation for the lack of response.

Table 2. The effect of plowdown and annual rates of K_2O on yield of alfalfa grown on an irrigated sandy soil.

Plowdown K_2O	Cutting	Annual Rate (lb. K_2O/acre) 0	60	120	180	240
lb./acre		ton dry matter/acre				
0	1	1.77	1.86	1.73	1.85	1.79
	2	1.08	1.07	1.10	1.20	1.16
	3	1.69	1.39	1.61	1.88	1.77
	Total:	4.53	4.33	4.43	4.93	4.72
80	1	1.90	1.82	1.84	1.76	1.82
	2	1.20	1.16	1.19	1.22	1.18
	3	1.78	1.79	1.62	1.75	1.49
	Total:	4.87	4.77	4.64	4.72	4.49
160	1	1.67	1.62	1.53	1.81	1.65
	2	1.20	1.26	1.17	1.27	1.27
	3	1.83	1.97	1.67	1.81	1.84
	Total:	4.70	4.85	4.38	4.88	4.75
240	1	1.94	1.90	1.83	1.82	1.84
	2	1.14	1.20	1.11	1.20	1.15
	3	1.62	1.63	1.91	1.76	1.71
	Total:	4.69	4.73	4.85	4.78	4.70
320	1	1.85	1.75	2.14	1.92	1.89
	2	1.11	1.10	1.26	1.20	1.24
	3	1.57	1.56	1.94	1.83	1.88
	Total	4.53	4.40	5.34	4.95	5.01

ESTABLISHMENT OF FORAGE LEGUMES ON SANDY SOILS IN NORTH-CENTRAL MINNESOTA

George Rehm, Dan Schmitz, Andy Scobbie, Craig Sheaffer, and Neal Martin[1/]

ABSTRACT: This study was conducted in both 1991 and 1992 to evaluate the effect of various methods of establishment on yield of legumes in the year of establishment and subsequent production years. The 1992 yield of legumes established in 1991 was affected by both the legume and the method of establishment that was used. The same was true for legumes seeded in 1992. The method of establishment also had a significant effect on the density of stand measured in early September. This study will be continued in 1993.

There are legumes other than alfalfa that are adapted to the climate and soils of North-Central Minnesota. These legumes may be used for either pasture or hay production. As with alfalfa, establishment of an acceptable stand is a major problem in the region. Therefore, this study is being conducted to evaluate the effect of various methods of establishment. Four legumes (alfalfa, birdsfoot trefoil, cicer milkvetch, red clover) are involved.

Experimental Procedure:

This study was initiated at the Irrigation Center at Staples in 1991 and repeated at an adjacent location at the Center in 1992. Prior to seeding, adequate rates of lime, phosphate, potash, and sulfur were broadcast and incorporated with a disk. The experimental area was disked and packed prior to seeding.

Five establishment methods were evaluated. These are described below.

A. Clean Seedbed: With this method, Balan herbicide was applied at a rate of 3 quarts per acre at 2 weeks before seeding and incorporated with a rototiller. The Balan restricts the growth of grassy weeds as well as volunteer small grain. The legumes were seeded into the prepared seedbed.

B. Conventional: Oats is used as a companion or nurse crop. Oats was seeded into a prepared seedbed approximately 2 weeks before the seeding of the legumes. The legumes are then seeded into the emerging oats crop. The oats was harvested as oatlage when it reached the milk to soft dough stage of development.

C. Companion Oats Plus Herbicide: The sequence of seeding oats and legumes is identical to that used for method B described above. The oats was killed when 10-15 inches tall by spraying with Poast (1.5 pint/acre) plus Dash (1 qt./acre).

D. Lake Summer Companion Crop: For this method, oats was planted in early spring and allowed to mature and the grain was harvested. A new seed bed was prepared by rototilling the stubble. A second oats crop was planted in late July. The legumes were seeded into the emerging oats in early August. Freezing temperatures in the fall kill the established oats.

E. No-Till Establishment: The legumes were seeded into existing stubble in early August. The initial oats crop was planted in early spring, allowed to mature, and was harvested for grain.

In the year of establishment, legumes were harvested when growth appeared to be adequate. Late harvest was avoided so that the possibility of winter-kill would be reduced.

The legumes established in 1991 were harvested in 1992. Three cuttings of alfalfa were taken. The other legumes were harvested twice. One 1992 harvest was taken for all legumes established using methods A, B, and C in 1992.

Adequate fertilizer and lime was applied in both years of the study. Both experimental sites were irrigated as needed to prevent moisture stress in both 1991 and 1992.

The stand density for each legume in all establishment methods at both sites was measured in early September, 1992. For this measurement, plants were dug from a 3 ft^2 area and the number of plants in that area was counted.

[1/] Extension Soil Scientist, Junior Scientist, Assistant Scientist, Professor, and Extension Specialist-Forage Crops, respectively.

Results and Discussion:

The 1992 yields of the legumes seeded in 1991 are summarized in Table 1. Total forage produced during the 1992 growing season was significantly affected by both legume and establishment method. There was also a highly significant interaction between legume and method of establishment.

Considering the legumes, the alfalfa and red clover produced the largest amounts of dry matter. Even though there were 3 cuttings of alfalfa and two of red clover, total yields for these 2 legumes were not statistically different. The cicer milkvetch produced the lowest amount of dry matter while birdsfoot trefoil yields were intermediate.

Table 1. The effect of method of establishment on 1992 yields of legumes established in 1991.

Legume	Cutting	Method of Establishment				
		A	B	C	D	E
		- - - - - - - - - - - - ton dry matter/acre - - - - - - - - - - - -				
alfalfa	1	3.06	2.65	2.55	1.31	1.80
	2	1.60	1.61	1.53	1.25	1.37
	3	1.44	1.33	1.54	1.09	1.29
	Total:	6.10	5.59	5.62	3.65	4.46
birdsfoot trefoil	1	2.57	2.27	2.34	1.04	1.72
	2	1.86	1.98	1.95	2.02	2.06
	Total:	4.43	4.25	4.29	3.06	3.78
cicer milkvetch	1	1.87	.62	.84	.15	.25
	2	1.99	1.17	1.55	.90	1.19
	Total:	3.86	1.79	2.39	1.05	1.44
red clover	1	2.89	2.66	2.81	2.24	2.68
	2	2.33	2.44	2.60	2.24	2.50
	Total:	5.22	5.10	5.41	4.48	5.18

When averaged over all legumes, highest yields were associated with the clean seedbed method of establishment. Yields decreased significantly and progressively when methods B, C, D, and E were used. The 1992 yields from the methods that involved late summer seeding were substantially lower than yields from methods that utilized the early spring seeding. It's obvious that competition from the nurse or companion crop reduced the 1992 yield. There should be less competition from the oats if method C is compared to method B. Except for alfalfa, forage yields were higher for method C.

The 1992 yields for the legumes established in 1992 are summarized in Table 2. These yields were measured in early September. The yield of each legume (one cutting only) was significantly affected by method of establishment. Highest yields were recorded when no companion/nurse crop was used (Method A). Lowest yields were associated with the conventional method of establishment (Method B). The yields resulting form the use of method C were intermediate.

Table 2. Effect of method of establishment on the 1992 yields of legumes seeded in 1992.

Legume	Method of Establishment		
	A	B	C
	- - - ton dry matter/acre - - -		
alfalfa	1.79	1.16	1.82
birdsfoot trefoil	1.38	.83	1.41
cicer milkvetch	1.24	.84	1.29
red clover	2.09	1.42	1.94

The stand densities measured in September for legumes seeded in 1991 and 1992 are summarized in Tables 3 and 4, respectively. For the 1991 seeding, density was significantly affected by both legume used and the method of establishment. There was, however, no significant interaction between these two factors.

For the 1991 seeding, stand density for all legumes was highest when the August seeding was made into emerging oats. The competition of the oats crop did not reduce the measured stand of alfalfa, birdsfoot trefoil, and red clover. The early season protection provided by the oats increased the stand of cicer milkvetch. The measured stand of cicer milkvetch was especially improved by the late summer seeding.

Table 3. The effect of establishment method used in 1991 on measured legume stand density in September 1992.

Legume	Method of Establishment				
	A	B	C	D	E
	plants/3 ft^2				
alfalfa	41	41	43	57	36
birdsfoot trefoil	28	27	30	49	37
cicer milkvetch	18	15	25	49	46
red clover	28	27	30	39	36

The measured stand from the 1992 seeding was significantly affected by both legume and method of establishment. There was no significant interaction between these two factors.

Except for the birdsfoot trefoil, measured stands were increased substantially by the late summer seeding (methods D, E). The competition from the oats crop had a mixed effect on the stands resulting from the use of methods A, B, and C. These legumes have not been subjected to the stress of winter and stands may be different in 1993.

Table 4. The effect of establishment method used in 1992 on measured legume stand density in September 1992.

Legume	Method of Establishment				
	A	B	C	D	E
	plants/3 ft^2				
alfalfa	56	55	37	70	89
birdsfoot trefoil	30	27	37	28	39
cicer milkvetch	35	54	33	63	66
red clover	55	55	67	87	82

TILLAGE AND ROW CULTIVATION EFFECTS ON RESIDUE MANAGEMENT, STAND ESTABLISHMENT, CORN PHENOLOGY, AND N AVAILABILITY TO IRRIGATED CORN [1]

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

This study is designed to evaluate tillage and row cultivation on the N available to third year corn following alfalfa. Tillage and cultivation affected stand establishment and emergence rate. Corn grown under conservation tillage systems required more N than with a moldboard plowing system. The cultivation response by corn interacted with tillage system. Cultivation increased corn growth and N uptake most under no till conditions but also with moldboard plowing. Corn that was planted into spring discing plots resulted in a smaller increase in growth and N uptake when cultivated. This is consistent with previous years.

The objective of this study is to evaluate the effect of full width tillage and row cultivation in June on the amount of nitrogen available to corn from alfalfa. Alfalfa was killed with herbicide in the spring of 1990 and planted to corn. This is the third and final year of a three year study. The experimental design is a randomized complete block with split plots and four replications. Tillage main plots are split with four nitrogen rate subplots. Tillage systems established in the spring were: moldboard with plow packer, discing twice, and no tillage. All plots received 17 pounds per acre of urea as starter fertilizer at planting. Nitrogen was broadcast applied as urea in two equal applications at the 4-6 and 8-12 leaf growth stage of corn (table 1). Urea was irrigated in to prevent volatilization losses. Irrigation amounts and timing are presented in table 5. Thirty six pounds per acre of additional nitrogen was applied during the season with 5.99 inches of irrigation water. The resulting N rates (starter, broadcast, and irrigation water) are 53, 113, 193, and 273 pounds per acre.

Soil cover by corn residue was measured in (6" centered over the row) and between the row (the remaining 24") before and after planting but before cultivation. Corn emergence was also monitored in the same location as soil cover measurements in adjacent 10' rows at two places in each plot. These data are shown in table 2a and 2b.

Only the no till soil cover data is shown in table 2a. There was a significant but small affect of N rate on soil cover. Cultivation in 1991 reduced soil cover in the row 18%. Soil cover between the row was only reduced 6% due to the ridges left from the 1991 cultivation. The clearing discs on the planter reduced the "in row" cover from 81% and 99% before planting to 63% and 78% after planting for the cultivation and no cultivation treatments respectively in the no till plots. The ridge that was created in 1991 during cultivation helped move the residue out of the row area over winter and increased the effectiveness of the clearing discs on the planter. Disced plots had in row cover reductions due to cultivation in 1991 of only 9% after planting (table 2b).

The planter equipped clearing discs were only partially successful in removing crop residue from the row area even if ridges were built in 1991 with row cultivation. It is recommended that "in row" cover by corn residue be less than 10% to minimize the potential of detrimental effects on corn emergence and early growth.

The emergence rate date in table 2b is shown in figure 1. Emergence was delayed about ten days with the no till system compared to discing and moldboard plowing. Cultivation in 1991 had very little effect on emergence or final stand with the moldboard and disc systems. Cultivation in 1991 did increase the rate of emergence and final stand under no till conditions. Final stands were reduced significantly under no till conditions compared to moldboard and discing systems.

The dip in emergence for most treatments during the May 26th observation is the result of a frost on May 24th. The no till system without cultivation incurred the greatest drop in emerged corn. The stand reductions with other treatments were small. By May 28 corn regrowth showed very little permanent stand loss due to this frost. Frost damage elsewhere in Minnesota was correlated with high residue systems that allowed air temperatures to cool more just above the soil surface.

---

[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 B.J. Johnson are Associate Professor and Assistant Scientist in the Soil Science Department at the University of Minnesota, St. Paul, MN, 55108. M.J. Wiens and B. Sheets are Senior Plot Coordinator and Plot Technician respectively at the Staples Irrigation Center, Staples Area Technical College, Staples, MN.*

Treatment means and statistical significance are shown in tables 3, 4a, and 4b. Grain and stover yield, moisture, and stand were similar for the disc and moldboard systems. Corn grown under the no till conditions had reduced yield and increased moisture. A similar trend was found in N concentration and uptake. Corn responded up to 193 pounds of applied N. Nitrogen uptake continued to the 273 pound per acre rate.

The interaction between tillage and cultivation is shown in table 3 and figure 2. Cultivation generally increased yield, development, and N uptake. There were many interactions between cultivation and tillage system however. Reduced grain moisture due to cultivation (indicating increased development) occurred only with the no till system. There was a yield response with all systems although the response was the greatest with the no till grown corn. Corn grown with moldboard plowing and discing systems responded to row cultivation also however. Responses of corn to row cultivation have been consistently no till>moldboard>disc at this site. Cultivation of no till grown corn increased stand and harvest index also. The trends for the interaction between cultivation and tillage for N uptake followed yield trends.

There was a significant interaction between tillage and N rate for grain, stover, and total dry matter yields (figure 3). The corn grown with the no till and disc systems responded to the highest rate of N. Moldboard grown corn did not respond beyond the 193 pound per acre rate. Although the moldboard grown corn responded in N uptake to the highest rate of N the interaction was similar to the yield trends.

The amount of N applied in the irrigation is shown in table 5. The water source for this study is an open pit dug for irrigation purposes. Concentrations of nitrate increased through the season. A total of 36 pounds N per acre was applied with 5.99 inches of irrigation water. Concentrations in this pit are about three times what they were in 1991.

Table 1. Cultural practices at Staples Irrigation Center, Wadena County, MN. 1992.

Tillage

No Till
Spring disc
Moldboard plowed with plow packer April 27
Cultivated with a Hiniker 5000 on July 18

Planting and Harvest Date

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

	Planting		Harvested	
Crop	Date	Rate	Grain	Stover
Corn	May 5	35,200 seeds/A	October 15	October 16

Soil

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

Previous Crop **1992 Crop**

Alfalfa 1987-89 Corn-Pioneer 3790
Corn 1990-92

Fertilizer 1991

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

1. Planter applied 2" below and 2" beside row.
2. Broadcast as split urea and irrigated in.
3. The resulting N rates are: 12, 72, 152, and 244 lbs/A.

Fertilizer 1990

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

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

Fertilizer 1992

Material Analysis	Rate[3]	Actual N	P_2O_5	K_2O	S	Date Applied
	------ lb/A --------					
15-5-30-10[1]	115	17	6	34	12	5/5/92
46-0-0[2]	0	0	0	0	0	6/8/92
46-0-0[2]	65	30	0	0	0	6/8/92
46-0-0[2]	152	70	0	0	0	6/8/92
46-0-0[2]	239	110	0	0	0	6/8/92
46-0-0[2]	0	0	0	0	0	6/30/92
46-0-0[2]	65	30	0	0	0	6/30/92
46-0-0[2]	152	70	0	0	0	6/30/92
46-0-0[2]	239	110	0	0	0	6/30/92

1. Planter applied 2" below and 2" beside row.
2. Broadcast as urea and irrigated in with .24" and .60" for the 6/8 and 6/30 application dates respectively.
3. The resulting N rates are: 53, 113, 193 and 273 lbs/A (36 lbs.NO_3-N/A from irrigation was added to N rates, refer to table 5).

Table 2a. Effect of row cultivation in 1991 on soil cover by corn residue on No Till plots.

N rate	IN ROW 5/5/92		IN ROW 6/4/92		BETWEEN ROW 5/5/92		BETWEEN ROW 6/4/92	
(lb/a)	C	NC	C	NC	C	NC	C	NC
53	76.5	98.0	63.5	76.0	87.5	89.0	74.0	80.0
113	76.5	98.5			88.0	93.5		
193	92.5	99.0			88.0	96.5		
273	80.0	100.0	63.0	80.0	88.0	97.0	67.0	82.0
mean	**81.4**	**98.9**	**63.3**	**78.0**	**87.9**	**94.0**	**70.5**	**81.0**

1.The p values for the 5/5 date for position relative to the row, cultivation, N rate, the N rate by cultivation, row position by cultivation and the N rate by cutivation by row position interactions are: .729, <.001, .084, .728, .015, .728, .305 respectively. C=cultivated NC=no cultivate

Weed Control

2.25 pt/A (3.0 lb/A) Bladex + 2.0 pt/A (1.5 lb/A) Dual on 5/8/92.
1 qt/A 2,4-D Amine spot sprayed on 10/27/92.

Table 2b. Effect of tillage on soil cover by corn residue, and emergence from 5-15-92 to 6-4-92 at Wadena Co[1].

	Residue[2] Date 6/4/92				Date							
Tillage	In Row		Bet Row		5-15	5-17	5-19	5-21	5-26	5-28	6-1	6-4
	C	NC	C	NC	---------- plants/acre x 10^{-3} ----------							
No Till	63.2a	78.0a	70.5a	81.0a	1.7a	5.3a	8.3a	18.6a	26.2a	24.4a	27.7a	28.4a
Disc	31.5b	42.2b	36.5b	43.0b	7.7b	15.5b	18.7b	34.4b	37.1b	36.8b	36.8b	37.1b
Moldboard	7.5c	9.0c	17.2c	19.0c	13.9c	16.4b	19.1b	33.4b	35.0b	35.1b	35.3b	35.1b
Signif.(Pr > F)					.004	.016	.047	.001	.004	.004	.003	.003

1. Means within the same column when followed by the same letter are not significantly different(α=.10).
2. The p values for residue, row position, cultivation, tillage, tillage by row position, and the cultivation by row position interactions are .076, .005, .001, .720, .446, respectively. C=cultivated. NC=no cultivation.

Table 3. Effect of tillage, nitrogen rate, and cultivation on corn response., 1992[1].

Treatment	Stover Moisture	Stover Yield	Grain Moisture	Grain Yield	Total D.M.	Harvest[1] Index	Final Stand	Grain Protein	Grain N	Stover N	N uptake Grain	N uptake Stover	N uptake Total
	--%--	-T/A-	--%--	-bu/A-	-T/A-		1000's Acre	-------%---------			---------lb/A---------		
Tillage (n=32)													
No Till	59.4a	1.6a	46.7a	37.8a	2.4a	0.36a	29.4a	8.6a	1.38a	.756a	24.8a	23.8a	48.6a
Disc	57.7a	1.7b	36.7b	62.4b	3.2b	0.46b	33.2b	8.0b	1.28b	.755a	39.1b	27.9a	67.0b
Moldboard	56.2a	1.8b	35.8b	68.5b	3.5b	0.46b	32.5b	8.3b	1.32b	.748a	43.9c	28.2a	72.6b
Sig. (Pr > F)	.309	.051	.001	.001	.002	.004	.016	.041	.041	.982	.001	.226	.003

1. Ratio of grain to total dry matter.

N Rate lb N/A (n=24)													
53	57.6a	.74a	39.6b	25.8a	1.4a	0.44a	32.6a	7.7a	1.23a	.715a	14.7a	10.6a	25.1a
113	57.7a	1.6b	37.5a	52.3b	2.8b	0.43a	30.7a	7.2b	1.16b	.599b	28.3b	18.8b	47.1b
193	57.8a	2.1b	40.2b	70.9b	3.8c	0.43a	31.4a	8.7c	1.38c	.757a	46.1c	32.2c	78.3c
273	57.7a	2.3b	41.2b	73.1b	4.1c	0.41a	32.2a	9.5d	1.53d	.938c	52.5d	44.1d	96.6d
Sig. (Pr > F)	.999	<.001	.028	<.001	<.001	.484	.289	<.001	<.001	<.001	<.001	<.001	<.001
Cultivation (n=48)													
Cultivation	43.0a	1.7a	38.8a	63.3a	3.2a	0.46a	32.1a	8.2a	1.32a	.792a	40.5a	27.8a	68.6a
No Cultivation	41.6b	1.7a	40.5b	49.9b	2.9b	0.40b	31.3b	8.4a	1.34a	.714a	31.8b	25.7a	57.5b
Sig. (Pr > F)	.068	.627	.015	.000	<.001	<.001	<.001	.297	.297	.037	<.001	.196	<.001
Interactions													
Tillage X Cultivation (n=16)													
No Till W/	58.0	1.6	43.3	49.8	2.7	0.43	30.7	8.3	1.33	.755	32.0	23.6	55.6
No Till W/O	60.7	1.6	50.2	25.9	2.2	0.28	28.1	9.0	1.43	.757	17.7	24.1	41.8
Disc W/	57.0	1.7	36.6	65.3	3.3	0.47	33.4	8.1	1.30	.820	41.4	29.4	70.8
Disc W/O	58.3	1.8	36.7	59.4	3.2	0.45	32.9	7.9	1.26	.690	36.7	26.5	63.2
Mldbd W/	56.1	1.8	36.5	74.5	3.6	0.48	32.2	8.3	1.32	.798	48.0	30.0	78.0
Mldbd W/O	56.2	1.8	35.2	62.8	3.3	0.45	32.7	8.2	1.32	.698	40.1	26.4	66.5
Sig. (Pr > F)	.350	.848	<.001	.006	.028	<.001	.089	.017	.017	.308	.032	.524	.162
Tillage X N Rate lb N/A (n=16)													
Notill 53	58.7	.64	48.4	17.1	1.0	0.37	32.3	8.4	1.34	.826	10.4	10.6	21.0
Notill 113	62.1	1.4	44.6	31.5	2.2	0.33	27.6	7.6	1.22	.602	18.1	17.2	35.3
Notill 193	58.0	1.8	45.9	47.0	2.9	0.38	29.0	9.0	1.44	.752	31.7	26.7	58.4
Notill 273	58.6	2.1	48.5	50.5	3.3	0.34	29.4	9.5	1.52	.860	35.5	37.4	72.9
MEAN	59.4	1.5	46.8	37.8	2.4	0.36	29.4	8.6	1.38	.756	24.8	23.8	46.9
Disc 53	57.0	.67	35.8	25.8	1.3	0.47	33.1	7.3	1.17	.640	14.3	8.6	22.9
Disc 113	57.8	1.6	34.4	61.3	3.0	0.47	32.9	6.9	1.10	.641	31.9	20.7	52.6
Disc 193	59.0	2.2	37.7	76.5	4.0	0.45	31.9	8.4	1.34	.753	48.4	33.2	81.6
Disc 273	56.9	2.5	38.8	86.0	4.5	0.45	34.9	9.5	1.52	.988	61.8	49.3	111.1
MEAN	57.7	1.7	36.7	62.4	3.2	0.46	33.2	8.0	1.28	.755	39.1	28.0	67.0
Mldbd 53	57.5	.89	36.4	33.1	1.7	0.48	32.4	7.6	1.21	.707	18.8	12.6	31.4
Mldbd 113	53.1	1.6	33.5	64.1	3.2	0.48	31.5	7.2	1.16	.555	35.0	18.3	53.3
Mldbd 193	56.5	2.4	37.1	89.3	4.5	0.47	33.1	8.6	1.38	.766	58.4	36.6	95.0
Mldbd 273	57.5	2.4	36.4	83.0	4.3	0.44	32.8	9.6	1.54	.966	60.2	45.4	105.7
MEAN	56.2	1.8	35.8	68.4	3.4	0.47	32.5	8.3	1.32	.748	43.9	28.2	72.6
Sig. (Pr > F)	.225	.008	.750	.001	.003	.891	.560	.787	.787	.225	.042	.062	.001

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

Table 4a. Interaction of tillage, nitrogen rate, and cultivation on corn response., 1992[1].

Treatment		Stover Moisture		Stover Yield		Grain Moisture		Grain Yield		Total D.M.		Harvest Index		Final Stand	
		---%---		-T/A-		---%---		-bu/A-		-T/A-				Plants Ax10^{-3}	
Till x N Rate(lb/A)x Cult, (n=4)															
		C[2]	NC[2]	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC
NT	53	60.2	57.2	.69	.59	45.9	50.9	24.0	10.3	1.3	.83	0.44	0.29	33.3	31.2
NT	113	61.0	63.1	1.5	1.4	41.6	47.6	42.1	20.9	2.5	1.9	0.40	0.26	28.4	26.8
NT	193	54.3	61.6	1.7	1.9	42.4	49.3	59.3	34.8	3.1	2.7	0.46	0.31	31.8	26.3
NT	273	56.9	60.2	2.1	2.2	44.0	53.0	67.4	33.6	3.7	3.0	0.43	0.26	30.1	28.7
MEAN		58.0	60.7	1.5	1.5	43.5	50.2	49.8	25.9	2.6	2.1	0.43	0.28	30.7	28.1
DISC	53	56.5	57.4	.71	.63	36.2	35.4	25.8	25.8	1.3	1.2	0.46	0.48	34.6	31.5
DISC	113	57.6	58.1	1.6	1.6	34.2	34.6	65.5	57.0	3.1	3.0	0.49	0.46	33.4	32.5
DISC	193	58.3	59.6	2.2	2.2	38.0	37.4	81.7	71.3	4.1	3.9	0.47	0.43	31.4	32.4
DISC	273	55.6	58.1	2.4	2.6	38.1	39.4	88.3	83.6	4.5	4.6	0.46	0.43	34.2	35.3
MEAN		57.0	58.3	1.7	1.8	36.6	36.7	65.3	59.4	3.3	3.2	0.47	0.45	33.4	32.9
MB	53	55.0	60.0	.99	.79	37.7	35.5	34.9	31.8	1.9	1.5	0.46	0.48	31.4	33.4
MB	113	56.0	50.1	1.6	1.7	35.1	31.8	64.1	64.1	3.1	3.2	0.49	0.47	29.4	33.7
MB	193	55.4	57.6	2.5	2.3	35.8	38.4	93.2	85.4	4.7	4.3	0.47	0.47	34.3	32.0
MB	273	58.0	57.3	2.3	2.5	37.9	35.0	96.0	67.0	4.5	4.1	0.50	0.37	33.8	31.7
MEAN		47.7	50.3	1.8	1.8	36.5	35.2	74.5	62.8	3.5	3.3	0.48	0.45	32.2	32.7
SIG. (Pr> F)		.075		.747		.718		.226		.685		.808		.138	

1. Means within the same column with the same mean are not significantly different.
2. C = cultivated. NC= not cultivated.

Table 4b. Interaction of tillage, nitrogen rate, and cultivation on various corn response at Wadena Co., 1992[1].

Treatment		Grain Protein		Grain Nitrogen		Stover Nitrogen		N uptake Grain		N uptake Stover		N uptake Total	
		---%---						---lb/A---					
Till x N Rate(lb/A)x Cult, (n=4)													
		C	NC	C	NC	C	NC	C	NC	C	NC	C	NC
NT	53	7.7	9.0	1.23	1.44	.880	.773	13.8	7.0	12.0	9.2	25.8	16.2
NT	113	7.4	7.9	1.18	1.26	.573	.631	23.6	12.6	16.8	17.7	40.4	30.3
NT	193	8.9	9.0	1.43	1.44	.763	7426	40.0	23.4	26.1	27.3	66.1	50.7
NT	273	9.1	9.9	1.45	1.60	.836	.885	46.0	25.0	36.4	38.4	82.4	63.4
MEAN		8.3	9.0	1.33	1.43	.755	.757	32.0	17.7	22.8	23.1	53.8	40.2
DISC	53	7.3	7.3	1.16	1.17	.723	.558	14.1	14.4	10.3	6.8	24.4	21.2
DISC	113	7.2	6.5	1.15	1.04	.736	.546	35.8	28.1	23.8	17.7	59.6	45.8
DISC	193	8.6	8.1	1.38	1.30	.788	.722	53.0	43.7	33.7	32.7	86.7	76.4
DISC	273	9.4	9.6	1.50	1.54	1.04	.936	62.8	60.7	50.0	48.6	112.8	109.3
MEAN		8.1	7.9	1.30	1.26	.820	.690	41.4	36.7	29.4	26.5	70.9	63.2
MB	53	7.7	7.4	1.24	1.19	.778	.636	20.1	17.9	15.0	10.1	35.1	28.0
MB	113	7.1	7.3	1.14	1.18	.561	.549	34.1	35.8	17.8	18.9	51.9	54.7
MB	193	8.6	8.6	1.38	1.38	.812	.720	60.9	55.8	39.9	33.3	100.8	89.2
MB	273	9.6	9.6	1.54	1.53	1.04	.889	69.8	50.8	47.4	43.5	117.2	94.3
MEAN		8.3	8.2	1.32	1.32	.798	.698	48.0	40.1	30.0	26.4	76.2	66.5
SIG. (Pr> F)		.466		.466		.956		.417		.942		.681	

1. Means within the same column with the same mean are not significantly different.
2. C = cultivated. NC= not cultivated.

Table 5. Irrigation water and nitrate amounts in the Irrigation Center pit for the 1992 growing season.

Date	6/6	6/10	6/13	7/1	7/23	7/28	7/30	8/4	8/14	8/21	Total
Amount (in.)	.45	.24	.65	.60	.88	.37	.45	1.15	.70	.50	5.99
NO_3 Conc. (ppm)	23.5	23.7	21.9	21.1	21.8	29.7	23.7	29.7	34.6	42.3	
NO_3-N (lbs/Acre)	2.39	1.28	3.22	2.86	4.34	1.98	2.41	7.72	5.47	4.78	36.4

Fig. 1a. Effect of Tillage and row cultivation in 1991 on corn emergence at Staples, Mn. 1992

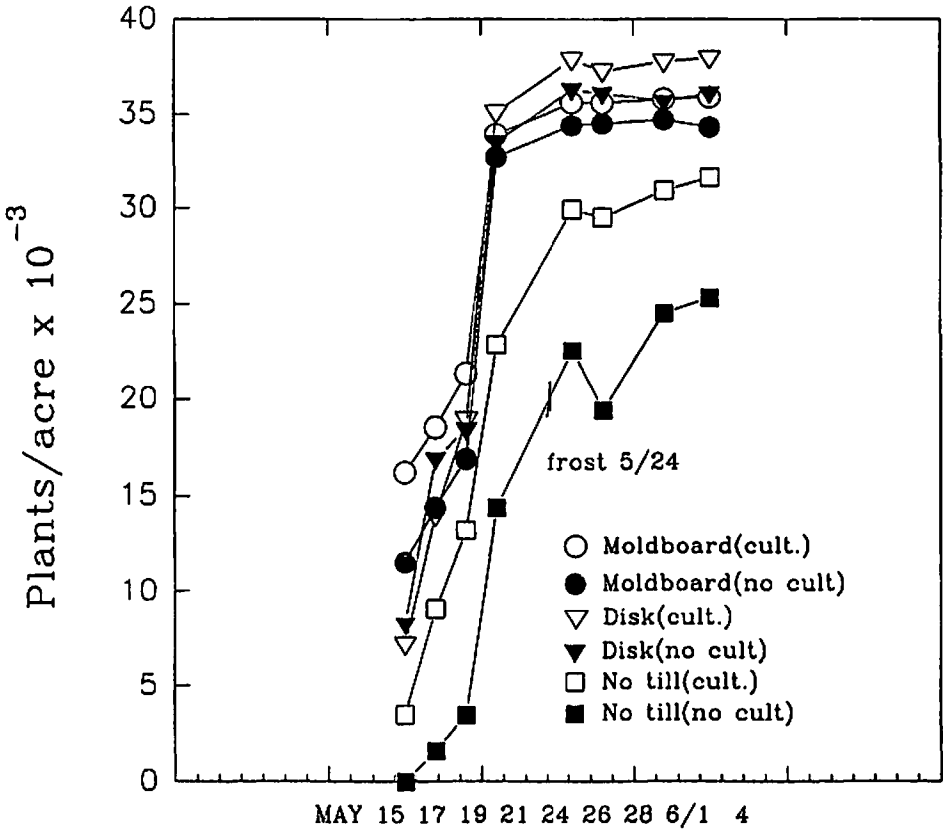


Fig. 1b. Growing degree days for 1992 growing season.

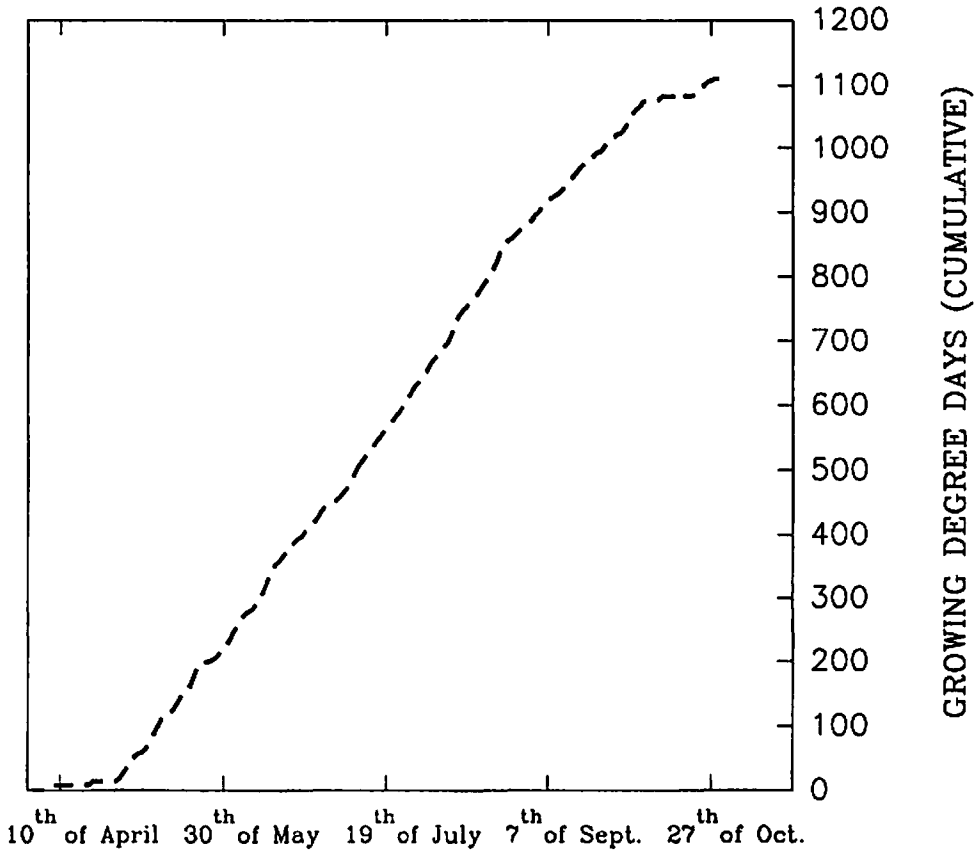


Fig. 2a. Grain yield and moisture response to tillage and cultivation treatments. Staples, Mn, 1992.

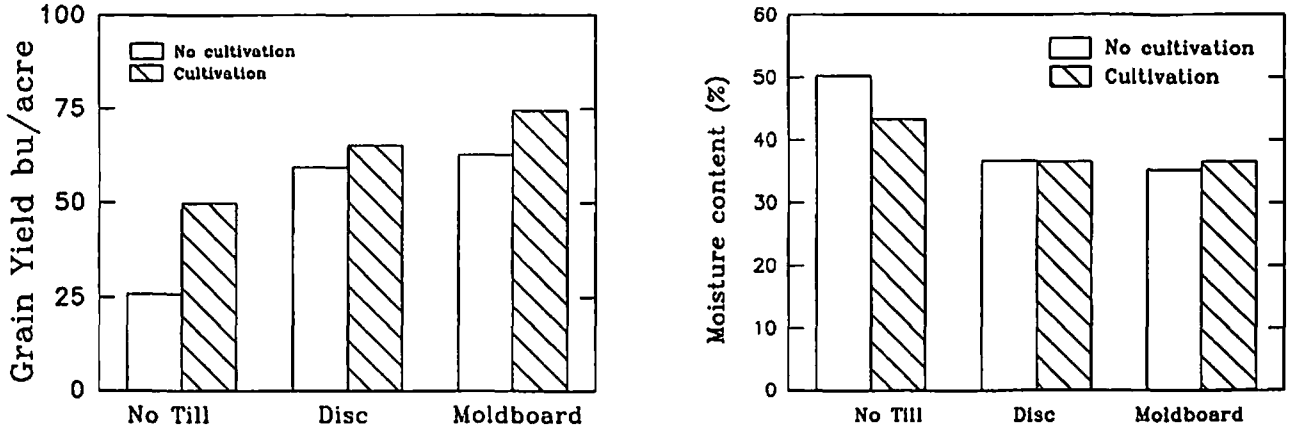


Fig. 2b. Barren and Total plant number response to tillage and cultivation treatments, Staples, Mn, 1992.

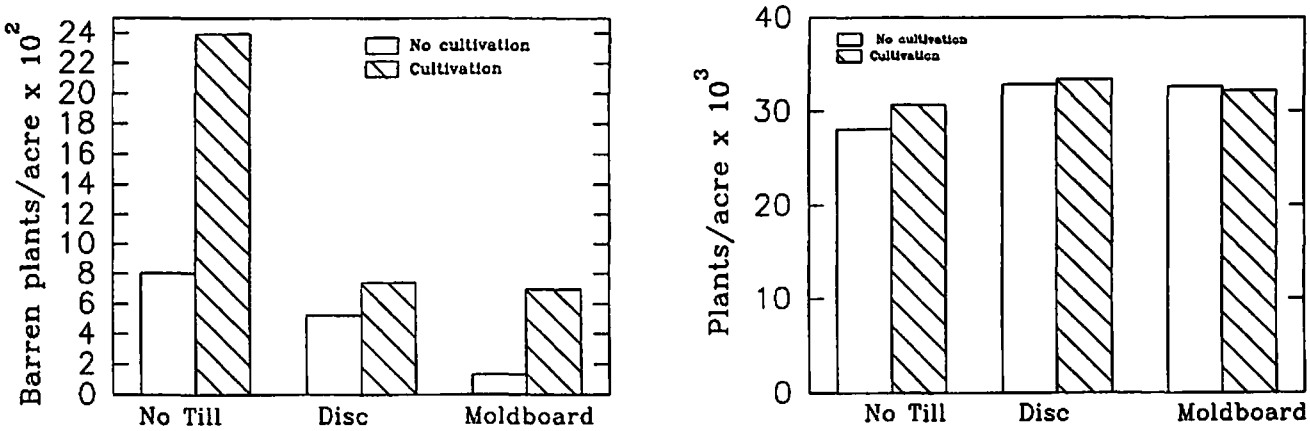


Fig. 2c. Total dry matter and harvest index response to tillage and cultivation treatments, Staples, Mn., 1992

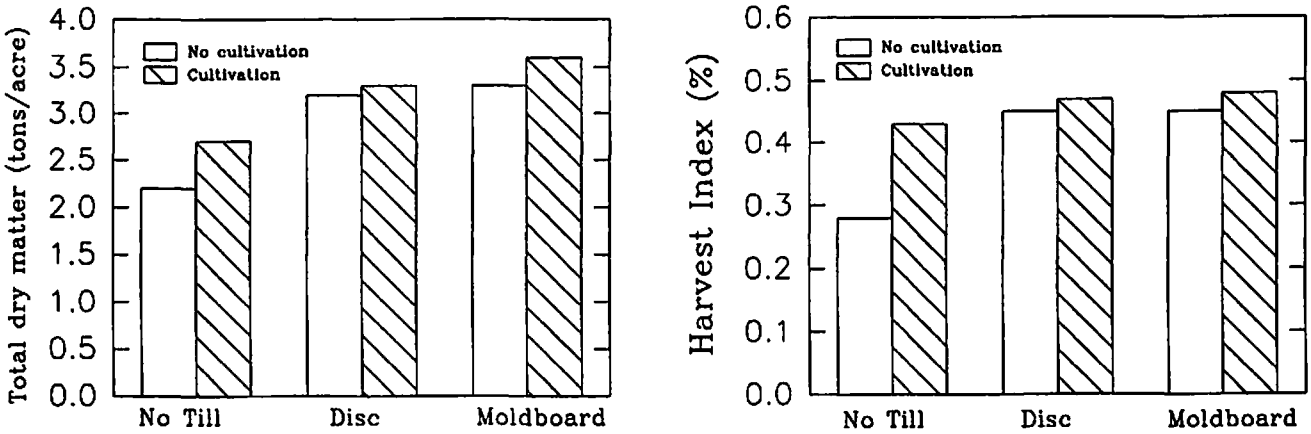
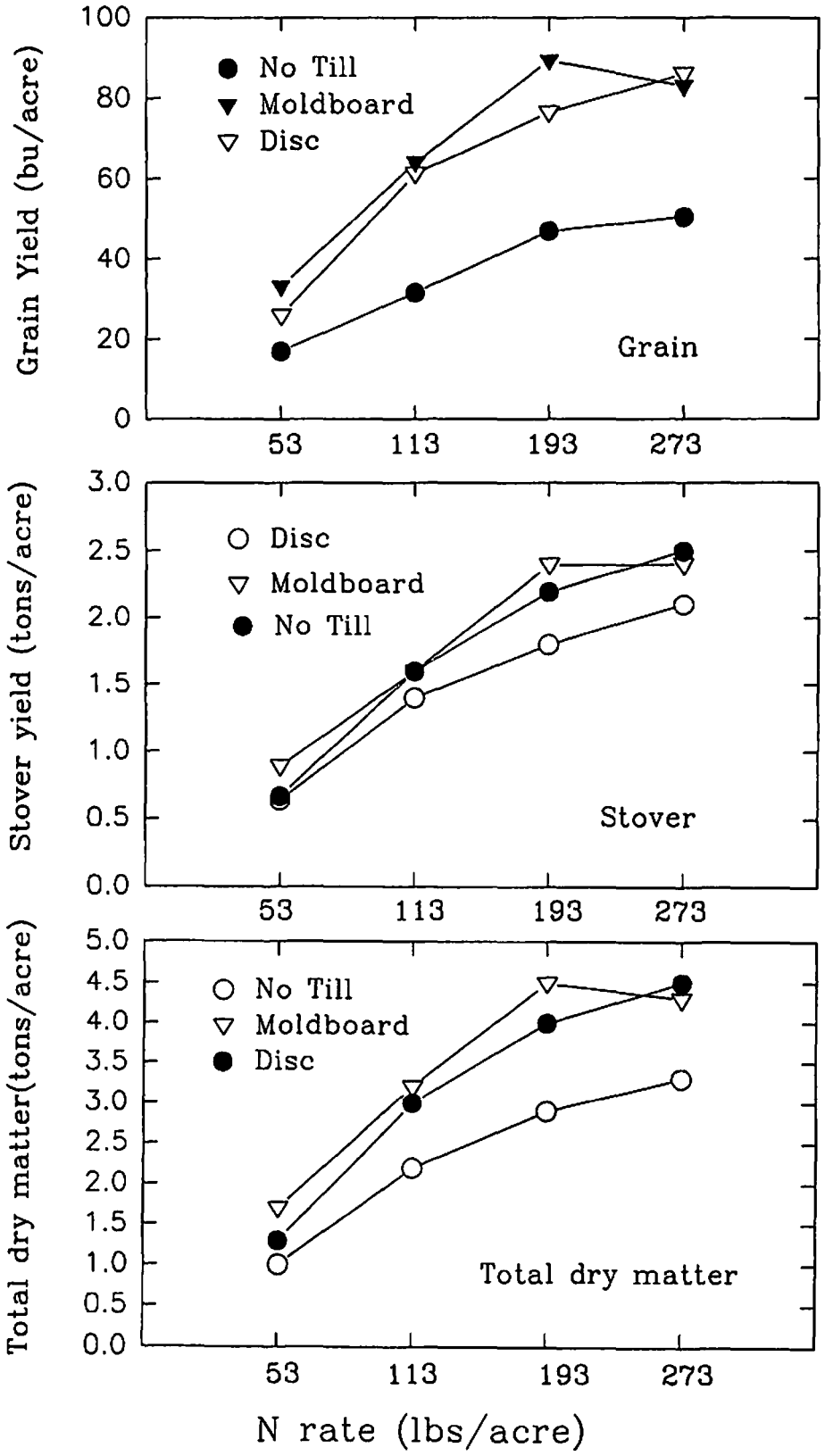


Fig. 3 Yield responses to four nitrogen rates of urea (split application) at Staples, Mn. 1992



Potato Hill Shape Influences on Yield, Infiltration, and Nitrate Concentrations

B.M. Carlson, C.F. Reece, C.J. Rosen, and M.J. Wiens.

Abstract

Three types of hilling systems were investigated to determine the possible effects on the Russet Burbank potato. No significant differences were noted in growth, yield, and infiltration. The major finding was that soil water nitrate concentrations in the furrows were approximately three times higher than in the rows. In addition calculated water infiltration was often twice as high in the row as compared to the furrows. Based on these discoveries further investigation of the preferential leaching process is planned.

Introduction

Recently hill shape has been discussed by growers as having a possible effect on potato yields. This study explored some effects of hill shape on the Russet Burbank potato. In order to evaluate this two hilling types were studied: a pointed shape, a more rounded type, and a no-hill control. Plots were located at the Staples Irrigation Center, which is in a high potato production region.

Methods

Nine plots were laid out consisting of three blocks and three hilling treatments (POINT, ROUND, and NO-HILL). Each plot had five 25 ft. rows spaced 36 in. apart running east to west, giving an overall dimension of 15 ft. by 25 ft. Russet Burbank seed pieces were planted 12 in. apart giving a plant density of 3.6 plants/m^2. Soil at the site was a Verndale sandy loam, with 0 to 2 percent slopes. Previous crops were lupines and peas. The site was moldboard plowed, and packed prior to planting.

Planting occurred on 5 May, with emergence on 27 May. Ammonium Nitrate was applied as a nitrogen source, in three splits of approximately 53 lb. N/A for a total of 160 lb. N/A. These were banded in at planting, just prior to emergence (24 May), and at hilling (8 June). The POINT treatment hills had the geometry of a triangle with approximate dimensions of base 90 cm and height 22 cm. The ROUND treatment hills had a geometry of a trapezoid with approximate dimensions of base 80 cm, top 40 cm, and height 13 cm. No hilling was done on the NO-HILL treatment. Herbicides applied were Treflan, on 7 May, pre-emerge at a rate of 1.2 Pt/A incorporated, and Dual at 3 Pt/A + Lorax at 2 Pt/A on 10 May. Bravo fungicide was applied on 6, 13, and 20 July. In addition Sevin insecticide was applied periodically to control the presence of Colorado Potato Beetle (*Lepitnotarsa decemlineata*).

A weather station was installed 40 ft to the north of the third series. Measurements of wind speed, wind direction, solar radiation, air temperature, relative humidity, and precipitation were taken every 10 s and either averaged or totaled (as appropriate) every hour and stored on a Campbell Scientific 21x datalogger. An additional tipping bucket rain gauge was installed in the alley between the second and third series to monitor irrigation water.

A Tektronix® 1502B Time Domain Reflectometry (TDR) unit was installed in conjunction with the weather station. Wave guides were buried in plots 201, 301, and 302, each corresponding to a different hill type. Guides were buried 5 and 15 cm from the surface in the row and furrow, and then midway in between in the shoulder. The TDR unit, coupled with the datalogger monitored volumetric water contents every 15 min.

Pan lysimeters were installed in each plot on 7 July. They were placed beneath the row and furrow at the top of the argillic horizon (approximately 20 in. deep). In addition, suction samplers were installed in the first series so that soil water could be sampled during unsaturated flow. They too were positioned in the row and furrow, approximately 18 in deep from the average soil level. Roughly 2.5 in of precipitation were necessary to get a sample in the event samplers. Samples were taken from the suction samplers corresponding to irrigations.

Leaf area index (LAI) readings were taken every 5 to 10 days using a Licor LAI-2000. With this the growth and progress of the plants was monitored.

Irrigation was scheduled using the Checkbook method, and was handled by the staff of the Irrigation center. Fixed standpipe irrigation was used for the study. In addition to standard waterings three large irrigation events were applied late in the year after the plants were mostly dead, so that additional data from the event samplers could be collected.

Due to early blight the plants began to die off on 6 August, and were approximately 95 % dead by 26 August. Because of this a defoliant was not needed to kill the plants for harvest. Potatoes were harvested on 17 September using a single row lift. Tubers were then separated into size classes, with special attention paid to green and damaged potatoes which were inherent to the no hill plots.

Results

Yield. With the growing season cut short from early blight, it is hard to compare yield data to normal yields. The main thing that can be done is to look at the treatments versus one another. The total yields of grade 1 potatoes was very low for all treatments, but there was not significant difference between the treatments. This is the same for all grades with the exception of misshapen, where the pointed and flat treatments differed significantly. Since the relative yields of misshapen potatoes was rather small it is not of interest as to why this was. Total yields, while low, were respectable and showed no significant difference between treatments.

Table 1. Effect of potato hill shape on marketable yields.

	MARKETABLE	TOTAL
	----------cwt./A--------	
POINT	300	405
ROUND	269	380
FLAT	259	379

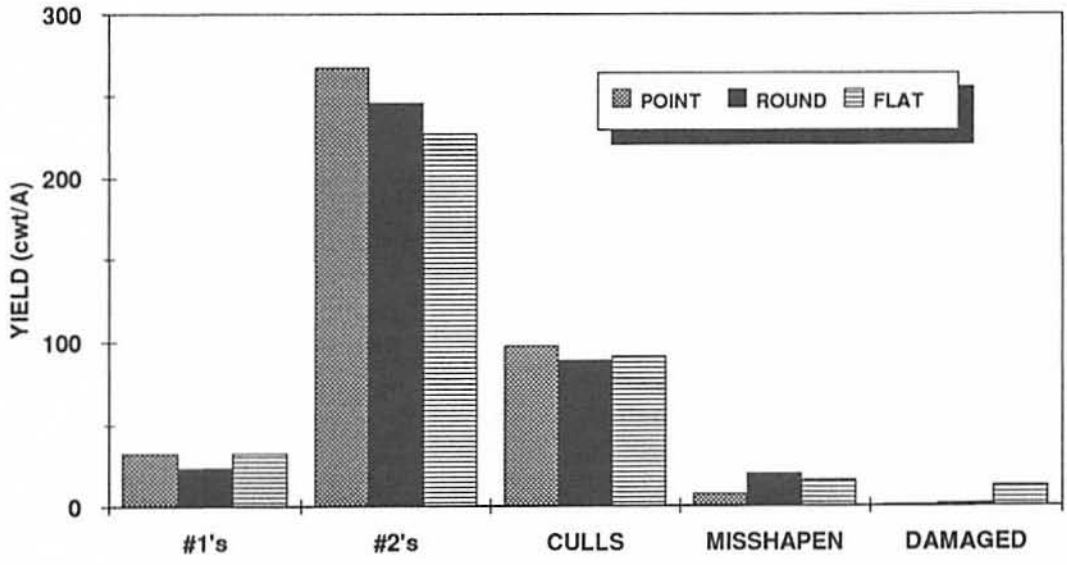


Figure 1. Effect of potato hill shape on graded yields.

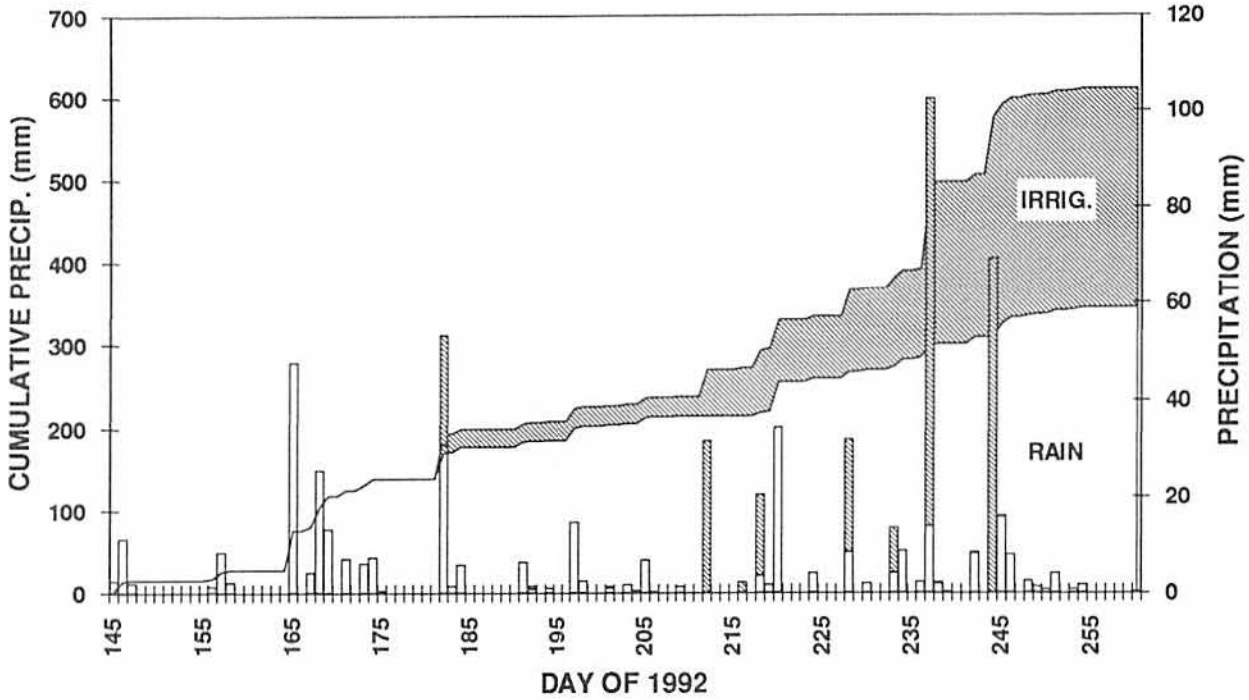


Figure 2. Rain and irrigation summary.

Infiltration. Figure 2 summarizes the rain and irrigation for the growing season. We calculated changes in soil water storage over the 20 cm depth during precipitation using our TDR data. If drainage past the 20 cm depth was negligible, then we can interpret the change in soil water storage as the amount of infiltration under each row position. We found infiltration under the row was consistently greater than under the furrow for all hilling treatments and days. Table 2 shows infiltration data for selected days for the NO-HILL and POINT treatments. Early in the growing season and prior to hilling (Day 156), infiltration in the row was slightly greater than in the furrow. At peak growth (Day 212), infiltration in the row was twice as much as in the furrow. Late in the growing season when plants were dying (Day 228), infiltration in the row was approximately 1.5 times infiltration in the furrow. Mass balance of water was within 25% of total precipitation using this analysis.

Table 2. Differences in soil water storage according to row position and hilling treatment on selected days.

		NO-HILL			POINT		
Day of 1992	Precipitation	Row	Shoulder	Furrow	Row	Shoulder	Furrow
	mm						
156	13.5	17.0	15.3	14.8	15.3	15.3	11.2
212	31.8	31.6	25.5	15.6	32.5	26.2	15.2
228	32.0	29.0	25.8	18.4	27.5	24.8	16.2

Nitrate Concentration. The event samplers tended to be very sporadic in capturing samples. And since only three plots contained suction samplers, soil water nitrate concentration could not be compared by hilling treatment. The data did however show a very notable trend. This is that the nitrate concentrations of samples from the furrow tended to be roughly three times as great as samples taken from the row. this trend continued through the year, until after the plants had been long dead. At that time the concentrations of samples from the row began to rise until on the last sampling date concentrations in the row were higher than in the furrow. This was possibly caused by the breakdown of root material in the row, and seems logical since 20 to 30 days had passed since the plants were approximately 95% dead. It should be noted that these samples were the results of intense irrigation, and the concentrations are relatively low compared to those obtained earlier in the year.

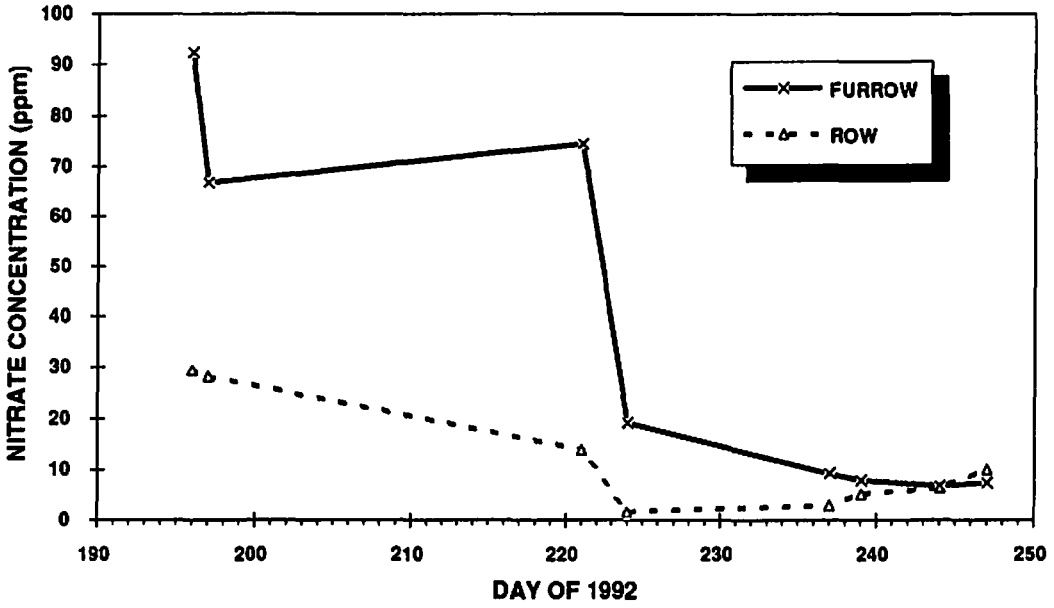


Figure 3. Soil water nitrate concentrations at top of argillic horizon.

Leaf Area Growth. Growth of the plants (as measured using LAI) for each treatment followed each other quite closely. A drop in LAI associated with day 198 (16 July) can be attributed to a storm which lodged many plants. The plants did recover, and grew through day 211 (29 July). This corresponds closely to the day in which the first symptoms of early blight are noticed (day 219). As the disease progresses the LAI falls rapidly, until the latter readings are mostly stems. the last reading was taken on day 239 (26 August), the day on which an estimated 95% of the plants were dead.

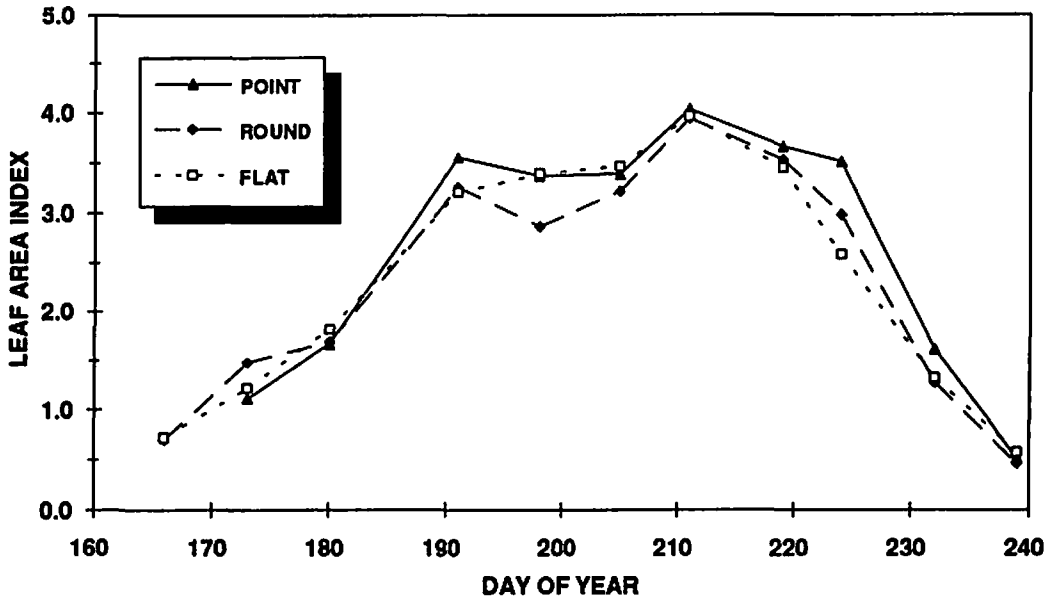


Figure 4. Effect of potato hill shape on leaf area index. (n=3)

Discussion and Conclusions

Even though no major differences were found between treatments in any of the measured quantities, hill shape should not be discounted as having no effect on some properties of potato production. Since the number of repetitions was rather small, one might want to investigate the effects of hill shape more extensively, possibly including more sites, before any real solid conclusions could be drawn. Something to consider about the hilling treatments is that even though little difference was noted in yield and growth characteristics the flat treatment is more difficult to harvest, causes some damage to tubers, and requires more power from the harvester to operate. These factors all lead to decreased profits. Therefore it is not advisable that unhilled potatoes be thought of as equal to hilled ones.

The most interesting aspect of our research from 1992 is that soil water nitrate concentrations immediately below the rooting zone differ markedly between the furrow and the row. This combined with the infiltration findings adds an interesting twist to the topic of preferential flow which is currently getting much attention. Since the water budget does not equal out, our measurements may only be used to hypothesize what happened. It is our feeling that the missing water can be accounted for from the storage above the wave guides, as well as the water necessary to wet the plants. Increased flow in the row is most likely caused by the "funneling" of water down the stems of the plants. Differences in nitrate concentration may be caused by fertilizer placement, or by uptake by the roots. The implications of our findings are that even though more water is entering the profile in the row there is still more nitrate flux in the furrow. The impacts of this phenomenon may lead to a greater reliance on fertigation which might minimize nitrogen loss to the furrow. Because of the potential impacts on management we will be using the data from this study to launch a more extensive look at the leaching process as it applies specifically to position underneath the plant canopy.

CORN NITROGEN RATE STUDY

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

ABSTRACT: A nitrogen rate study was initiated in 1990 on an irrigated sandy loam soil on the research area at the Staples Irrigation Center. The study is a multi-year ongoing research project to determine the optimum yield of irrigated corn in response to applied N, and intensive management.

Introduction: Production of high yields of corn on coarse textured soils with optimum use of supplemental moisture from irrigation is a common practice. These soils are subject to leaching of soluble constituents, especially nitrates. This study evaluates the response of corn to various rates of applied nitrogen.

Experimental: A Pioneer hybrid 3861 was seeded with a Duetz-Allis Model 385 four-row planter in 30-inch rows on April 30, 1992. The rate of planting was 32,000 seeds per acre. Nitrogen as urea was applied in three equal applications beginning one month following planting, one month later, and the last increment was applied just prior to tassel. Nitrogen was applied at the 60, 90, 120, 150, 180, 210, and 240 pounds of N per acre.

Discussion: The 1992 growing season was unseasonable cold. Yields were disappointingly low. Highest yield resulted from 120 pounds of applied nitrogen.

Table 1. N rates, corn yield and grain moisture. Staples 1992.

N Treatment	Grain Yield[1/]	Grain Harvest Moisture
lbs/A	bu/A (15.5% H_2O)	%
0	39.8	30.2
60	83.0	26.7
90	96.6	27.0
120	112.5	25.8
150	106.1	28.3
180	102.5	29.0
210	103.0	28.2
240	112.1	27.0

[1/] Average of four replications

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

LUPIN BEAN STUDY

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

ABSTRACT: Organic residues were added to the soil prior to planting and incorporated to measure impact of an improved soil environment on lupin production. Alfalfa meal at the rate of 3.3 tons/A and aged turkey litter at the rate of 10 tons/A were applied uniformly over the designated plots in a randomized design with four replications. Seed corn maggots devastated the plots receiving organic additions. Lupins should receive a seed corn maggot treatment at planting as a precautionary measure.

Table 1. Lupin seed yield, population, and treatments, Staples, 1992.

Treatment	Yield Bu/A @ 13.5% H_2O	Stand Count x 1000
Turkey litter @ 10 T/A	26.8	112
Alfalfa meal @ 3.3 T/A	33.7	183
Control	36.6	248

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

CORN SOYBEAN AND LUPIN ROTATION

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

ABSTRACT: A rotational study was initiated in 1992 with lupins, soybeans, and corn. Corn follows either lupins or soybeans in the rotation.

Table 1. Corn yields and grain moisture from plots where previous crop was soybeans or lupins, Staples 1992.

Previous Crop	Grain Yield Bu/A @ 15.5% H_2O	Grain Moisture % H_2O
Lupins	131.0	24.6
Soybeans	133.8	27.0
Corn	112.5*	25.8

* From continuous corn plot, nitrogen rate study.

1/ Regional Manager, TVA; Research Plot Supervisor, Staples Irrigation Center; Assistant Scientist; Junior Scientist, University of Minnesota, respectively.

WATER QUALITY STUDIES

H. Meredith and Mel Wiens[1/]

ABSTRACT: For the past several years, a limited quantity of irrigation water samples have been collected and analyzed. Samples were taken from pumping wells, streams, and dug pits. The purpose of this study is to monitor the contents of dissolved nutrients from the irrigation water and to use this information as a guide to measure the long-term effects of irrigation.

The primary nutrients of significance are calcium and magnesium. Sodium, of great concern in arid regions where irrigation is common, is uncommonly low in Minnesota water used for irrigation.

Table 1. Analysis of Irrigation Water in Proximity of Staples, MN - 1992

	PPM or Mg/L							
Lab #73	N	P	K	Ca	Mg	Na	S	Conductivity from HOS/cm
1	7.7	.16	23.3	41	12	9	7	375
2	0.5	.16	1.0	45	12	5	5	234
3	0.5	.17	1.7	95	28	4	1	369
4	0.5	.30	2.3	76	29	17	1	390
5	0.5	.16	2.3	74	27	13	1	362
6	17.0	.08	2.3	156	47	22	17	835
7	0.5	.34	1.2	49	15	11	1	268
8	0.5	.07	0.9	91	28	4	8	389
9	0.5	.16	1.6	76	25	23	8	387
10	0.5	.30	2.1	99	32	10	1	485
11	0.5	.40	5.0	72	38	52	1	525
12	0.5	.16	.7	-	-	185	14	645
13	0.5	.27	2.5	99	32	7	6	478
14	0.5	.16	2.8	90	25	7	4	444
15	4.7	.07	2.3	84	25	4	6	444
16	3.0	.10	1.8	197	64	30	23	1100
17	0.5	.11	2.1	94	28	8	10	460
18	3.1	.18	1.6	51	13	32	3	350
19	13.5	.15	16.9	120	42	14	9	695
20	0.5	.12	2.0	93	20	5	8	363
21	0.5	.29	4.8	27	20	102	1	577
22a	0.5	.13	4.4	63	18	28	1	458
22b	0.5	.28	2.7	57	28	15		327
23	7.9	.07	9.1	77	27	10	2	468
24	0.5	.18	2.4	64	27	10	1	475
25	0.5	.35	2.3	80	33	24	9	527
26	0.5	.08	2.4	91	27	4	9	497
27	0.5	.66	2.0	72	30	6	1	360
28	0.5	.13	2.1	119	19	5	14	600
29	0.5	.20	2.4	95	29	11	3	550
30	1.0	.09	2.5	78	33	5	20	393
31	0.5	.23	3.0	84	30	8	7	319
32	0.5	.22	3.2	72	32	11	13	332
33	0.5	.29	3.3	70	36	14	1	355
34	0.5	.30	3.0	76	32	10	1	307
35	0.5	.17	2.5	70	28	4	1	349
36	0.5	.24	1.4	63	8	4	1	267
37	7.7	.13	1.7	88	23	3	4	284
38	13.4	.09	1.9	92	26	3	7	472
39	10.8	.08	1.9	65	28	4	12	404
40	-	-	-	-	-	-	-	-
41	3.5	.13	1.8	74	19	2	4	377
42	5.8	.11	2.1	55	17	7	6	278
43	0.5	.10	1.4	51	11	3	4	184
44	7.2	.10	2.9	65	21	4	14	346
45	0.5	.14	1.6	65	19	3	12	280
46	1.8	.09	2.0	68	20	4	16	309
47	1.3	.10	2.0	74	25	5	4	265
48	0.5	.14	2.2	106	36	5	6	533
49	0.5	.22	2.6	69	31	4	2	437
50	12.2	.07	4.5	26	29	17	5	340

SOUTHERN EXPERIMENT STATION
1101 WEST ELM
WASECA, MINNESOTA

WEATHER DATA - 1992

Month	Period	Precipitation 1992	Precipitation Normal[1]	Avg. Air Temp. 1992	Avg. Air Temp. Normal[1]	Growing Degree Units 1992	Growing Degree Units Normal[1]
		------ inches -----		------- ° F ------			
January	1-31	2.26	0.96	21.2	10.2		
February	1-29	1.29	0.97	27.0	16.1		
March	1-31	3.34	2.28	32.5	29.1		
April	1-30	3.18	2.97	41.7	43.1		
May	1-10	0		60.5		133.5	
	11-20	1.62		62.7		135.0	
	21-31	1.32		57.7		122.0	
	Total	2.94	3.65	60.2	57.7	390.5	327
June	1-10	.25		65.8		162.5	
	11-20	3.04		71.3		208.0	
	21-30	.59		61.6		127.5	
	Total	3.88	4.11	66.2	67.1	498.0	515
July	1-10	2.52		66.3		165.0	
	11-20	.57		65.3		153.0	
	21-31	1.20		62.7		144.0	
	Total	4.29	4.21	64.8	71.3	462.0	646
August	1-10	3.24		69.2		188.5	
	11-20	1.08		62.3		132.0	
	21-31	1.69		64.5		165.5	
	Total	6.01	4.20	65.3	68.4	486.0	567
September	1-30	3.23	3.56	58.6	59.9	345.5	316
October	1-31	4.24	2.45	47.2	47.9	0	31
November	1-30	3.86	1.72	30.4	32.3		
December	1-31	1.44	1.35	19.5	16.2		
Year	Jan-Dec	39.96	32.43	44.6	43.4	2182.0[2]	2402
Growing Season	May-Sep	20.35	19.73	63.0	64.9	2182.0	2371

[1] 30-year normal from 1961 – 1990.
[2] 50 to 86 ° F base, May 1 until first fall frost.

Notes:
1) Eighth highest annual precipitation in 78-year record.
2) Highest 24-hour precipitation on October 7 - - - 2.18".
3) Growing degree units 9% below normal for season, 4th lowest since 1950.
4) Coldest July in 78-year record.
5) Highest temperature on May 2 - - - 91°F.
6) Only 6 days of ≥90°F.
7) Last spring frost - - - May 26.
8) First fall frost - - - September 29.

1992 Soil Moisture

0-5' Profile, Webster Clay Loam

Continuous Corn

Southern Experiment Station, Waseca, MN 56093

Depth	4/15	5/1	5/18	6/1	6/15	6/30	7/15	7/31	8/14	8/31	9/14	10/1	10/16	10/30	11/16
inches	inches available water in zone														
0 - 6[1]	.73	.95	.85	.97	.57	.50	.86	.71	.92	.83	.99	.72	.95	.80	1.06
6 - 12	.68	.79	.83	.83	.51	.43	.56	.44	.65	.49	.49	.47	.71	.67	.72
12 - 18	.90	.82	.83	.81	.58	.68	.68	.41	.69	.83	.81	.70	.77	.69	.80
18 - 24	.61	.66	.69	.64	.44	.54	.58	.39	.71	.56	.63	.57	.61	.63	.75
24 - 36	1.54	1.79	1.84	1.77	1.12	1.52	1.47	1.34	1.57	1.36	1.72	1.35	1.93	1.90	2.08
36 - 48	2.51	2.75	3.05	2.79	1.92	2.18	2.29	2.16	2.27	2.09	2.41	1.91	2.43	2.54	2.69
48 - 60	2.16	2.16	2.62	2.82	1.44	1.49	1.64	2.14	2.16	1.79	1.95	1.31	1.54	1.65	2.64
Total available water in 0-5' profile (inches)	9.13	9.92	10.70	10.63	6.58	7.33	8.08	7.59	8.98	7.94	8.99	7.03	8.93	8.88	10.76
% of Capacity[2]	83	90	97	96	60	66	73	69	81	72	81	64	81	80	97

[1] All values obtained by gravimetric sampling using Waseca D_b and WP constants.

[2] Assuming 11.05" field moist capacity.

Available soil moisture in the five-foot profile was plentiful throughout 1992. Lowest soil moisture levels occurred in June prior to the onset of the cool weather and on October 1 after a 3-wk dry period and some warm temps in September. Soil moisture conditions going into 1993 are saturated with the profile being 97% full in mid-November.

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

Waseca, 1992

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 1992 was 7.5" above normal and tile flow was plentiful. The slightly higher tile drainage with NT was offset by higher NO_3-N concentrations with the MP system. Nitrate-N losses to the tile lines were 20% higher for the MP system. Corn yields, N uptake, and N removal in the grain were all significantly higher for MP compared to NT. Grain yield was 47% less with NT. Low but equal amounts of NO_3 remained in the 8-foot soil profile in November with the two tillage systems.

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. Beginning in 1990, three replications and 6 plots were used. Corn was grown on these plots in 1982 through 1990. The stalks were chopped in October, 1990 and moldboard plots plowed.

On April 30, 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 4 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 8. Weed and insect control were excellent. Percent surface residue was measured on April 6 and averaged 13 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 31 and NT = August 10) 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 line flow began on March 2 and continued with some flow each month until Nov. 25. 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 November 16, 1992. Fifteen soil cores were taken on Sept. 25 from each plot in 0-2", 2-4", 4-6", 6-9" and 9-12" layers, composited by depth, and analyzed for total N.

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 seventh year of eleven where MP yields were significantly higher. Grain moisture at harvest was significantly higher with NT. Leaf N and grain N concentration were not affected by tillage (P = 90% level). Final population was slightly higher with MP.

Precipitation during the growing season and for the year was 0.6 and 7.5" above normal, respectively. Consequently, tile flow was higher than usual and averaged about 27% higher with NT compared to MP tillage (Table 2). Flow-weighted NO_3-N concentration for the season averaged 52% higher with MP tillage. Thus, NO_3-N losses via the drainage water were 20% higher for MP tillage. On an annual basis these NO_3-N losses were the equivalent of 21% and 26% of the fertilizer N added for NT and MP, respectively.

[1] Funding provided by the North Central Regional Research Committee (NC-201) and the Southern Experiment Station.

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

Table 1. Influence of tillage system on corn production and N utilization at Waseca in 1992.

Tillage System	Final Population	Leaf N	Silage Yield	Silage N uptake	Grain Yield	Grain N	Grain N removal	Grain H_2O
	X10[3]	%	T DM/A	lb N/A	bu/A	%	lb N/A	%
Moldboard Plow	26.1	2.40	6.22	129.9	120.9	1.44	82.6	31.0
No Tillage	24.3	2.38	4.52	95.1	63.8	1.59	48.1	37.9
Signif. Level (%):[1/]	97	10	97	94	99	84	97	99
CV (%) :	1.6	7.7	7.3	10.	4.8	5.6	12.	2.2

[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 1992.

Month	Tile Flow	NO_3-N Concentration	NO_3-N Loss
	acre-in.	ppm	lb/A
		Moldboard plow	
March	4.09	16.1	14.33
April	3.45	14.1	10.60
May	0.86	13.5	2.48
June	2.04	13.2	6.09
July	0.27	12.4	0.72
August	0.33	10.4	0.87
September	0.22	10.9	0.52
October	2.18	10.1	5.00
November	2.33	10.3	5.33
Total	15.77	Avg = 12.8	45.94
		No tillage	
March	3.55	8.6	6.94
April	4.08	7.5	6.76
May	1.42	7.1	2.21
June	2.87	8.4	5.40
July	0.92	10.1	2.03
August	1.12	11.4	2.84
September	0.37	9.6	0.86
October	2.58	8.7	5.13
November	3.15	8.7	6.28
Total	20.06	Avg = 8.4	38.15

Residual NO_3-N in the soil profile at the end of the 1992 growing season showed equal amounts of N remaining in the two systems (Table 3). The largest differences between the two tillage systems occurred in the 1 to 3' zone where more NO_3 accumulated with MP. These results are different from previous years where MP tillage consistently contained higher amounts of residual NO_3-N. The low amounts found in 1992 probably reflect the wet conditions and higher drainage losses in the past two years and the cool temperatures in 1992.

Table 3. Influence of tillage systems on residual NO_3-N in the soil profile in Oct., 1992.

Profile depth	Tillage System: Mb. Plow	Tillage System: No Tillage
feet	NO_3-N (lb/A)	
0-1	8.7	8.9
1-2	6.7	3.3
2-3	6.8	2.8
3-4	7.7	8.1
4-5	9.6	9.7
5-6	9.9	9.5
6-7	10.3	10.5
7-8	9.1	12.1
Total (lb NO_3-N/A 0-8')	68.7	65.1

Soil samples analyzed for total N indicated higher N concentrations in the top 4" with NT, but no large differences between the two tillage systems at depths below 4" (Table 4). Assuming a bulk density of 1.2 g/cc in the 0-6" depths and 1.25 g/cc in the 6-12" depth, NT contained 218 lb more total N/A than did the MP tillage system. This is approximately the difference in the amount of N removed in the grain between the two tillage systems (Table 5).

Table 4. Total N in the 0-12" soil layer as affected by tillage system.

Depth	Tillage MP	Tillage NT
inches	%	
0 - 2	.243	.285
2 - 4	.246	.255
4 - 6	.250	.253
6 - 9	.235	.223
9 - 12	.165	.168

ELEVEN-YEAR SUMMARY

The cumulative totals for the 11-year period (1982-1992) are shown in Table 5. Corn yields over this period averaged 21.8 bu/A better with moldboard plow tillage. Approximately 23% 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 42% of the applied N has been removed in the grain by the MP and NT systems, respectively. Even though total water flow through the tile lines was 13% higher with NT compared to MP tillage, 5% more NO_3-N was lost via the tile lines with MP. This was due to higher NO_3-N concentrations, especially in the last three years. This small difference is considered to be insignificant when considering tile flow variability among the plots. The equivalent of 20 to 21% of the fertilizer N applied to these plots has been lost to tile drainage over this 11-year period.

Table 5. Cumulative effects of the two tillage systems over the 11-year period.

Parameter	Tillage System: Mb. plow	Tillage System: No tillage
Fert. N applied (lb/A)	1980	1980
Corn grain removed (bu/A)	1516	1287
N removed in grain (lb/A)	1011	823
N removed in grain as a percent of applied N (%)	51	42
Tile flow (acre inches)	120.4	136.4
Nitrate-N lost in tile (lb/A)	418.6	399.2
N lost via tile lines as a percent of applied N (%)	21	20

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

Waseca, 1992

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 1992. Results from this sixth year showed significant yield improvement over the control with all N treatments, but no differences among the four primary application time/method treatments. Nitrogen efficiency, however, was consistently highest with the spring N treatments. Tile lines flowed from early March through mid-November. Tile flow averaged 6.62" for corn and 8.06" for soybean. Highest NO_3-N losses in the corn plots occurred with the fall application of N without N-Serve while the highest losses under soybean occurred with spring and split application of N to the previous corn crop. Nitrate-N concentrations and losses from continuous fallow plots that did not receive fertilizer N or a planted crop for six years were 70% higher than from the fertilized corn. This was due to moderately 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 soybean.

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 soybean was planted on the other half. Thirty two plots (16 with corn and 16 with soybean) 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 22. Average soil temperature at the 4" depth on that date was 51°F with an average of 47°F over the following 10-day period. Spring preplant treatments were applied on May 6. The sidedress portion (60%) of the split treatments was applied at the V-8 stage on June 26.

The soybean area that was planted to corn in 1992 was field cultivated once before planting. The corn area (1991), however, was fall chiseled and field cultivated once prior to planting soybean. Surface residue accumulation was not estimated in 1992. Because of high soil P and K tests, no broadcast nor starter fertilizer was used.

Corn (Pioneer 3578) was planted at 30,200 plants/acre on May 8 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).

Soybeans (Sturdy) were planted in 30" rows at 9 beans per foot of row on May 8. Weeds were chemically controlled with 3.0 lb/A Lasso preemergence plus a post emergence application of Pursuit (4 oz/A) at the 1st trifoliate stage.

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 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 31) 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

1/ Partial funding provided by Dow Chemical U.S.A., Minnesota Agric. Exp. Stn., and Center for Agric. Impacts on Water Quality.
2/ Professor, So. Exp. Stn.; Professor, Dept. of Soil Science; Assistant Scientist, So. Exp. Stn., Waseca.

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.

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 28. The same technique was used to sample all fallow and corn plots and selected soybean plots on November 16.

RESULTS AND DISCUSSION

Plant

Whole plant N concentration at the silking stage was highly affected by the N treatments (Table 1). This is similar to 1991. Plant N concentrations at silking tended to be higher with the spring N applications compared to fall application but these differences were not statistically significant at the P = 95% level. Dry matter accumulation at silking was increased significantly over the control by all but one of the N treatments with no consistent differences between fall and spring application. Stover N concentration was increased significantly over the control by all spring applications but not by either of the fall-applied treatments. Dry matter yield of the stover at physiological maturity (PM) was increased by all of the N treatments over the control. However, no consistent trend between fall and spring application was observed except that spring-applied N with N-Serve resulted in significantly higher stover yield than all other 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	N	Yield	Population
		%	g/plt	%	TDM/A	ppA x 10^3
Primary trts						
Fall (Oct.)	No	1.19	115	.37	3.06	29.3
Fall (Oct.)	Yes	1.18	122	.39	2.99	29.3
Spr. (April)	No	1.24	116	.44	2.91	29.4
Split[1]	No	1.29	108	.48	3.17	29.4
Additional trts						
Check	-	0.83	98	.34	2.09	29.4
Spr. (April)	Yes	1.29	128	.47	3.71	29.4
Split[1/]	Yes	1.34	118	.50	3.15	29.4
		Statistical Analysis				
Latin square (Primary Trts)						
Signif. Level (%) :		55	64	99	49	8
BLSD (.05) :		-	-	.05	-	-
CV (%) :		8.4	8.8	7.3	7.9	1.4
Completely randomized (7 trts)						
Signif. Level (%) :		99	99	99	99	2
BLSD (.05) :		.17	12	.06	.49	-
CV (%) :		10.	6.7	9.2	11.	1.2

[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). However, grain and silage yields were not significantly different between fall and spring application and between with and without N-Serve. Grain moisture at harvest was not affected by any of the N treatments. Grain N concentration and N removal in the grain were increased over the 0-lb control by all of the N treatments. Even though no significant (P = 95% level) differences between fall and spring application or between with and without N-Serve for grain N or N removal were found, fall application consistently showed less grain N and N removal regardless whether N-Serve was used or not. Total N uptake was increased over the control by 52.1 lb/A (91%) for the fall N without N-Serve, 55.1 lb/A (97%) for the fall N with N-Serve, and over 70 lb/A (129%) with the four spring N treatments.

Total N removal in the grain ranged from 86.3 to 104.0 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 32 to 45% for the six N treatments. Efficiency of the spring treatments ranged from 38 to 45% and was somewhat higher than the 32 and 34% with the fall treatments without and with N-Serve, respectively. Nitrogen efficiency based on total plant uptake ranged from 39 to 58% for the six N treatments. Again, N efficiency with the spring N treatments (46 to 58%) was clearly higher than from the fall treatments (39 to 41%) regardless if N-Serve was used.

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	141.8	31.2	1.28	86.3	6.42	109.1
Fall (Oct.)	Yes	143.8	31.6	1.31	88.9	6.39	112.1
Spr. (April)	No	141.8	32.7	1.40	94.3	6.26	119.7
Split[1/]	No	156.7	31.4	1.36	101.3	6.88	132.1
Additional trts							
Check	-	99.6	32.1	0.91	43.1	4.45	57.0
Spr. (April)	Yes	155.4	33.4	1.36	100.4	7.39	135.6
Split[1/]	Yes	149.9	32.8	1.46	104.0	6.70	135.9
			Statistical Analysis				
Latin square (Primary trts)							
Signif. Level (%) :		46	45	82	45	60	75
BLSD (.05) :		-	-	-	-	-	-
CV (%) :		11.	4.8	5.7	16.	7.8	13.
Completely randomized (7 trts)							
Signif. Level (%) :		99	87	99	99	99	99
BLSD (.05) :		19.8	-	.09	16.5	.85	20.0
CV (%) :		9.8	3.7	5.2	14.	9.5	13.

[1/] 40% preplant + 60% sidedress

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	89.1	22.8	86.3	66.3	20.0	21
Fall (Oct)	Yes	92.3	23.2	88.9	69.1	19.8	22
Spr (April)	No	94.4	25.4	94.3	68.9	25.3	27
Split[4/]	No	90.0	30.8	101.3	59.2	42.1	41
Additional trts							
Check	-	52.9	14.0	43.1	38.9	4.2	8
Spr (April)	Yes	107.5	35.2	100.4	72.3	28.1	28
Split[4/]	Yes	102.5	31.9	104.0	70.6	33.4	31
			Statistical Analysis				
Latin square (Primary trts)							
Signif. Level (%):		6	99	45	32	85	78
BLSD (.05) :		-	3.7	-	-	-	-
CV (%) :		14.	8.2	16.	20.	49.	47.
Completely randomized (7 trts)							
Signif. Level (%):		99	99	99	99	98	83
BLSD (.05) :		18.1	6.3	16.5	15.4	21.1	-
CV (%) :		14.	17.	14.	16.	52.	61.

[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.

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 59 to 92% 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 8% in the check treatment to between 21 and 41% for all treatments receiving fertilizer N. Under the 1992 conditions there was a consistent trend toward greater amounts of post-silk (NEW N) N uptake into the grain with the spring treatments, especially the split treatments. However, these differences were not statistically significant (P = 90% level) due to the high variability (CV = 61%).

The General Linear Model program in SAS was used to "contrast" the four primary treatments and determine if significant differences existed. The significance levels shown in Table 4 show no consistent yield and N efficiency differences among the N-Serve treatments with fall-applied N. Spring application of N showed significant advantages over fall-applied N for stover and grain N concentration, grain N removal, and silage N uptake. With the exception of grain moisture at harvest, there was no difference between the spring preplant and split application of N.

Table 4. Significance levels for differences among the four primary treatments as determined by contrast statistics.

	Contrast		
Parameter	Fall w/o N-Serve vs Fall w/N-Serve	Fall vs Spring	Spring preplant vs Split
	---------- Significance Level (%) ----------		
DM Yield at Silking	73	87	86
Plant N Conc. at Silking	14	80	36
Stover N Conc. at PM	46	99	91
Grain N Conc. at PM	49	99	58
Grain Moisture	40	78	92
Grain Yield	18	69	89
Stover Yield	23	5	71
Silage Yield	5	42	85
Final Population	8	58	0
Grain N Removal	25	92	61
Silage N Uptake	24	96	78

Water

Weather conditions during the 1992 growing season were colder than normal but were 7.5" wetter than normal. Rainfall during April through October totaled 2.62" above normal. This resulted in tile flow from March 5 through November 16. Tile drainage volumes shown in Table 5 indicate highest flows in April, June and October. Drainage from the 16 corn plots averaged 6.62" with a 1.88" range among the four time/method treatments. Soybeans showed slightly more tile drainage compared to corn with an average of 8.06" from the 16 plots and a range of 1.29" among the four time/methods. Ideally, drainage should be uniform among the time/method treatments; however, normal soil and drainage variability exists in these plots and results in these unfortunate differences.

Monthly flow-weighted NO_3-N concentrations in the corn plots ranged from 10 to 15 mg/L in March and April but increased slightly to 13 to 19 mg/L in July (Table 6). Nitrate-N concentrations generally decreased after July to November when concentrations ranged from 8 to 14 mg/L. Nitrate-N concentrations in the spring and early summer months were generally highest with the fall-applied N treatments while highest concentrations in the fall were noted with the spring and split treatments. Flow-weighted NO_3-N concentration for the year was highest for the fall treatment without N-Serve and the split application treatment. In the soybean plots, where N had been applied either in the fall of 1990 or spring of 1991, NO_3-N concentrations were consistently lower throughout the season and seldom averaged greater than 10 mg/L. The fall treatments did not produce any change in NO_3-N concentration over the 9-month period whereas NO_3-N concentrations in the spring treatments started at about 7.5 mg/L in March, rose to 11 mg/L in July and declined to about 6 mg/L in November. Highest flow-weighted annual NO_3-N concentrations were associated with the spring and split treatments applied to corn the previous year. Nitrate-N concentrations under a 6-year continuous fallow system (no fertilizer N applied) were approximately 2x and 4x higher as from corn and soybean, respectively, over the 9-month flow period.

Under corn, slightly higher NO_3-N losses occurred with the fall application without N-Serve compared to the remaining treatments (Table 7). Little difference was observed among the NO_3-N losses from the fall with N-Serve, spring and split treatments. Nitrate-N losses under soybean were highest for the spring and split application treatments that were applied for the 1991 corn crop. This was due primarily to higher NO_3-N concentrations with these two treatments. Very high NO_3-N losses occurred under the fallow system where 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 5. Tile water discharge from the corn, soybean, and fallow plots in 1992.

N application		Month									Year
Time	N-Serve	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
		acre-inches									
		CORN									
Fall (Oct.)	No	0.64	2.13	0.26	1.10	0.01	0.01	0.07	1.90	0.93	7.05
Fall (Oct.)	Yes	0.62	2.07	0.23	0.83	0.04	0.08	0.09	2.10	1.27	7.33
Spr. (April)	No	0.64	1.93	0.31	1.00	0.01	0.03	0.07	1.67	1.01	6.67
Split	No	0.47	1.38	0.05	1.01	0.04	0.16	0.01	1.54	0.79	5.45
		SOYBEANS									
Fall (Oct.)[1/]	No	1.73	1.82	0.28	1.42	0.10	0.06	0.03	1.54	1.11	8.09
Fall (Oct.)[1/]	Yes	1.85	2.05	0.30	1.69	0.10	0.02	0.03	1.59	1.18	8.81
Spr. (April)[1/]	No	1.53	1.83	0.21	1.37	0.12	0.14	0.01	1.34	0.97	7.52
Split[1/]	No	1.51	1.94	0.25	1.59	0.07	0.01	0.05	1.33	1.08	7.83
		FALLOW									
NONE		1.02	1.61	0.20	0.94	0.07	0.01	0.01	0.74	0.69	5.29

[1/] N applied for the 1991 corn crop.

Table 6. Flow-weighted NO_3-N concentrations for each month from the corn, soybean, and fallow plots in 1992.

N application		Month									Year
Time	N-Serve	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Avg.
		mg NO_3-N/L									
		CORN									
Fall (Oct.)	No	14.1	14.9	13.3	17.3	18.8	15.4	13.8	12.5	12.5	13.1
Fall (Oct.)	Yes	11.7	11.7	15.0	14.7	12.7	13.0	10.3	8.1	7.8	10.1
Spr. (April)	No	10.6	10.0	9.8	11.8	13.5	11.8	10.4	10.6	13.5	11.1
Split	No	12.8	13.0	7.4	15.7	17.4	14.9	15.8	11.7	10.7	13.4
		SOYBEANS									
Fall (Oct.)[1/]	No	6.3	5.2	4.9	6.0	5.2	6.0	5.1	6.1	6.0	5.4
Fall (Oct.)[1/]	Yes	6.6	5.5	5.9	6.0	5.2	7.4	6.1	5.3	4.4	5.6
Spr. (April)[1/]	No	7.0	7.4	11.4	8.4	10.8	11.2	13.3	7.0	5.9	8.6
Split[1/]	No	7.6	8.4	8.4	9.5	8.0	10.7	9.0	8.1	7.2	8.4
		FALLOW									
NONE		25.0	32.0	21.4	27.9	15.1	24.8	29.0	28.6	21.0	25.1

[1/] N applied for the 1991 corn crop.

Table 7. Nitrate-N loss for each month from the corn, soybean and fallow plots in 1992.

N application		Month									Year
Time	N-Serve	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
		lb NO_3-N/A									
		CORN									
Fall (Oct.)	No	2.02	6.67	0.78	3.94	0.01	0.05	0.23	4.87	2.36	20.93
Fall (Oct.)	Yes	1.62	5.29	0.67	2.90	0.11	0.23	0.16	3.64	2.13	16.75
Spr. (April)	No	1.57	4.41	0.70	2.68	0.03	0.08	0.17	4.14	2.99	16.77
Split	No	1.53	4.40	0.09	3.65	0.14	0.52	0.05	4.14	2.05	16.57
		SOYBEANS									
Fall (Oct.)[1/]	No	2.46	2.12	0.34	1.84	0.11	0.07	0.03	1.69	1.22	9.88
Fall (Oct.)[1/]	Yes	2.90	2.53	0.38	2.17	0.11	0.03	0.04	1.66	1.20	11.02
Spr. (April)[1/]	No	2.72	3.64	0.62	2.96	0.29	0.24	0.06	2.36	1.79	14.68
Split[1/]	No	2.78	3.89	0.59	3.36	0.14	0.03	0.13	2.43	1.62	14.97
		FALLOW									
NONE		5.75	9.88	0.98	5.44	0.23	0.02	0.08	4.42	3.34	30.12

[1/] N applied for the 1991 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 8). Normalized values for corn were highest for the fall w/o N-Serve and split application treatments with no difference between them. In the year following corn and its associated treatments, normalized losses ranked in the order split = spring preplant > fall w/N-Serve = fall w/o N-Serve. Apparently, sufficient N was not utilized by the corn and remained in the soil profile following the split and spring applications; thus, higher NO_3 losses in the succeeding year. Normalized NO_3-N losses for the corn-soybean system were highest for the two spring application treatments and lowest for the fall w/N-Serve treatment. Additional years with adequate drainage losses are necessary to determine if these findings are consistent over time.

Table 8. "Flow-normalized" NO_3-N losses to tile drainage in a corn-soybean sequence in 1992.

Crop[1/] System	Time/Method of N Application: Fall No N-Serve	Fall N-Serve	Spring No N-Serve	Split
	NO_3-N Lost (lb/A/inch of drainage)			
Corn	2.97	2.28	2.51	3.04
Soybean	1.22	1.25	1.95	1.92
C-Sb System	2.04	1.72	2.22	2.38

[1/] Continuous fallow (6 years without fertilizer N) = 5.69

Soil

Nitrate-N remaining in the 0-8' soil profile in late-April was high in the fallow plots (214 lb/A) compared to those where soybean was grown in 1991 (Table 9). Soybean that had not received fall-applied N averaged 98 lb/A with 52 lb/A remaining in the top 5'. Distribution of NO_3 within the profile was markedly different among the crop/fallow systems. In the fallow plots NO_3-N concentration increased with depth to 4 feet and then remained consistently high. With soybean, NO_3-N concentrations were highest in the surface foot, decreased in the 1-3' layer, and then increased slightly throughout the rest of the profile.

Table 9. Nitrate-N in the soil profile in April, 1992 as influenced by previous crop in 1991.

Profile depth	1991 Crop: Fallow	Soybean
feet	lb/A	
0 - 1	11.3	13.7
1 - 2	15.4	6.2
2 - 3	22.6	8.3
3 - 4	32.5	10.3
4 - 5	41.4	14.0
5 - 6	37.9	13.1
6 - 7	29.0	15.2
7 - 8	23.5	16.9
Total in		
0 - 5' profile	123.2	52.5
0 - 8' profile	213.6	97.7

A comparison of the residual NO_3 amounts found in April, 1992 (Table 9) with those amounts found in the same plots in October, 1991, shows the spring NO_3 levels to be approximately 25% less for the fallow plots.

Residual NO_3-N remaining in the 0 to 5' profile after the 1992 season shows very low amounts of NO_3 and somewhat less than after the 1991 season (Table 10). This was not surprising considering the high amount of rainfall and subsequent leaching in both years. Residual NO_3 in the fallow plots was reduced 41% in the 0-5' profile and 42% in the 0-8' profile in this one-year period. The low amounts of NO_3 found in all of the corn plots showed no large differences among time/method of application or between the N-Serve treatments. The spring preplant application of N with N-Serve, however, did show slightly higher amounts of residual NO_3 in the top four feet. Residual NO_3-N levels for the fallow plots were slightly lower in October than in April (Table 9).

Table 10. Residual NO_3-N remaining in the 0-8' soil profile after harvest as influenced by time of N application and N-Serve.

Profile depth	Fallow	Check	Application Time: N-Serve Fall	N-Serve Preplant	N-Serve Split	No N-Serve Fall	No N-Serve Preplant	No N-Serve Split
feet	lb NO_3-N/A[1/]							
0-1	21.6	10.3	5.5	15.0	13.4	8.2	9.0	6.7
1-2	18.9	6.0	4.3	7.1	8.8	3.5	4.2	5.0
2-3	17.7	2.3	4.7	13.2	4.7	2.3	4.9	3.9
3-4	18.7	2.7	3.7	6.3	5.2	2.5	7.5	4.2
4-5	19.1	3.2	4.6	7.6	6.6	7.2	6.8	5.6
5-6	22.8	4.2	5.4	8.8	6.6	8.6	7.8	7.3
6-7	19.6	6.0	7.9	9.9	10.7	10.0	7.4	8.9
7-8	25.2	11.3	8.6	7.1	7.7	12.6	8.1	9.7
Total in								
0-5' profile	96	24	23	49	39	24	32	26
0-8' profile	164	46	44	75	64	55	56	51

[1/] Avg. of 4 replications

CONCLUSIONS

The cold and wet conditions resulted in fair corn production and adequate tile drainage. Corn production was greatly improved by the various N treatments over the control. Corn grain and silage production was not influenced by time of application (fall, spring or split) or by the inclusion of N-Serve with the fall-applied anhydrous ammonia. Nitrogen uptake (efficiency) was consistently higher with the spring and split treatments, however. Tile flow data indicated only small differences among the four N treatments with respect to amount of drainage but did show slightly elevated NO_3-N concentrations and losses with the fall application w/o N-Serve and split application compared to the single spring application and fall application w/N-Serve. Nitrate-N concentrations and losses in the drainage water in the "residual" year with soybeans were much lower but were highest with the previous spring and split application treatments. Residual soil NO_3 at the end of the season was low except in the fallow plots. These data again indicate the importance of growing a crop to utilize the N mineralized from these high organic matter soils.

DECLINE RATES OF SOIL TEST P AND K IN A CORN-SOYBEAN ROTATION[1]

1992

G. W. Randall and S. D. Evans[2]

ABSTRACT: Decline rates of soil test P and K are being measured following 12 years of various application rates of P and K at two locations. Soil test P declined by about 10% at both Waseca and Morris in 1992. Soil test K increased by 10% at Waseca and decreased by 15% at Morris. Soybean yields were increased 28 to 62% over the long-term control plots at the two sites when soil test Bray P_1 was greater than 22 lb/A. Soil K tests of >300 lb/A at Waseca resulted in 6 to 8 bu/A higher yield than plots testing about 250 lb K/A. Over the 6-year (1986-92) period soil test P declined by 1.3, 4.2 and 5.4 lb/A/yr when no fertilizer P was applied to soils testing 16, 48 and 89 lb/A initially at Waseca. Soil test K varied considerably from year to year and did not allow consistent decline rate calculations. At Morris soil P declined by 4.7 lb/A/yr when the initial Bray P_1 test was 66 lb/A.

With good fertilization practices over the last 20 to 30 years, many farmers throughout the Cornbelt have built their P and K soil tests to high and very high levels. Studies conducted over the last 12 years have not shown corn and soybean yield increases from additional broadcast P and K at these high to very high test levels. Consequently, a number of farmers have curtailed P and K fertilization on these high testing soils. Two commonly asked questions in this scenario are: (1) How fast will my soil test drop if I don't continue to add fertilizer P and K and (2) At what test level should I begin to add P and K to maintain fertility at an optimum level for efficient and economical production? The purposes of this study are to determine (1) the decline rates of soil test P and K and (2) the optimum soil test level which should be maintained for economical corn and soybean production.

EXPERIMENTAL PROCEDURES

High rates of P and K were applied over a 12-year period (1973-84) in studies at the Southern Experiment Station at Waseca (Table 2) and the West Central Experiment Station at Morris (Table 3). These rates created a wide range of soil test values upon which we can evaluate the decline rates of soil test P and K when no additional fertilizer is added. Treatments 2, 3, and 4 have not received additional P since 1984 while treatments 6 and 7 at Waseca have not received K. The K treatments were not included at Morris because of very high native soil test K levels. Treatment 5, which had a moderately high level of fertilization prior to 1985, continues to receive P and K, and thus, serves as the high fertility control. The P and K materials (0-46-0 and 0-0-60) were broadcast on the soil surface and incorporated by chisel plowing the corn residue in the fall of 1991 10. Specific experimental procedures used for soybeans at the two locations are presented in Table 1. Management practices providing for optimum yields were employed at each location. Starter fertilizer was not used.

Table 1. Experimental procedures for soybeans on the high P and K rate study at the two branch stations in 1992.

Variable	Location	
	Morris	Waseca
Planting date	5/12	5/13
Row spacing	30"	30"
Planting rate (plants/A)	10-12 seeds/ft	9-10 seeds/ft
Variety	Evans	Sturdy
Herbicide	3# Lasso (Bdct)	3# Lasso + 4 oz Pursuit/A (Bdct)
Harvest date	10/25	10/14
Soil type	Aastad clay loam	Webster clay loam

RESULTS AND DISCUSSION

Total phosphate (P_2O_5) and potash (K_2O) applied over the 12-year period ranged from 0 to 1200 lb/A (Tables 2 and 3). These application rates plus the 1985-91 rates resulted in highly significant differences in soil test P at both locations and soil test K at Waseca. At Waseca soil test P ranged from 7 to 86 lb/A (Table 2). Soil test P declined about 10% compared to 1991, but soil test K increased by 10% even though K was not applied. Soybean yields were increased significantly by P but plateaued at soil P levels higher than 22 lb/A. Soybean yield was also reduced about 6 to 8 bu/A where K was not added and soil test K was less than 260 lb/A.

[1] Funding provided by the TVA-National Fertilizer Development Center.

[2] Soil scientists and professors at the Southern Experiment Station (Waseca) and West Central Experiment Station (Morris), respectively.

At Morris, Bray P_1 ranged from 9 to 67 lb/A while Olsen's $NaHCO_3$ test ranged from 11 to 55 lb P/A (Table 3). Soil test P values declined about 10% at Morris, while soil K values decreased about 15%. Soybean yields at the Bray P_1 levels of 9 and 20 lb/A were significantly lower than those from the plots testing 41 lb/A and above.

Table 2. Soil test values, seed moisture, and seed yield as influenced by 19 years' application of P and K at Waseca.

	P and K Treatments				Soil Test[2]			Seed	
	Total								
No.	1973-84		1985-91[1]		pH	P	K	Moisture	Yield
	- - - - - - - lb P_2O_5 + K_2O/A - - - - - - -					- - - - lb/A - - - -		%	bu/A
2	0	+ 1200	0	+ 100	6.9	7	316	9.5	34.5
3	600	+ 1200	0	+ 100	6.7	22	349	9.8	42.6
4	1200	+ 1200	0	+ 100	6.9	57	309	10.1	43.1
5	600	+ 1200	100	+ 100	6.8	86	319	10.4	45.3
6	1200	+ 0	100	+ 0	7.0	84	247	9.7	37.1
7	1200	+ 600	100	+ 0	7.0	85	259	9.7	39.4
Signif. Level (%):					22	99	99	86	97
BLSD (.05) :					-	12	32	-	7.0
CV (%) :					3.3	12.	5.9	3.9	8.8

[1] Treatments applied each fall. P was discontinued for treatments 6 & 7 in 1988.
[2] Samples were taken in October before 1992 treatments were applied.

Table 3. Soil test values, seed moisture, and seed yield as influenced by 19 years' application of P and K at Morris.

	P and K Treatments			Soil Test[2]			Seed	
	Total							
No.	1973-84	1985-91[1]	pH	P_1	P_{ol}	K	Moisture	Yield
	- - - - lb P_2O_5 + K_2O/A - - - - -			- - - - - - - lb/A - - - - - - -			%	bu/A
2	0 + 1200	0 + 100	7.8	9	11	484	9.8	27.2
3	600 + 1200	0 + 100	7.9	20	18	402	10.0	34.0
4	1200 + 1200	0 + 100	7.8	41	31	428	9.9	43.1
5	600 + 1200	100 + 100	7.8	67	55	436	10.0	44.6
Signif. Level (%):			-	99	99	94	24	99
BLSD (.05) :			-	25	19	-	-	9.1
CV (%) :			-	45.	41.	8.2	2.6	15.

[1] Treatments applied each fall.
[2] Samples were taken in October before 1992 treatments were applied.

SIX-YEAR SOIL TEST DECLINE RATES

Regression analysis was used to assess the average decline rates for Bray P_1 and exchangeable soil test K at Waseca and Bray P_1 at Morris. Soil test data from each of the plots in treatments 2, 3 and 4, which have not received fertilizer P since 1984, were included for the 6-year period (1986-1992) for both sites. Similarly, soil test data for each of the plots in treatments 6 and 7, which have not received fertilizer K since 1984, were included for the 6-year period at Waseca. Both soil test P and K were included from all plots in treatment 5, which received 100 lb P_2O_5/A + 100 lb K_2O/A annually.

Soil Bray P_1 change over the 6-year period at Waseca is shown by each of the lines in Fig.1. Average soil P test for each of the treatments in any particular year is shown by the appropriate symbol. Coefficients of determination (R^2) indicate highly significant relationships (99% level) for the treatments where fertilizer P was not applied and a significant (95% level) relationship where P was applied (Table 4). Soil test P was shown to decline by 1.3 lb/A/yr when the initial soil test was 16 lb/A. At initial soil test values of 48 and 89 lb/A, soil Bray P_1 declined by 4.2 and 5.4 lb/A/yr, respectively, in this corn-soybean rotation. Annual additions of 100 lb P_2O_5/A increased the soil test an average of 4.3 lb/A/yr when the initial test was 62 lb/A.

No relationship was found between the exchangeable soil K test and time (years after 1986) when 100 lb K_2O/A was applied annually (trt 5) or with treatments 6 and 7 (Fig. 2). Soil test K was extremely variable over this period as shown by the symbols in Fig. 2. Very high K levels were found in 1988, 1991 and 1992 while K tests were much lower in 1987 and 1990.

At Morris, soil test P variability was high and decline rates could not be calculated from the regression equations, which were not significant, for treatments 2 and 3. However, soil P did decline by 4.7 lb/A/yr when P was not added to the plots that initially tested 66 lb P/A. This decline rate was slightly less than at Waseca where soil P test was also very high.

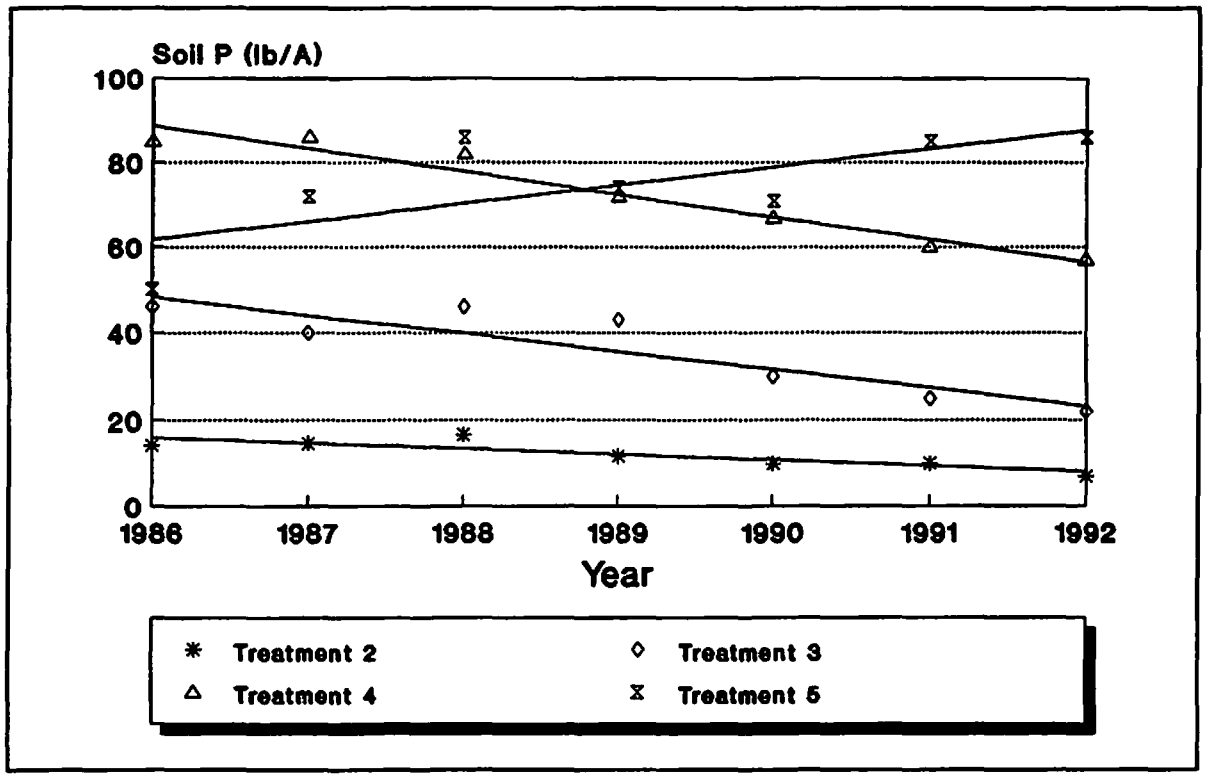


Figure 1 Decline rate of soil P over a 6-year period as influenced by P treatment at Waseca.

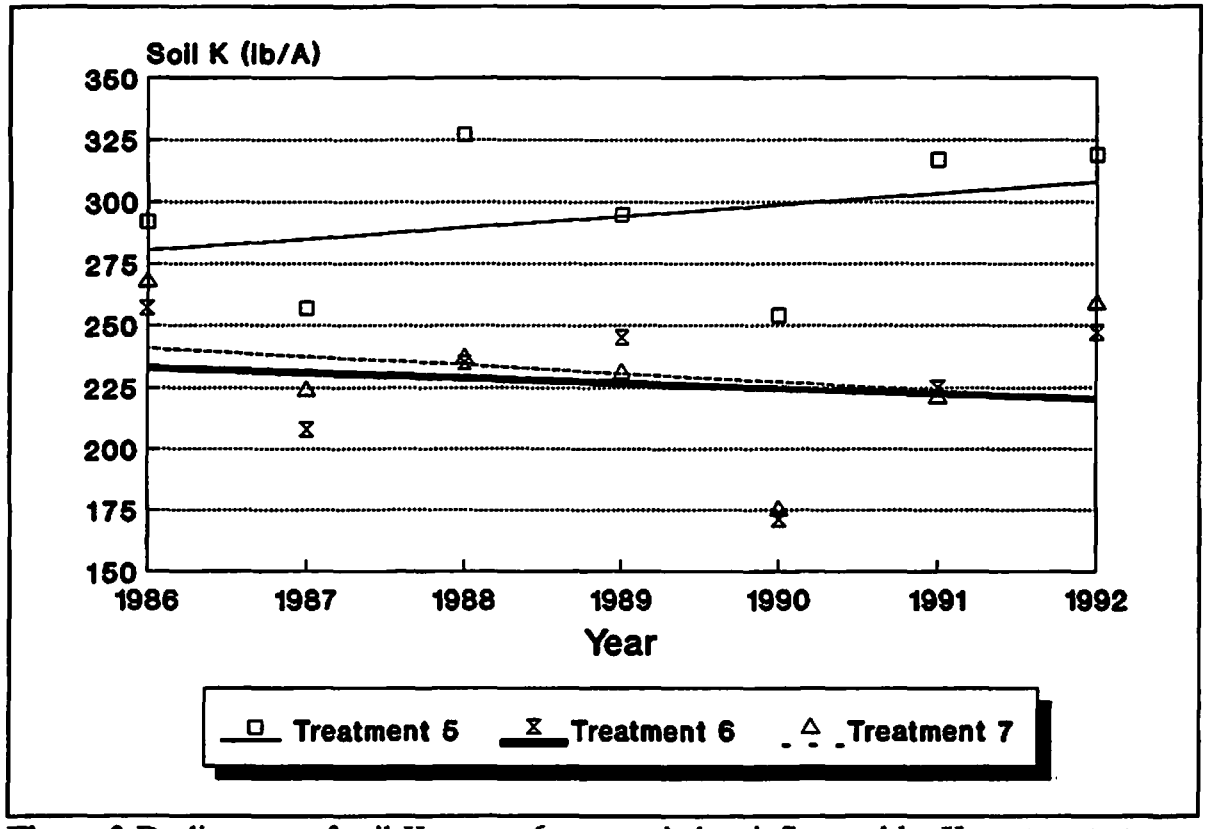


Figure 2 Decline rate of soil K over a 6-year period as influenced by K treatment at Waseca.

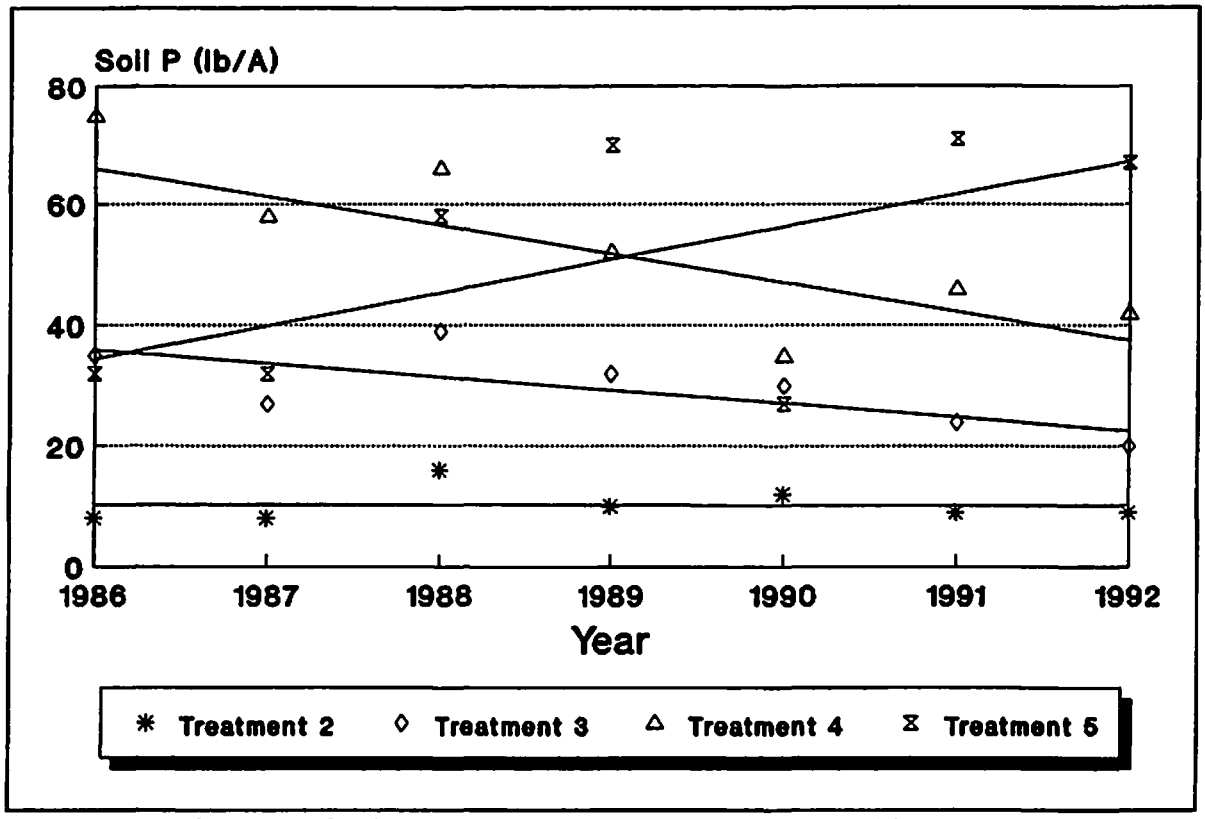


Figure 3 Decline rate of soil P over a 6-year period as influenced by P treatment at Morris.

Table 4. Linear regression equation and coefficient of determination (R^2) for the various P and K treatments at Waseca and Morris.

Location	Nutrient	Treatment	Regression Equation[1/]			R^2
Waseca	P	2	ST =	16.1	1.31 X	56.6**
"	P	3	ST =	48.2	- 4.15 X	65.0**
"	P	4	ST =	88.7	- 5.38 X	86.3**
"	P	5	ST =	61.8	+4.30 X	30.0*
"	K	5	ST =	280.5	+4.58 X	5.2^{NS}
"	K	6	ST =	233.0	- 2.10 X	1.2^{NS}
"	K	7	ST =	240.8	- 3.42 X	3.3^{NS}
Morris	P	2	ST =	10.3	- 0.02 X	0.0^{NS}
"	P	3	ST =	36.0	- 2.22 X	8.2^{NS}
"	P	4	ST =	66.0	- 4.74 X	35.6**
"	P	5	ST =	34.5	+5.45 X	19.7*

[1/] ST = Soil Test (lb/A), X = Years

CONCLUSIONS

Long term (12-yr) additions to these two soils created a wide range in soil test P levels. Soybean yields were optimized over the no P treatments at soil test P levels of 22 lb/A or higher at Waseca. Yields were consistently higher at Waseca when soil K tested >300 lb/A compared to those plots testing around 250 lb K/A. At Morris, soybean yields were improved about 16 bu/A with soil test P levels of 41 lb P/A and higher. Soil test P declined by about 10% at both Waseca and Morris. Soil test K was increased by about 10% at Waseca and decreased by about 15% at Morris in 1992. Over the 6-year period (1986-92), soil Bray P_1 tests declined by 1.3, 4.2 and 5.4 lb/A/yr when no fertilizer P was applied to these soils initially testing 16, 48 and 89 lb/A, respectively, at Waseca. When 100 lb P_2O_5/A was added annually, soil Bray P_1 increased by 4.3 lb/A/yr when the initial test was 62 lb/A. At Morris, soil test P was more variable, but soil P declined by 4.7 lb/A/yr when the initial Bray P_1 was 66 lb/A. Because of extremely high soil test K variability from year to year, it was difficult to show a consistent soil test change over time. This information on soil test decline rates when fertilizer is not applied should be very helpful to farmers who are considering omitting fertilizer P for a few years when their soils test high in P.

NITROGEN FERTILIZATION OF ESTABLISHED REED CANARYGRASS

Waseca, 1992

G. W. Randall, M. P. Russelle, and B. W. Anderson[1/]

ABSTRACT: Recently developed low-alkaloid varieties of Reed canarygrass are being considered as an alternative forage for dairy enterprises. This one-year study was conducted to determine the optimum nitrogen (N) rate for Reed canarygrass and whether a split application would be superior to a single application. Forage yields and N concentration in the forage (quality) were optimized at the 250-lb N rate. Total N uptake and protein levels (as high as 19.5%) were maximized at the 300-lb N rate. Residual soil NO_3-N in the 0-3' profile after the third cutting was not affected by any of the fertilizer N rates. Based on these 1-year data Reed canarygrass production can be optimized with N rates from 250 to 300 lb/A without impact on NO_3 leaching from the rooting profile.

Research conducted in Iowa in the early 70's indicated that Reed canarygrass contained high concentrations of N and utilized fertilizer N very efficiently when fertilized with ample N. The purpose of this study was to determine the optimum rate of N and whether split application was advantageous over a single application for an established stand of low-alkaloid Reed canarygrass.

EXPERIMENTAL PROCEDURES

Reed canarygrass (var. Palaton) was established in 24 plots each measuring 24' x 54' in August 1990. These plots were intended for use in 1991 as part of a graduate thesis study. Because these plots were not used, they were maintained without additional fertilization and were harvested three times during 1991.

In early May 1992, 16 plots with the most uniform stand of Reed canarygrass were selected and fertilized with varying rates of N as ammonium nitrate (Table 1). After the first cutting on June 5, the main plots were split into four subplots. Four rates of N (0, 50, 100 and 150 lb/A) as ammonium nitrate were applied on June 9 to the subplots. The split-plot experimental design used for the second (July 20) and third (Oct. 29) cuttings was randomized four times on this Webster clay loam soil.

Yields were taken by harvesting two 3' x 50' swaths from each main plot for the first cutting and one 3' x 24' swath from each subplot for the second and third cuttings. Subsamples from the forage were taken for moisture and total Kjeldahl N analyses. The total N analysis was conducted by the Research Analytical Laboratory in St. Paul.

Soil samples were taken from one plot within each replication to a 5-foot depth on May 6 for NO_3-N analyses. On November 12, three cores per plot were taken to a 3-foot depth from the control and the six treatments that received 200 lb N/A or more. All soil samples were immediately forced-air dried at 125°F, ground and analyzed for NO_3-N by the Research Analytical Laboratory.

RESULTS AND DISCUSSION

Yield

First cutting dry matter yields were increased significantly over the control by all of the May N treatments with no difference among the 50, 100 and 150-lb rates (Table 1). Dry conditions (2.97") during the 30-day period between N application and harvest may have limited the degree of response to the topdressed treatments.

Second cutting yields were increased significantly by both the May and June applications. The significant May x June interaction indicated that yields were increased by all of the June N rates when rates of 0 and 50 lb N/A were applied in May but not with the 100 and 150-lb June rates coupled with the 100 and 150-lb May rates. The 150-lb May rate without a June application gave a yield that was significantly less than the 150-lb rate applied in June when no N was applied in May. This latter treatment was sufficient for maximum yield. Third cut yields responded only to the 150-lb rate applied in May and to the 100 and 150-lb rates applied in June. There was no interaction between the May and June rates of application.

Total dry matter yield was maximized at the 250-lb N rate. Under this year's weather conditions, Reed canarygrass yields were impacted more with the June application than the May application. However, both application times increased yields significantly. Perhaps an application in mid-April prior to plant growth would have had a greater effect on first cut and total yield. The highly significant interaction for the May x June time of application is similar to that found with the second cutting. Total yield did not continue to increase with the 150-lb rate applied in June when 150 lb N/A had also been applied in May.

N Concentration

Total N concentration in the first cutting forage was increased significantly by each of the N rates applied in May (Table 2). In the forage from the second cutting, total N concentration was increased significantly up through the 100-lb rate applied in May and with all N rates applied in June. No interaction between the May and June applications indicated that the highest N concentration was achieved with the 150-lb rate applied in June regardless of the May treatments. Total N in the third cutting was not influenced by the May treatments but was significantly increased by only the 150-lb rate applied in June.

[1/] Professor, Southern Experiment Station, Waseca; Soil Scientist, USDA-ARS-US Dairy Forage Research Center, St. Paul; Asst. Scientist, Southern Experiment Station, Waseca.

Table 1. Dry matter yield of Reed Canarygrass as influenced by N fertilization at Waseca in 1992.

Rate/Time of N Applc'n		Cutting Number & Date			
		1st	2nd	3rd	
May 7	June 9	6/5	7/20	10/29	Total
lb N/A		Tons DM/A			
0	0	1.05	0.52	0.21	1.78
0	50		1.61	0.36	3.02
0	100		2.29	0.43	3.77
0	150		2.75	0.60	4.40
50	0	1.46	1.04	0.27	2.77
50	50		2.12	0.32	3.90
50	100		2.49	0.42	4.37
50	150		2.83	0.50	4.79
100	0	1.44	1.45	0.31	3.20
100	50		2.34	0.32	4.10
100	100		2.73	0.58	4.75
100	150		2.81	0.69	4.94
150	0	1.62	1.65	0.45	3.72
150	50		2.53	0.48	4.63
150	100		2.84	0.78	5.24
150	150		2.71	0.87	5.20
Individual Factors					
May N Rate					
0		1.05	1.79	0.40	3.24
50		1.46	2.12	0.38	3.96
100		1.44	2.33	0.48	4.25
150		1.62	2.43	0.65	4.70
Signif. Level (%):		99	99	93	99
BLSD (.05) :		0.33	0.17	-	0.57
June N Rate					
0		-	1.16	0.31	2.87
50		-	2.15	0.37	3.91
100		-	2.59	0.56	4.54
150		-	2.77	0.67	4.83
Signif. Level (%):		-	99	99	99
BLSD (.05) :		-	0.12	0.24	0.14
Interaction		Signif. Level (%)			
May x June Applc'n		-	99	43	99
CV (%):		14.	8.4	26.	5.6

Table 2. Nitrogen concentration in and N uptake by Reed Canarygrass as influenced by N fertilization in 1992.

Rate/time of N application		N Concentration			N Uptake		
May 7	June 9	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut
lb N/A		%			lb N/A		
0	0	1.70	1.68	1.47	36.1	17.5	6.2
0	50		1.90	1.34		60.6	9.6
0	100		2.29	1.27		104.9	10.8
0	150		2.87	1.41		157.6	16.9
50	0	2.48	1.67	1.40	72.1	34.8	7.4
50	50		2.07	1.40		87.7	8.8
50	100		2.47	1.36		122.8	11.5
50	150		2.76	1.58		156.5	16.2
100	0	2.82	1.87	1.37	81.0	54.4	8.6
100	50		2.16	1.28		101.2	8.2
100	100		2.67	1.44		146.5	16.4
100	150		2.80	1.50		157.1	20.6
150	0	3.10	2.14	1.39	99.8	70.9	12.8
150	50		2.30	1.39		116.0	13.2
150	100		2.46	1.40		139.9	21.2
150	150		3.12	1.86		169.0	32.2
Individual Factors							
May N Rate							
0		1.70	2.19	1.37	36.1	85.2	10.9
50		2.48	2.24	1.43	72.1	100.5	11.0
100		2.82	2.38	1.40	81.0	114.8	13.4
150		3.10	2.51	1.51	99.8	123.9	19.8
Signif. Level (%):		99	97	80	99	99	98
BLSD (.05) :		0.24	0.23	–	18.1	14.0	6.4
June N Rate							
0		-	1.84	1.40	-	44.4	8.7
50		-	2.11	1.35	-	91.4	9.9
100		-	2.47	1.36	-	128.5	14.9
150		-	2.89	1.59	-	160.0	21.5
Signif. Level (%):		-	99	99	-	99	99
BLSD (.05) :		-	0.14	0.10	-	8.2	2.4
Interaction							
May x June Applc'n		-	73	80	-	98	93
CV (%):		6.1	9.2	11.	16.	12.	27.

N Uptake

Total N uptake for all cuttings was significantly increased by the May and June treatments (Table 2). The 150-lb N rate at each time of application resulted in the highest N uptake for all cuttings. However, the significant May x June interaction indicated a greater increase in N uptake with the high rates of June-applied N when no N was applied in May compared to when N was applied in May.

Total N uptake for the three crops was very high and related well to the N rates applied (Table 3). Apparent N recovery was also very high with values of 80% or more for all of the treatments. Highest percent recovery was generally obtained with the split applications; a single application of 100 or 150 lb N/A in May resulted in somewhat lower recoveries.

Table 3. Total N uptake and nitrogen use efficiency of Reed canarygrass as affected by N treatments in 1992.

Rate/Time of N Application		Total N	Apparent N[1/]
May 7	June 9	Uptake	Recovery
---------- lb N/A	----------	lb N/A	%
0	0	59.8	-
0	50	106.3	93
0	100	151.8	92
0	150	210.6	100
50	0	114.3	109
50	50	168.6	109
50	100	206.4	98
50	150	244.8	92
100	0	144.0	84
100	50	190.4	87
100	100	243.9	92
100	150	258.7	80
150	0	183.5	82
150	50	229.0	85
150	100	260.9	80
150	150	301.0	80

[1/] (Total N uptake - N uptake from control) ÷ Total N applied.

Soil Residual Nitrate-N

Soil samples taken on May 6 indicated very low amounts of NO_3-N in the 0-5' profile (13.0 lb/A). Samples taken in mid-November showed no impact of any of the N treatments on NO_3-N remaining in the 0-3' profile (Table 4). Reed canarygrass was capable of scavenging essentially all of the NO_3 from the soil system even when 300 lb N/A had been applied.

Table 4. Nitrate-N remaining in the 0-3' soil profile on Nov. 12 as influenced by N rates applied to Reed canarygrass.

N rate applied on:		NO_3-N in Soil Profile			
May 7	June 9	0 - 1'	1 - 2'	2 - 3'	0 - 3'
---------- lb/A	----------	---------- lb NO_3-N/A	----------	----------	----------
0	0	10.5	5.1	5.7	21.3
50	150	12.0	6.3	7.3	25.6
100	100	8.9	5.8	7.0	21.7
100	150	10.7	6.5	6.9	24.1
150	50	13.8	7.1	7.0	27.9
150	100	13.7	7.4	7.5	28.6
150	150	12.6	6.2	7.0	25.8

NITRATE REMOVAL FROM THE SOIL PROFILE AS INFLUENCED BY CROP

Waseca, 1992

G. W. Randall, M. P. Russelle, and D. D. Walgenbach[1/]

ABSTRACT: Annual manure applications to the same field can lead to high levels of NO_3-N in the soil profile. The purpose of this first-year study was to determine the ability of four crops (corn, soybean, alfalfa, and Reed canarygrass) to remove NO_3 from the soil profile. Corn yield was excellent but soybean yield was depressed due to severe lodging. Alfalfa and Reed canarygrass yields were also very good in this establishment year. Highest total N uptake was obtained with alfalfa and Reed canarygrass. Nitrate removal from the 0 - 8' profile during the period from April to late October averaged 34, 35, 57 and 62% with corn, soybean, alfalfa and Reed canarygrass, respectively. These results indicate that soil NO_3 levels in the profile, especially in the top four feet, can be reduced considerably in one year by planting either alfalfa or Reed canarygrass.

Livestock producers are sometimes forced to land-apply manure at rates higher than nutrient removal by their crops. As a result nutrients, notably nitrate (NO_3), can accumulate in the soil profile and are susceptible to leaching toward surface and groundwaters. Evidence exists in the literature that alfalfa will scavenge large amounts of NO_3 from the soil rather than symbiotically fix atmospheric N to meet its high N needs. Soybean grown in Goodhue Co. in 1991 was also able to reduce soil NO_3 levels markedly. The purpose of this study was to determine the efficacy of four crops to scavenge NO_3 from soils that contained high levels of NO_3 due to past manure applications.

EXPERIMENTAL PROCEDURES

Liquid dairy manure was applied to a Nicollet clay loam from 1987 thru 1989 to build high levels of NO_3 in the soil profile. A study was established in 1990 to pursue the above objective but failed because of atrazine carryover. Thus, additional manure was applied in the fall of 1990 and spring of 1991 and a bulk crop of corn was grown in both years.

The experiment was re-established in 1992 with the planting of four crops (corn, soybean, alfalfa, and Reed canarygrass). Each plot measured 90' long by 30' wide and was replicated four times in a randomized, complete-block design. Establishment procedures, pesticides used, and harvest dates for each crop are shown in Table 1. Each plot was subdivided into the north 30', center 30' and south 30' to determine if significant variability existed within the individual plots. Crop yields were taken from 27' long sections within the center of each 30' long subplot. Soil samples were taken in 1-foot increments to an 8-foot depth from the center of each subplot in April prior to establishment and again in late October after harvest. Grain, stover, seed or forage samples were taken from each subplot, dried, ground and submitted to the Research Analytical Laboratory for total N analyses. All soil samples were forced-air dried at 125°F immediately after sampling, ground and analyzed for NO_3-N and NH_4-N.

RESULTS AND DISCUSSION

Crop yields, N concentrations, and N uptake by each of the crops are shown in Table 2. Although corn yield was very high, low N concentrations limited total N uptake by corn. The grain was removed while the stover was returned to the soil. Soybean yield was surprisingly low, primarily due to severe lodging that began in late July shortly after flowering started. Apparently the Sturdy variety, known for lodging resistance, was not able to tolerate the high levels of manure-supplied NO_3 in the profile. The severe lodging negated obtaining soybean stover yields. Two cuttings each of alfalfa and Reed canarygrass were taken. Yields in this establishment year were quite good and N concentrations high. As a result N removal by alfalfa (219 lb/A) and Reed canarygrass (189 lb/A) greatly exceeded the N removal by corn (113 lb/A) and soybean (101 lb/A).

Soil NO_3-N in late April was quite uniform among the plots where each of the crops were to be established (Table 3). Most of the variability existed in the 0-5' profile where the amount of NO_3-N ranged from 247 to 309 lb/A. Nitrate-N in the 5-8' profile was substantially higher than in the surface five feet but was much more uniform among the cropped areas. Apparently, much of the NO_3 from the surface four feet was leached into the 5 to 8 foot layer during 1991 when record precipitation was recorded (50.5"). Total NO_3-N in the 0-8' profile ranged from 569 to 645 lb/A.

At the end of the season substantially less NO_3-N remained in the 0-8' profile with the alfalfa and Reed canarygrass crops than with corn or soybean (Table 4). Most of the NO_3 removal occurred in the top four feet. Over 65% and 80% of the NO_3-N in the 0-5' profile at the beginning of the season was not found in the alfalfa and Reed canarygrass plots, respectively, at the end of the season. Presumably, most of the change in soil NO_3-N was due to crop uptake in this year of normal growing season precipitation. Only 46 and 36% of the NO_3-N in the 0-5' layer of the corn and soybean plots, respectively, was not found at the end of the season. In the 5-8' layer, 23, 33, 49 and 46% of the early season NO_3-N was not found after harvest in the corn, soybean, alfalfa and Reed canarygrass plots, respectively. Post-harvest NO_3-N amounts in the 0-8' profile were 66, 65, 43 and 38% of the early-season amounts for corn, soybean, alfalfa and Reed canarygrass, respectively.

CONCLUSIONS

High levels of NO_3-N in the soil did not hamper establishment or yields of corn, alfalfa or Reed canarygrass; however, soybean lodging was severe and yield poor. Total N uptake was markedly higher for alfalfa and Reed canarygrass compared to corn and soybean. In addition, substantially more NO_3 was removed from the 0-8' soil profile with alfalfa and Reed canarygrass than with corn and soybean. Although the majority of NO_3 removal occurred in the top four feet NO_3 reductions from 23 to 49% were found in the 5-8' profile. Very little difference was observed between alfalfa and Reed canarygrass in this establishment year.

[1/] G. W. Randall is Professor, So. Expt. Stn., Waseca; M. P. Russelle is Soil Scientist, USDA-ARS, US Dairy Forage Research Center, St. Paul; D. D. Walgenbach is Superintendent, So. Expt. Stn., Waseca.

Table 1. Experimental procedures for the Nitrate Removal Study in 1992.

Crop	Procedures
Corn	
Secondary Tillage	Field cultivated
Hybrid	Northrup King 4428
Planting rate & date	30,200 on May 1
Row width	30"
Insecticide	Counter at 8.7 #/A
Herbicide - date	3.5 #/A Lasso + 3 #/A Bladex (PE) on May 8
Harvest date	Oct. 20
Fall tillage	Moldboard plow on Nov. 16
Soybean	
Secondary tillage	Field cultivated
Variety	Sturdy
Planting rate & date	9 - 10 beans/ft on May 22
Row width	30"
Herbicide - date	3 #/A Lasso (PE) on June 2
	4 oz/A (2nd trifol.) Pursuit on June 30
Harvest date	Oct. 23
Fall tillage	None
Alfalfa	
Secondary tillage	Field cultivated 2x on April 28
Herbicide	1 gal/A Balan (Incorp.) on April 28
Seeding rate & date	12 #/A on May 1
Harvest dates	1st cutting - July 20
	2nd cutting - Sept. 10
Reed Canarygrass	
Secondary tillage	Field cultivated on April 28
Seeding rate & date	10 #/A on May 1
Harvest dates	1st cutting - July 20
	2nd cutting - Oct. 29

Table 2. Crop yields, N concentration, and N uptake in 1992.

Cropping System	Yield	N Concentration	N Uptake
		%	lb/A
Cont. Corn			
Grain (bu/A)	184.5	1.29	112.6
Stover (lb DM/A)	6008.	0.65	39.0
Total	8.17 T DM/A		151.6
Soybean-C			
Seed (bu/A)	30.5	6.36	101.2
Alfalfa			
1st Cut (lb DM/A)	4315	2.75	118.7
2nd Cut (lb DM/A)	2978	3.38	100.7
Total	7293		219.4
Reed Canarygrass			
1st Cut (lb DM/A)	4466	2.91	129.9
2nd Cut (lb DM/A)	1779	3.35	59.4
Total	6245		189.3

Table 3. Soil NO_3-N amount in the 0-8' profile on April 27, 1992 prior to establishment of the crops.

Depth	Crop to be planted			
	Corn	Soybean	Alfalfa	Reed Canarygrass
feet	lb/A			
0 - 1	47.3	44.6	45.5	57.7
1 - 2	51.6	56.5	47.4	65.4
2 - 3	44.9	44.7	39.8	54.0
3 - 4	42.0	45.7	41.6	55.4
4 - 5	75.5	73.8	72.9	76.4
5 - 6	108.7	108.6	114.7	106.7
6 - 7	103.3	119.5	111.7	123.1
7 - 8	95.3	98.5	132.6	106.5
Total in				
0 - 5	261.3	265.3	247.3	308.9
5 - 8	307.3	326.6	359.0	336.3
0 - 8	568.6	591.9	606.3	645.3

Table 4. Soil NO_3-N amount in the 0-8' profile on October 30, 1992.

Depth	Crop grown			
	Corn	Soybean	Alfalfa	Reed Canarygrass
feet	lb/A			
0 - 1	48.4	47.6	30.8	20.8
1 - 2	22.8	25.6	12.8	8.8
2 - 3	14.0	17.6	8.4	6.4
3 - 4	17.6	31.6	8.8	8.8
4 - 5	38.4	45.6	18.4	16.4
5 - 6	66.8	62.0	41.2	42.8
6 - 7	80.0	73.2	67.2	65.6
7 - 8	90.0	83.2	72.8	73.2
Total in				
0 - 5	141.2	168.0	79.2	61.2
5 - 8	236.8	218.4	181.2	181.6
0 - 8	378.0	386.4	260.4	242.8

WATER QUALITY RESEARCH WITH NITROGEN AT THE HERMAN ROSHOLT WATER QUALITY RESEARCH FARM, WESTPORT, MN 1992 [1]

Small plot phases

G.L. Malzer, T.J. Graff[2]

Abstract: The objective of the **small plot** water quality research phase is to evaluate and quantify the impact of a variety of agricultural practices on crop nitrogen utilization efficiency and the potential impact on water quality. Currently agricultural practices such as crop rotation, tillage, and fertilizer N management including, rates, sources, time of application, methods of application and use of nitrification inhibitors are being evaluated. Corn grain yields were approximately 10% higher when the previous crop was soybeans rather than corn. Corn grain yields were not influenced by tillage systems (chisel-plow vs. ridge-till systems). Nitrogen fertilizer significantly increased corn grain yield when 105 lbs N/A was applied to both continuous corn or corn following soybeans. No yield increase was obtained with N rates over 105 lbs N/A with either system. The weather conditions in 1992 were probability the single most important factor to influence crop production. Corn grain moisture was in excess of 30% at harvest on Oct. 20th.

In 1987 three phases of nitrogen (N) research were started at the Herman Rosholt Water Quality Research Farm at Westport, MN. The three phases of research included a lysimeter phase, a large plot groundwater phase and a small plot N management/crop production phase. The large plot phase was terminated in 1991, and the small plot phases are reported here, the lysimeter phase will be reported separately.

The soil at the Rosholt farm is an Estherville sandy loam with 15-30 inches of sandy loam soil overlying glacial outwash composed mainly of coarse sand and gravel. Because of the coarse nature of these soils and the low water holding capacity, they are frequently irrigated to attain high yields. The higher yield potential along with higher fertilizer inputs, low water holding capacity, and shallow underlying aquifer create conditions which could result in groundwater contamination with nitrate N. Improper fertilizer N management can result in reduced yields, reduced fertilizer use efficiency, decreased profits, and increased groundwater contamination. The purpose of these phases of research was to determine the impacts of different N and crop management practices on crop yield, N utilization and their resulting impacts on groundwater quality.

Experimental Procedures

Small Plot N Management/Crop Production Phase: consisted of 25 N treatments randomized within a split-split plot design with three replications. The main plot consisted of two cropping sequences (continuous corn and corn following soybeans) with the sub-plots being tillage (ridge till and chisel plow). Ridges were constructed in 1987. In 1992 the entire experiment was planted to corn and in 1991 soybeans were planted in the corn-soybean rotation. The 25 N treatments within each sub-plot consisted of a control (zero N) plus four N rates (60, 120, 180, and 240 kg N/ha -- these will be reported as 50, 105 160, and 215 # N/A), two nitrification inhibitors (none and N-Serve) and three times/methods of application (all N early-3 leaf growth stage, all N late-8 leaf growth stage, and split with 2/3 N early and 1/3 N late). All fertilizer N treatments were applied as anhydrous ammonia. Early application was applied on June 2nd and late application was applied on June 29th. The nitrification inhibitor N-Serve was applied with an in-line injection pump which inserted the chemical in front of a bidirectional flow integrator and the manifold. N-Serve was applied at a rate of 0.5 #/A active ingredient.

---

1. Funding provided by the University of Minnesota Agricultural Expt. Station and the Center for the Impacts of Agricultural Practices on Water Quality. Appreciation is also expressed to Pioneer Hybrid International for supplying the seed.
2. Professor and Asst. Scientist respectively, Dept. of Soil Science. University of MN.

Soil samples were taken from 0-1 and 1-2 ft depth from 13 of the 25 treatments on April 23th before planting . The soil samples were analyzed for ammonium and nitrate concentration and the data is reported in table 4. Spring samples were taken on corn following corn and the corn following soybeans check plots.

Corn (Pioneer 3787 - 95 day R.M.) was planted on May 6th in 30 inch rows at a population of 30,700 seeds/A using a two row Hiniker planter. Starter fertilizer was placed below the seed at planting at the rate of 10 gal/A of 7-21-7 and Counter (8 #/A) was banded in the row at planting to control insects. Lasso (1.75 #/A) and Bladex (1.75 #/A) was applied on May 13th for weed control. For additional weed control the corn was cultivated and ridges were built on June 25th. The irrigation program (traveling boom) was started on July 24th with a total of 5 inches of water being applied through irrigation. An additional 11.85 inches of water was obtained during the growing season as rainfall.

Corn grain yields were obtained on October 20th by hand harvesting 100 ft^2 of plot area. All corn grain yields were adjusted to 15.5% . Grain yields and N concentration are reported in table 1,2 and 3.

General Results

Corn grain yields were poor in 1992. The cool growing season resulted in slow crop development and high moisture grain at harvest. Tillage system had no influence on grain yield regardless of previous crop. An N rate of 105 lbs N/A was needed to reach optimum yields in both corn following corn and corn following soybeans sequence. Grain yields following soybeans were approximately 10 % higher than corn yields with previous crop of corn. Time of fertilizer N application and/or the use of a nitrification inhibitor had relatively little influence on crop production. Soil samples collected in the spring indicated that very little residual nitrate-N was present in the soil profile from the applications made the previous year. A portion of the fertilizer-N in excess of crop need was probably moved deeper into the soil profile and toward the groundwater during late fall or early spring.

Table 1. Influence of N-rate, nitrification inhibitors, method of application and tillage on **continuous corn** grain yields, N-concentration, and N removal. Westport, MN. 1992

Total N-Rate	Early N	Inh.	Late N	Tillage	Grain Yield	Grain N-content	Grain N-removal
#/A	#/A		#/A		Bu/A	%	#/A
Control	----	--	----	C	47.7	1.05	23.86
50	50	--	----	C	86.1	1.40	56.97
50	----	--	50	C	82.1	1.28	50.06
50	35	--	15	C	82.1	1.16	45.00
50	50	NS	----	C	78.3	1.17	43.37
50	----	NS	50	C	89.6	1.23	52.11
50	35	NS	15	C	88.5	1.52	63.60
105	105	--	----	C	93.3	1.43	63.11
105	----	--	105	C	90.0	1.40	59.84
105	70	--	35	C	92.8	1.54	67.65
105	105	NS	----	C	92.6	1.31	57.27
105	----	NS	105	C	87.6	1.51	62.41
105	70	NS	35	C	94.8	1.58	70.94
160	160	--	----	C	85.0	1.67	67.10
160	----	--	160	C	91.3	1.44	62.16
160	105	--	55	C	98.1	1.55	71.96
160	160	NS	----	C	85.9	1.70	68.97
160	----	NS	160	C	89.2	1.55	65.44
160	105	NS	55	C	87.6	1.47	61.00
215	215	--	----	C	94.2	1.64	73.13
215	----	--	215	C	92.6	1.46	64.75
215	145	--	70	C	91.7	1.68	72.82
215	215	NS	----	C	95.4	1.65	74.54
215	----	NS	215	C	87.7	1.59	66.17
215	145	NS	70	C	92.9	1.68	73.88
Control	----	--	----	R	45.1	0.99	21.15
50	50	--	----	R	76.9	1.33	48.51
50	----	--	50	R	77.0	1.07	39.19
50	35	--	15	R	81.3	1.33	50.74
50	50	NS	----	R	80.0	1.40	53.14
50	----	NS	50	R	80.7	1.29	49.42
50	35	NS	15	R	82.0	1.49	57.95
105	105	--	----	R	85.3	1.59	64.06
105	----	--	105	R	96.8	1.45	66.22
105	70	--	35	R	88.9	1.49	62.60
105	105	NS	----	R	79.7	1.33	50.08
105	----	NS	105	R	89.2	1.43	60.49
105	70	NS	35	R	84.6	1.39	55.41
160	160	--	----	R	95.4	1.61	72.48
160	----	--	160	R	87.7	1.50	62.19
160	105	--	55	R	87.7	1.63	67.70
160	106	NS	----	R	89.6	1.49	63.37
160	----	NS	160	R	91.1	1.42	61.62
160	105	NS	55	R	82.4	1.55	60.56
215	215	--	----	R	84.3	1.73	68.96
215	----	--	215	R	86.4	1.65	67.37
215	145	--	70	R	88.5	1.65	69.11
215	215	NS	----	R	89.6	1.61	67.99
215	----	NS	215	R	85.9	1.42	57.72
215	145	NS	70	R	91.7	1.55	67.40

Table 1. continued. Continuous Corn Split Plot Statistical Analysis

	Corn Grain		
	Yield	N-Content	N-Removal
	Bu/A	%	#/A
Tillage			
Chisel	89.6	1.48	63.0
Ridge Till	85.9	1.47	60.1
P-Value	54	31	83
N-Rate X Method X Inhibitor			
N-Rate #/A			
50	82.0	1.30	50.8
105	89.6	1.45	61.6
160	89.2	1.54	65.3
215	90.1	1.61	68.6
P-Value	99	99	99
BLSD (.05)	2.6	0.16	2.3
Method			
1. 4 leaf	87.0	1.50	62.0
2. 8 leaf	87.8	1.41	59.1
3. Split 2/3 1/3	88.5	1.51	63.6
P-Value	51	99	99
BLSD (.05)		0.03	2.2
Inhibitor			
None	88.1	1.48	62.2
N-Serve	87.4	1.47	61.0
P-Value	56	63	79
N-Rate X Method	30	99	98
N-Rate X Inhibitor	86	99	99
Method X Inhibitor	6	99	94
N-Rate X Method X Inhibitor	73	99	99
N-Rate X Method X Inhibitor X Tillage			
N-Rate X Tillage	61	42	35
Method X Tillage	57	57	47
Inhibitor X Tillage	1	99	9
N-Rate X Method X Tillage	99	99	85
N-Rate X Inhibitor X Tillage	55	99	93
Method X Inhibitor X Tillage	9	54	37
N-Rate X Method X Inhibitor X Tillage	46	99	95

Table 2. Influence of N-rate, nitrification inhibitors, method of application and tillage on **corn** grain yields, N-concentration, and N removal following soybeans. Westport, MN. 1992

Total N-Rate	Early N	Inh.	Late N	Tillage	Grain Yield	Grain N-content	Grain N-removal
#/A	#/A		#/A		Bu/A	%	#/A
Control	----	--	----	C	50.5	1.08	25.79
50	50	--	----	C	83.5	1.49	58.86
50	----	--	50	C	90.2	1.29	54.96
50	35	--	15	C	86.2	1.35	54.98
50	50	NS	----	C	92.6	1.35	59.38
50	----	NS	50	C	80.1	1.34	51.02
50	35	NS	15	C	96.3	1.48	67.40
105	105	--	----	C	103.6	1.57	77.04
105	----	--	105	C	103.8	1.47	72.12
105	70	--	35	C	91.1	1.70	73.16
105	105	NS	----	C	88.7	1.42	59.56
105	----	NS	105	C	93.9	1.50	66.67
105	70	NS	35	C	103.2	1.53	74.91
160	160	--	----	C	97.2	1.62	74.30
160	----	--	160	C	92.8	1.63	71.41
160	105	--	55	C	97.2	1.49	68.43
160	160	NS	----	C	89.5	1.55	65.55
160	----	NS	160	C	99.2	1.62	75.93
160	105	NS	55	C	85.6	1.55	62.92
215	215	--	----	C	89.6	1.74	73.74
215	----	--	215	C	105.5	1.59	79.59
215	145	--	70	C	94.0	1.58	70.26
215	215	NS	----	C	96.3	1.70	77.49
215	----	NS	215	C	96.4	1.51	69.13
215	145	NS	70	C	96.6	1.71	78.05
Control	----	--	----	R	62.1	1.11	32.80
50	50	--	----	R	87.8	1.53	63.38
50	----	--	50	R	95.5	1.44	64.79
50	35	--	15	R	97.9	1.49	69.09
50	50	NS	----	R	82.7	1.35	53.04
50	----	NS	50	R	99.3	1.43	67.35
50	35	NS	15	R	98.8	1.51	70.67
105	105	--	----	R	93.3	1.53	67.54
105	----	--	105	R	87.5	1.49	61.55
105	70	--	35	R	100.2	1.62	76.95
105	105	NS	----	R	101.1	1.60	76.64
105	----	NS	105	R	85.3	1.52	61.52
105	70	NS	35	R	92.3	1.61	70.37
160	160	--	----	R	97.5	1.63	75.23
160	----	--	160	R	88.9	1.49	62.45
160	105	--	55	R	96.2	1.50	67.91
160	106	NS	----	R	95.2	1.59	71.51
160	----	NS	160	R	104.3	1.57	77.55
160	105	NS	55	R	99.0	1.50	70.49
215	215	--	----	R	97.6	1.61	74.61
215	----	--	215	R	102.5	1.63	78.87
215	145	--	70	R	100.9	1.74	83.01
215	215	NS	----	R	97.4	1.58	72.81
215	----	NS	215	R	93.4	1.53	67.43
215	145	NS	70	R	103.5	1.53	74.97

Table 2. continued. Corn Soybean Rotation Split Plot Statistical Analysis

	Corn Grain		
	Yield	N-Content	N-Removal
	Bu/A	%	#/A
Tillage			
Chisel	93.9	1.53	68.2
Ridge Till	95.8	1.54	69.9
P-Value	89	77	97
N-Rate X Method X Inhibitor			
N-Rate #/A			
50	90.9	1.41	61.2
105	95.3	1.54	69.8
160	95.2	1.56	70.3
215	97.8	1.62	74.9
P-Value	99	99	99
BLSD (.05)	2.9	0.03	2.4
Method			
1. 4 leaf	93.4	1.55	68.7
2. 8 leaf	94.9	1.50	67.6
3. Split 2/3 1/3	96.2	1.55	70.8
P-Value	90	99	98
BLSD (.05)		0.03	2.4
Inhibitor			
None	95.0	1.54	69.7
N-Serve	94.6	1.52	68.4
P-Value	31	93	84
N-Rate X Method	91	99	99
N-Rate X Inhibitor	42	52	74
Method X Inhibitor	55	94	82
N-Rate X Method X Inhibitor	99	96	99
N-Rate X Method X Inhibitor X Tillage			
N-Rate X Tillage	99	88	99
Method X Tillage	88	18	81
Inhibitor X Tillage	63	30	33
N-Rate X Method X Tillage	99	90	99
N-Rate X Inhibitor X Tillage	86	99	99
Method X Inhibitor X Tillage	89	87	98
N-Rate X Method X Inhibitor X Tillage	99	74	96

Table 3. Continuous Corn And Corn Soybean Combined Split Plot Statistical Analysis
Westport, MN 1992

	Corn Grain		
	Yield	N-Content	N-Removal
	Bu/A	%	#/A
Previous Crop			
Corn	87.7	1.47	61.6
Soybeans	94.8	1.53	69.0
P-Value	99	91	99
N-Rate X Method X Inhibitor X Tillage			
N-Rate #/A			
50	86.5	1.36	56.0
105	92.5	1.49	65.7
160	92.2	1.55	67.8
215	93.9	1.61	71.8
P-Value	99	99	99
BLSD (.05)	1.9	0.02	1.7
Method			
1. 4 leaf	90.2	1.52	65.4
2. 8 leaf	91.4	1.46	63.4
3. Split 2/3 1/3	92.3	1.53	67.2
P-Value	95	99	99
BLSD (.05)	1.9	0.02	1.5
Inhibitor			
None	91.6	1.51	65.9
N-Serve	91.0	1.49	64.7
P-Value	58	94	94
Tillage			
Chisel	91.7	1.50	65.6
Ridge Till	90.8	1.50	65.0
P-Value	76	5	60
N-Rate X Method	65	99	99
N-Rate X Inhibitor	85	99	99
N-Rate X Tillage	96	98	96
Method X Inhibitor	32	99	99
Method X Tillage	20	14	18
Inhibitor X Tillage	48	98	64
N-Rate X Method X Inhibitor	99	99	99
N-Rate X Method X Tillage	79	99	73
N-Rate X Inhibitor X Tillage	66	99	86
Method X Inhibitor X Tillage	79	92	96
N-Rate X Method X Inhibitor X Tillage	99	84	96
N-Rate X Method X Inh. X Tillage X Provious Crop			
N-Rate X P-Crop	62	99	98
Method X P-Crop	24	85	44
Inhibitor X P-Crop	48	45	8
Tillage X P-Crop	99	63	99
N-Rate X Method X P-Crop	82	92	99
N-Rate X Inh. X P-Crop	44	95	90
N-Rate X Tillage X P-Crop	90	42	74
Method X Inh. X P-Crop	41	39	27
Method X Tillage X P-Crop	94	60	88
Inhibitor X Tillage X P-Crop	48	92	87
N-Rate X Method X Inh. P-Crop	68	73	67
N-Rate X Method X Tillage X P-Crop	99	99	99
N-Rate X Inh. X Tillage X P-Crop	83	99	99
Method X Inh. X Tillage P-Crop	61	25	73
N-Rate X Method X Inh. X Tillage X P-Crop	99	99	97