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EFFECT OF SPLIT N-FERTILIZER APPLICATIONS ON DRAINAGE WATER QUALITY AND NO_3-N LEACHING

Project No. 88-7

July 1, 1988 to December 31, 1989

Prepared for

LEOPOLD CENTER FOR SUSTAINABLE AGRICULTURE

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February 1990

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by

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1 This project was also supported, in part, by the Aquitard/Till Hydrology Project and the Integrated Farm Management Demonstration Project with appropriations from the Iowa Groundwater Protection Act, and by a grant from the Iowa State Water Resources Research Institute.

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EFFECT OF SPLIT N-FERTILIZER APPLICATION ON DRAINAGE WATER QUALITY AND NO_3-N LEACHING

NON-TECHNICAL REPORT

Nitrate-nitrogen (NO_3-N) leaching losses to the groundwater sources can be minimized by better water and nitrogen (N) management practices in agricultural watersheds. It is difficult to control the volume of subsurface drainage water (except through some tillage practices), but control of NO_3-N leaching losses can be accomplished by decreasing the NO_3-N concentrations in the soil water. Typically an equivalent of 15 to 30% of the N currently applied to corn in a single pre-plant application is lost through leaching in tile-drained country. With about 1 million tons of N applied annually in Iowa (average rate on corn in 1986 was 131 lb/ac or 147 kg/ha), and an energy equivalence of 1/4 gallon of diesel fuel per lb, energy losses would range from 75 to 150 million gallons of diesel fuel. Therefore, a 5% decrease in losses through improved efficiency could save the equivalent 25 million gallons of diesel fuel. In addition, minimizing these leaching losses from the root zone could decrease the pollution potential of N fertilizers without decreasing the profitability of crop production. Therefore, it is necessary to study better N management practices as a function of tillage, better timing and rates of N-applications (such as split N-application).

This study involved intensive field investigations of N and water movement processes in an artificially drained agricultural field. The experimental site was located at the Iowa State University's Agronomy and Agricultural Engineering Research Center near Ames, Iowa. This site has ten established subsurface drains. Six of these ten subsurface drains were intercepted earlier for another study. Two more subsurface drains (each draining a plot area of about an acre) were intercepted by installing sumps for measuring drainage flow rates and collecting samples for NO_3-N analysis for this study. These two plots were planted to corn under conventional tillage and instead of a single 156 lb/ac N application, three split N-applications were made at different timings totaling 112 lb/ac. The experimental site was instrumented with several sets of piezometers and water table wells to develop an understanding of the underground hydrology of the area and to determine the NO_3-N leaching rates to deeper depths. The results of this split application study were compared with the on-going single application experiment which will eventually help to develop better N management practices to reduce NO_3-N leaching loss to the groundwater systems. Six years data (1984-1989) show a trend in improved water quality with split N-application and the no-till system of farming.

Because of severe drought conditions in 1988, water tables in the experimental area were below 10 feet in depth and tile lines did not flow at all until June 30, 1989. Therefore, very little data were collected on drainage water quality in 1988 and 1989. Unfortunately, Leopold Center did not renew this project because of lack of progress. Somehow, we will continue monitoring these tile lines until 1992 with the limited funding available through the experiment station and the Agricultural Energy Management Fund.

TECHNICAL REPORT

Abstract

Two experimental plots, each drained by a single subsurface tile line and having an area of about 0.6 ac, were established at the Agronomy and Agricultural Engineering

Research Center near Ames, Iowa. These two plots under conventional tillage have been planted to continuous corn since 1984. To provide permanent access to the tile lines, 152 mm deep sumps were dug to intercept the tiles, sumps were installed to permit access for sampling drainage water for NO_3-N analysis and flow measurements. Experimental plots were again planted to corn in May 1988 using conventional tillage. Three applications of N-fertilizer totaling 112 lb/ac were applied (first application of 22 lb/ac was made at the time of planting, a second application of 45 lb/ac was made in June, and third application of 45 lb/ac was made in July). Soil-water samples were taken from various depths using piezometers and were analyzed for NO_3-N by using a Technicon Autoanalyzer II system in the chemistry laboratory of the Agricultural Engineering Department. Because of drought conditions tile lines did not flow at all in 1988, therefore, no data were collected on drainage water sampling for that year and only a few drainage water samples were collected in 1989. The limited amount of data collected on drainage water quality during 1988 and 1989 were compared with the previous years data (1984-1987) to draw conclusions. The results of this study indicate that there is a significant trend in improved water quality with a reduced rate of N applied in split applications.

INTRODUCTION AND OBJECTIVES

Nitrogen is essential to the growth and development of all crop plants. Statistics show that the use of N fertilizers has increased steadily to make crop production profitable. Studies have shown that often 50% or less of the N-fertilizer applied is beneficially recovered in any one crop year. The remaining N either leaves the system through leaching, wash-off, and volatilization or stays in the soil profile for possible later use. The

N that is leached out of the root zone may reduce the quality of groundwater or surface water and present environmental, economic, and energy conservation concerns.

Agricultural activities on farmland are being viewed as the potential sources of water pollution. Increased use of fertilizers, changing tillage practices, diverse drainage systems and crop production practices may not only have pervasive but multifaceted effects on water pollution. More and more farmers are adopting conservation tillage practices for sustainable agriculture. Tillage practices directly affect the soil-water properties of the subsurface soil and, thus, the leaching characteristics. Tillage disturbs the macropores (open channels), whereas, no tillage allows the macropores to develop and persist. Transport of water through macropores may either increase or decrease the total N load to the underground water sources. The fate of N under different tillage systems is of considerable interest and importance, and it is thus essential to understand all factors that effect it. Therefore, the purpose of this research was to demonstrate the effects of split N-application under conventional tillage on drainage water quality and on the loss of NO_3-N through subsurface drainage water and below the root zone.

To the best of our knowledge, very little work has been done to study the effect of split N-applications on drainage water quality and NO_3-N leaching under different tillage systems. Kanwar et al. (1988) have reported that split N-applications at a reduced rate of 112 lb/ac under no-till systems (applied over the growing season) reduced NO_3-N concentrations in drainage compared with a single, higher rate application of 156 lb/ac, whereas corn yields were essentially equal for both application rates. Results of this study suggest that the effects of split N-applications on NO_3-N leaching under conventional tillage should also be investigated..

A research project was funded by the Iowa State Water Resources Research Institute in from 1984 to 1986 to study the effects of tillage and multiple N-application on nitrate leaching. As a part of this study, field plots were established at the Agronomy and Agricultural Engineering Research Center to study the effect of multiple applications (at a reduced rate of 112 lb/ac compared to a single application of 156 lb/ac) under no-till practices only. But need is also there to study the effect of split N-applications on drainage water quality and leaching of nitrate through the tile lines under conventional tillage. Therefore, a proposal was submitted to the Leopold Center with the understanding that there is a strong need for this applied research which may not be funded by other agencies. Leopold Center funded this project for one year but funding was not renewed for the second year. One of the reasons for not funding this project was that similar work is being done somewhere else. But according to our knowledge no one else is monitoring the quality of drainage water in Iowa as affected by tillage and split N-applications on a field plot scale.

MATERIALS AND METHODS

This study was proposed to be conducted in two parts. In the first part of the study, field experiments were conducted to determine the major N and water transport processes in the soil profile and to investigate the interactions between them. The experimental field was instrumented with water table wells and piezometers so that the soil-moisture and N fluxes can be monitored in the field as a function of depth and location. Measurements were made over time, agricultural activities (tillage and split N application) were varied, and the responses in drainage water quality and quantity were observed. The second part of this study will consist of using the information and data obtained in part one on basic N and water transport processes to develop N management practices to reduce the impact of agricultural activities on NO_3-N pollution of groundwater systems. Funding was sought to complete the first part of this study.

A field experiment was started at Iowa State University's Agricultural Engineering and Agronomy Research Center near Boone, Iowa. This area is the most appropriate location to investigate the N and water movement processes as it represents the most common agricultural activities (subsurface drainage, tillage, and nitrogen management) that are currently being used in the agricultural watersheds of Iowa. The soils at the experimental site are Nicollet loam which consist of deep, moderately to poorly drained soils formed in glacial till under prairie vegetation. Selected physical properties of these soils are given in Table 1. The experimental site has less than 2 percent slope and has established subsurface drains. Six of these subsurface drains, each draining about 0.4 hectare area were intercepted in an earlier study to study the interactions between tillage and N-fertilizer application. This study was started in 1984 with a funding from the Iowa State Water Resources Research Institute and is currently being supported with the AEMF. Two more subsurface drains (as shown in Figure 1) were intercepted as a part of this project by installing sumps for measuring subsurface discharge, and collecting drain water samples for NO_3-N. Subsurface drain flow rates are being monitored by installing a float-activated continuous water stage recorder and a calibrated V-notch on each of the intercepted subsurface drains. To provide a permanent access to drain lines, 152 cm deep sumps were dug to intercept the drain lines. The walls of sumps were made of 183 cm section of corrugated steel culvert. Figure 1 gives the location of sumps in each plot, and

Table 1. Physical properties of the Nicollet Soil at the experimental site.

Depth	Particle size, mm			Organic matter	Porosity	Bulk density	Soil-water characteristics					
	Sand 2-0.05	Silt 0.05-0.002	Clay <0.002				Volumetric soil moisture content at tensions of					
							9.6cm	108cm	152cm	325cm	1000cm	12000cm
cm	%	%	%	%	%	g/cm^3	%					
0-15	42.0	35.2	22.8	4.3	0.44	1.49*	0.37	0.33	0.32	0.31	0.28	0.15
15-30	35.7	38.2	26.1	4.0	0.49	1.36	0.39	0.32	0.31	0.30	0.25	0.17
30-45	34.1	38.4	27.5	3.2	0.51	1.30	0.38	0.31	0.30	0.28	0.24	0.17
45-90	38.0	36.0	26.0	2.6	0.49	1.37	0.36	0.29	0.28	0.27	0.24	0.17
90-120	53.1	25.2	21.7	0.5	0.46	1.44	0.35	0.27	0.26	0.25	0.22	0.13

*Bulk densities of the tilled plots were found to be close to that of no-till plots.

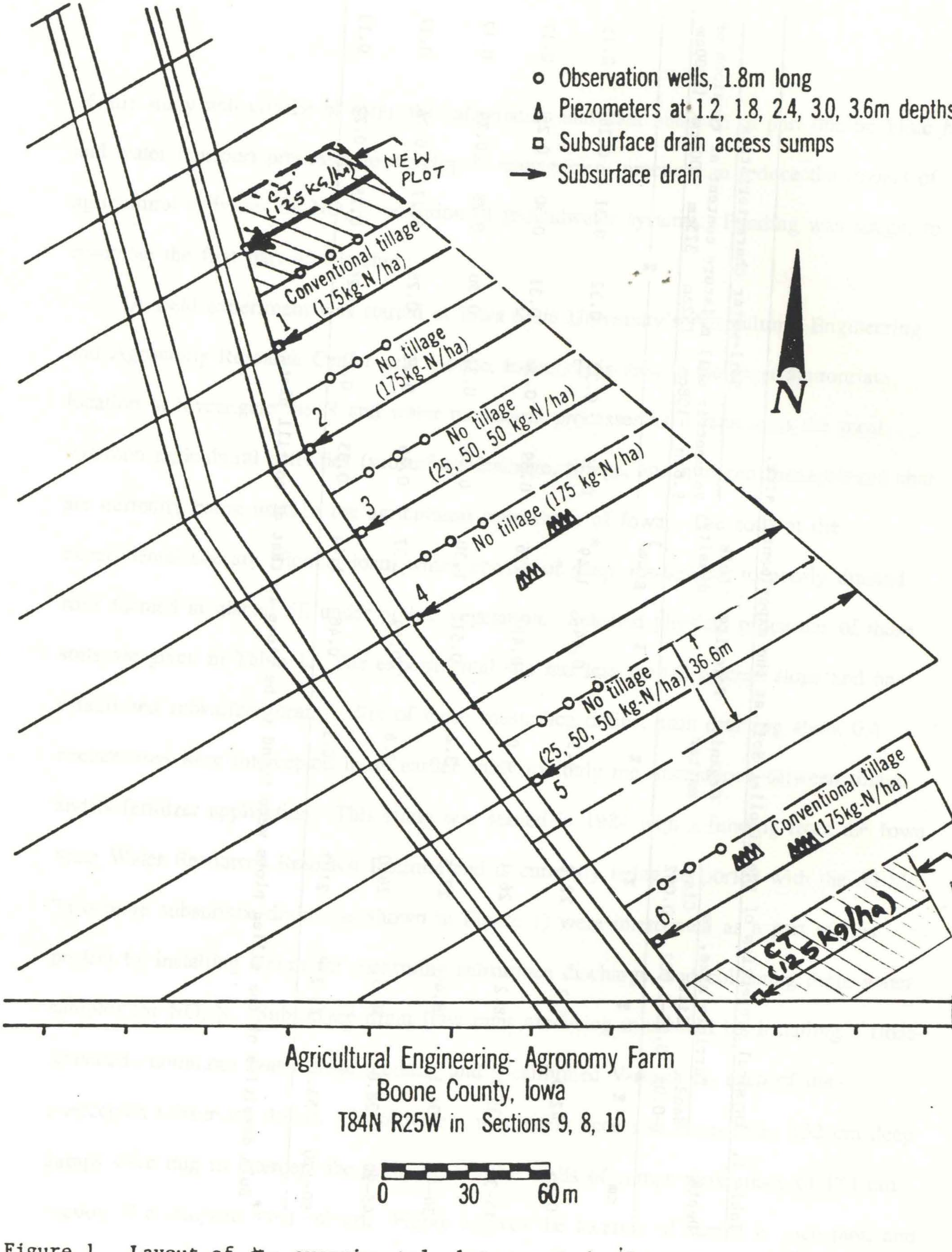

Figure 1. Layout of the experimental plots to study the transport of nitrogen and water through the soil profile to the groundwater system.

Figure 2 gives the schematic diagram of the sump installation. Subsurface drainage water samples were collected three times a week for water quality analyses when tiles are flowing. Also, drainage water samples were taken immediately after rains and snow melts. These data on water quality and quantity from the subsurface drainage system will provide a detailed record of the hydrologic balance of the subsurface drainage water of this area, and the N losses from the watershed.

The two plots which were instrumented for drainage water quality monitoring as a part of this project, were cropped to continuous corn using conventional tillage, but instead of a single N-application, three applications of N-fertilizer totaling 112 lb/acre were applied (one application of 22 lb/acre was made at the time of planting, a second application of 45 lb/acre was made in June, and the last application of 45 lb/acre was made in July). Figure 1 shows the layout of these two plots in addition to other plots. Thus, two replications of two tillage systems (no-till and conventional tillage) and two fertilizer management practices (single application of 156 lb/acre and three split application of three split application of 112 lb/acre) were used for continuous corn production. Table 2 gives dates of different planting operations.

Three observation wells (180 cm long, 3.8 cm diameter plastic pipe with open bottom and perforated sides) were installed in each plot midway between subsurface drain lines to measure the water table fluctuations in each plot. The data collected on water table depths were used to develop a relationship between the subsurface drain flow rates and water table depths above the subsurface drain. Also, these data were used to determine the slope of the water surface, and direction of lateral seepage to the groundwater.

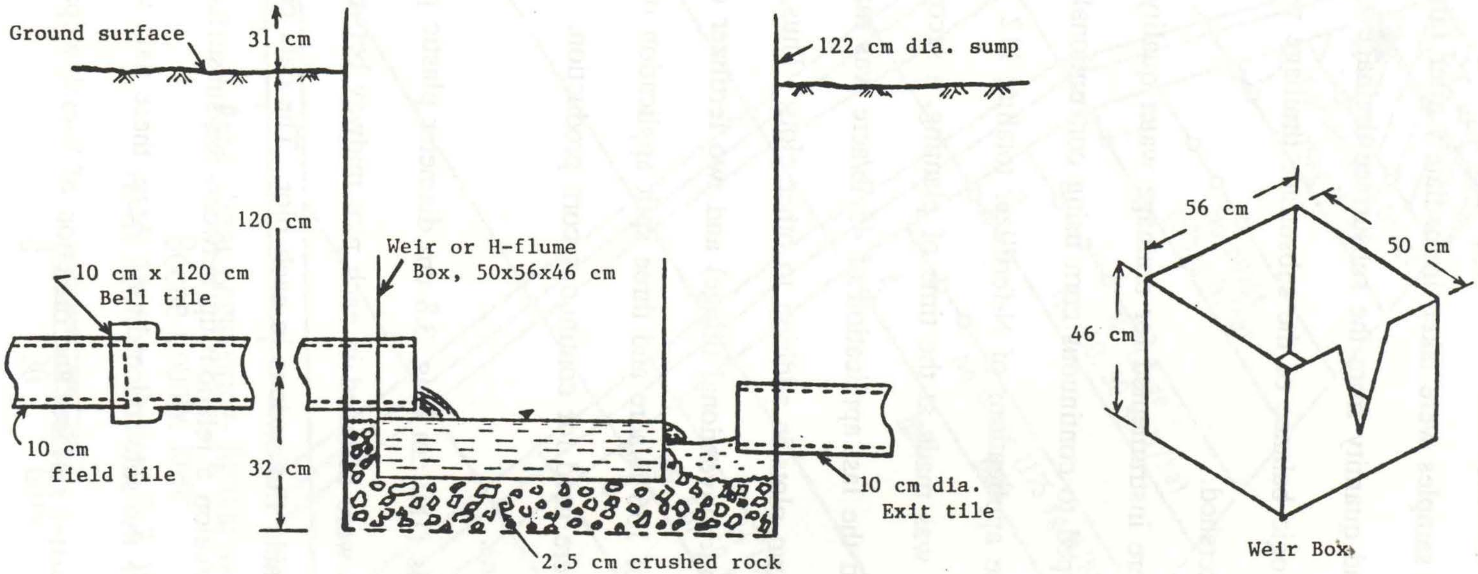

Figure 2. Schematic diagram of the subsurface tile sump installation.

Table 2. Dates of Planting, Harvesting, Fertilizer Application, and Plant Population Count (corn variety Pioneer # 3475)

Item	Year and Date					
	1984	1985	1986	1987	1988	1989
Planting	May 14	May 2	May 7	May 1	May 6	May 10
Plant pop. count	June 11	May 29	May 29	June 1-2	-	May 25
Plants/acre	25,636	26,821	27,723	25,709	27,500**	25,140
N-application Single (156 lb/ac)	May 23	May 2	May 20	May 15	May 20	May 15
N-application Multiple						
1st 22 lb/ac	May 23	May 17	June 8*	May 15	May 20	May 31
2nd 45 lb/ac	June 26	June 5	June 25	June 16	June 3	June 19
3rd 45 lb/ac	July 3	June 24	July 15	July 1	June 23	July 6
Harvesting	Oct. 2	Oct. 11	Oct. 21	Oct. 6	Oct. 6	Oct. 26

* Rainfall prevented earlier application

** Planting rate

A set of piezometers (3.8 cm diameters plastic pipe with an open bottom) have been installed in plot at depths of 120, 180, 240, and 360 cm (Fig. 1). There are two purposes for installing these piezometers. One purpose is to measure the underground gradients of the area by use of piezometric heads. This helped us to determine the deep percolation loss to the underground aquifer. The second purpose was to take water samples from 120, 180, 240, and 360 cm depths for nitrate analysis. This will help answer questions related to the determination of the NO_3-N concentrations of the drain water at specific locations more accurately as a function of water table depths, loss of NO_3-N with deep percolation water to the underground aquifer, and denitrification losses if they are occurring at soil depths below or near the subsurface drain.

Three to five sets of three rows (100 ft long and three ft apart) were either machine or hand harvested from each plot for yield measurements. Corn yields were corrected to a uniform moisture content of 15.5 % before final analysis.

RESULTS AND DISCUSSION

Table 3 gives the average corn yields for 1988 and 1989 and for the previous four years (1984 to 1987) as a function of tillage and two levels of N-fertilizer application (single application of 156 lb/ac and three split applications totaling 112 lb/acre). This yield data show that, on the basis of six years of crop data, corn yields were neither affected by tillage (except for 1987) nor by the fertilizer management scheme used in this demonstration experiment. In fact, very similar yields were obtained for five years under split (at a lower application rate of 112 lb/acre) and a single application (at a higher rate of 156 lb/acre) of N fertilizer for no-till conditions. But only two years of yield

Table 3. Tillage and Multiple N-applications Effect on Corn Yields.

Year	Tillage	N-Fertilizer Application Rates, lbs/acre		
		Check (0 lbs/ac)	Single (156 lbs N/ac)	Three-Way Split (112 lbs N/ac)*
1984	Plow	67	130	-
	No-Till	-	129	132
1985	Plow	37	113	-
	No-Till	-	118	119
1986	Plow	60	179	-
	No-Till	39	170	165
1987	Plow	57	153	-
	No-Till	39	121	121
1988	Plow	44	70	72
	No-Till	25	63	64
1989	Plow	-	119	121
	No-Till	28	131	118
Six Year Average	Plow	66	153	-
	No-Till	35	146	144

* Three applications of N-fertilizer were made totaling 112 lb/ac. First application of 22 lb/ac was made after planting. Second application of 45 lb/ac was made about 20 days after the first application. Third application of 45 lb/ac was made about 40 days after the first application.

comparison for 1988 and 1989 is available for split N-application treatment under conventional tillage condition (which shows very similar yields in comparison to a single N-application under conventional tillage). However, the question still remains if timing and amount of N-application under conventional tillage is a factor. Data obtained from future years may answer this question. As expected, corn yields for the unfertilized conventional tillage plots were greater than those for the no-till plots. This could be due to increased level of mineralization of organic matter with tillage. For fertilized continuous corn plots, the yields were higher for the conventional tillage plots, and this was the case for all years except for 1985 and 1989. In 1985 and 1989, no-till plots gave better yields than the conventional tillage plots. The six year (1984-89) average yields for no-till and conventional tillage plots with an application of 156 lb-N/acre were 146 bu/acre and 153 bu/acre, respectively.

Due to severe drought conditions in 1988, no drainage water samples could be collected in 1988 as none of the tile lines were flowing. However, the data on NO_3-N concentrations in drainage water, for the previous four years, show a very definite trend. Figure 3 and 4 show NO_3-N concentrations for the 1986 and 1987 tile flow data, respectively. These figures show that NO_3-N concentrations in drainage water under no-till conditions with three split applications of N at a lesser total rate of 112 lb/ac were considerably lower in comparison with plots that received a single, higher rate application of 156 lb/ac. In 1986, overall average NO_3-N concentrations in drainage water under split and single applications were much lower when compared to other plots. The results of 1987 (Figure 4) were even more consistent with coefficients of variation ranging from 12 to 20% for three treatments.

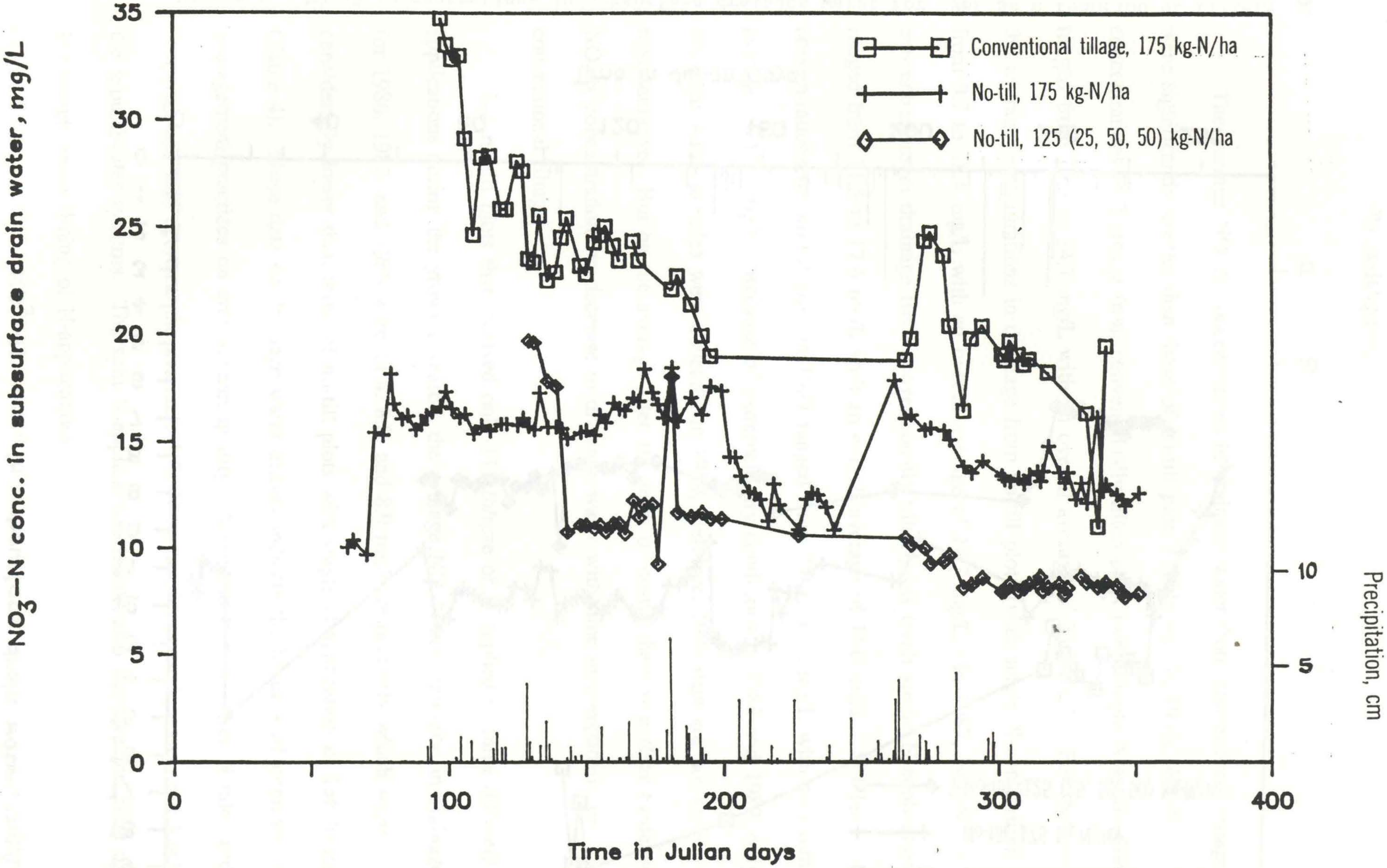

Figure 3. NO_3-N concentrations in subsurface drainage water for 1986 as a function of tillage and N-fertilizer management practice.

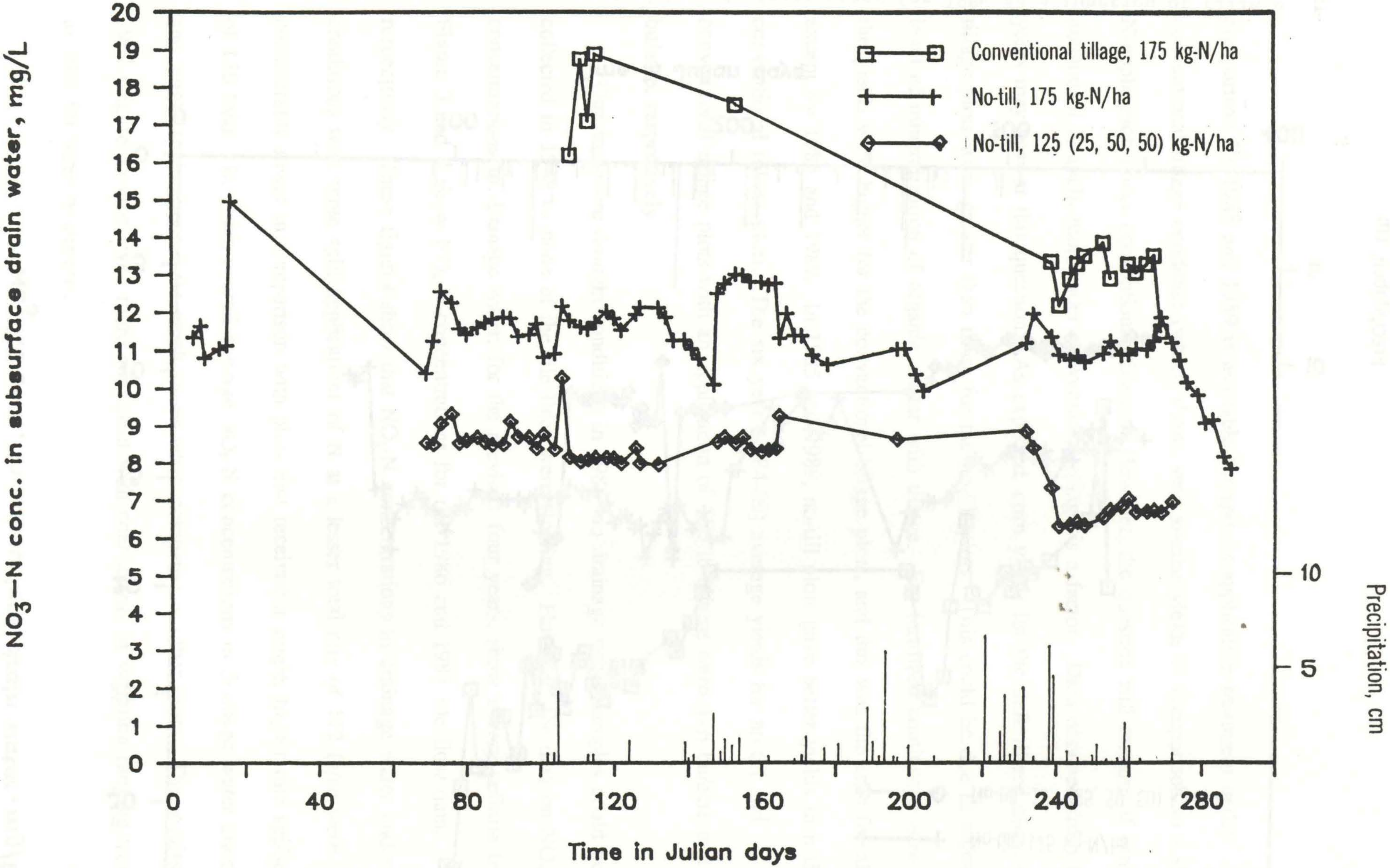

Figure 4. NO_3-N concentrations in subsurface drainage water for 1987 as a function of tillage and N-fertilizer management practice.

The average NO_3-N concentrations in drainage water from conventional tillage plots were significantly greater than those of no-till plots (Table 4). In 1986, NO_3-N concentrations in drainage from conventionally tilled plots (with single N-application) ranged from 16.3 to 34.7 mg/L with an overall average of 23.2 mg/L. For the same year, the average concentrations in drainage from no-till plots (with single N-application) ranged from 9.7 to 18.4 mg/L with an overall average of 14.7 mg/L. In 1987, NO_3-N concentrations in drainage from conventionally tilled plots (with single N-application) ranged from 11.5 to 17.6 mg/L with an overall average of 14.0 mg/L. Similar concentrations for no-till plots in 1987 ranged from 7.8 to 16.2 mg/L with an overall average of 11.5 mg/L. Because of extremely dry conditions in 1988 and 1989, only seven drainage water samples were collected in 1989, therefore, 1989 data are not very representative. But on the average after six years of no-till there is a clear evidence for NO_3-N concentrations to decrease in drainage water with time in comparison to conventional tillage.

For no-till plots that received only 112 lb/acre of N applied in three different applications during the growing season, the average NO_3-N concentration in drainage water for 1986, 1987, and 1989 were 11.4, 8.0, and 8.9 mg/L respectively which were considerably lower than those of no-till plots with single N-application of 156 lb/acre (Table 4). These data on drainage water quality indicate the benefits of improved nitrogen management practices on groundwater quality. A combination of lower N rates and split N-application will decrease the available NO_3-N in soil for possible downward leaching to the groundwater systems. The split N-applications should also improve the plant uptake of N through better timing of N-applications.

Table 4. Average NO_3-N Concentration in Tile Drainage Water as a function of tillage and N-Fertilizer application under continuous corn.

Year	NO_3-N concentrations in tile drainage water, mg/l			
	Conventional Tillage		No-Till	
	Single (156 lbs N/ac)	Three-way split (112 lbs N/ac)*	Single (156 lbs N/ac)	Three-way split (112 lbs N/ac)*
1984	10.7	-	11.1	11.8
1985	-	-	11.7	-
1986	23.2	-	14.7	11.4
1987	14.0	-	11.5	8.0
1988	-	-	-	-
1989	-	-	15.0	8.9

* Three applications of N-fertilizer were made totaling 112 lb/ac. (first application of 22 lb/ac was made after planting, second application of 45 lb/ac was made about 20 days after the first application, and a third application of 45 lb/ac was made about 20 days after the second application).

The effect of split N-applications under conventional tillage on drainage water quality can not be assessed without significant spring and early summer rainfall that may cause tiles to flow with a potential of NO_3-N leaching. Without more than normal rainfall, data on drainage water quality

cannot be collected. This experiment will be continued until 1992 with funds from other sources (with the limited support from the experiment station and with available funding from the Agricultural Energy Management Fund).

Table 5 gives the average NO_3-N concentrations in the individual piezometer water samples taken at different depths during the six years of study period (1984 to 1989). These data indicate that under no-till system NO_3-N concentration decreases with depth but under conventional tillage system there is accumulation of NO_3-N at 8 ft depth. These data suggest that NO_3-N is moving to deeper soil depths, but its movement below 10 ft might be decreasing by an attenuation process (such as denitrification). The data given in Table 5 indicate that tillage treatment is definitely affecting the transport mechanism of NO_3-N. The six year overall average concentration of 15.8 mg/L of NO_3-N at 4 ft depth in no-till plots is much higher than the 10.4 mg/L concentration of NO_3-N at 4 ft depth under conventional tillage system which indicates higher accumulations of NO_3-N at 4 ft depth under no-till system.

CONCLUSIONS

The role of weather is very important in drainage water quality research. Because of dry weather in 1988 and 1989, only a few drainage water samples could be collected for NO_3-N analysis. Also, the efficient use of N by corn depends very heavily on the available soil moisture in the root zone. Therefore, two years of data collected under

Table 5. Average NO_3-N Concentration of Piezometer Water Samples for six years of study period (1984 to 1989).

Year	Depth (ft)	No-Till N*	No-Till conc.	No-Till Std. dev.**	Conventional Tillage N*	Conventional Tillage conc.	Conventional Tillage Std. dev.**
		Average NO_3-N concentrations (conc.), mg/l					
1984	4	2	12.4	1.1	1	10.8	-
	6	8	10.0	1.6	8	7.8	4.7
	8	10	11.3	3.5	8	14.2	7.3
	10	14	11.3	3.4	11	9.5	4.5
	12	14	8.9	4.5	15	11.8	6.3
1985	4	-	-	-	-	-	-
	6	6	12.5	3.0	-	-	-
	8	9	15.7	4.1	5	10.0	2.4
	10	8	8.8	5.8	7	11.5	2.4
	12	10	6.1	5.1	9	3.4	3.6
1986	4	6	18.4	7.7	1	17.9	-
	6	12	16.5	1.6	11	12.7	3.0
	8	12	14.5	1.3	12	16.1	4.1
	10	12	8.7	5.9	12	15.1	1.9
	12	12	3.4	3.1	12	5.0	4.9
1987	4	8	14.3	4.7	2	6.4	4.7
	6	16	13.9	1.8	16	15.7	13.4
	8	16	14.8	2.3	16	15.6	9.3
	10	16	8.1	6.0	16	12.7	6.9
	12	16	4.7	3.0	16	5.1	6.8
1988	4	-	-	-	-	-	-
	6	-	-	-	-	-	-
	8	-	-	-	-	-	-
	10	-	-	-	-	-	-
	12	-	-	-	-	-	-
1989	4	-	-	-	-	-	-
	6	-	-	-	-	-	-
	8	3	10.5	2.1	-	-	-
	10	4	5.9	3.3	1	2.4	-
	12	4	2.8	1.2	4	10.6	7.7
6 Year average (84-89)	4	16	15.8	13.8	4	10.4	11.4
	6	42	13.7	11.9	35	12.9	14.0
	8	50	13.9	12.6	41	15.8	14.3
	10	54	9.0	9.5	44	13.0	12.0
	12	56	5.6	6.5	56	7.0	7.7

* Number of Observations

** Std. Dev. = Standard Deviation

draught conditions are not nearly sufficient to draw final conclusions to study the effects of the use of split N-application under conventional tillage systems on drainage water quality. However, the data obtained in the previous years (1984 to 1987) under no-till conditions show a potential of using split N-application for better N-uptake and reduced NO_3-N leaching.

The results from previous years (1984 to 1987) show that treatment effects at the soil surface took time to become evident at the depth of subsurface tile lines as there were no immediate effects of either tillage (no-till or conventional) or N-fertilizer management (single or split N-application) on NO_3-N concentrations in drainage water. Therefore, the two conventional tillage plots established in 1988 for split N-application study may not show the effects of the treatment until 1990.

The six years (1984 to 1989) for no-till plots showed that split N-applications at a reduced rate of 112 lb/acre decreased NO_3-N concentrations in drainage water compared to that of a single, high rate of N-application. Furthermore, corn yields were essentially equal for both application rates of N and between tillage as well. NO_3-N concentrations in soil water samples taken from wells as a function of depth indicated that some attenuation was taking place as water and solute moved through the deeper, saturated soil profile. If denitrification is occurring, that would help to reduce the impact of NO_3-N leaching on groundwater quality.

This project has provided funds to establish two large long term conventional tillage plots to monitor the effects of split N-applications on drainage water quality. To the best of our knowledge, this will be the only experiment in the state of Iowa where this kind of study is being conducted on isolated plots. This experiment will provide an excellent data base to study the effects of low-input agriculture on water quality. Because of dry weather, no drainage water quality data could be collected between May 1988 and June 1989.

APPLICATION OF RESULTS

Iowa farmers are currently using N fertilizer worth about three hundred million dollars a year, and most estimates suggest that less than half of this N is being recovered during corn harvest; the other half either remains in the soil for possible later uptake or leaching to groundwater systems or is lost through denitrification, runoff, and volatilization. If large amounts of N fertilizer are being leached from farmer's fields, the data collected in this study may aid in developing N-fertilizer application methods to correct this problem. Also, farmers should be made aware that some of their dollars spent on N fertilizer are lost without any further economic return. This study shows that for one set of conditions split N applications at a lower rate of 112 lb/acre produced as much crop yield as single higher rate of 156 lb/acre. If this can be applied across the state, then farmers can afford to apply less N fertilizer without reducing crop yields. This management practice would then save on the average 44 lbs of N-fertilizer per acre, i.e., about 29% of the total N-fertilizer use in the state. This will result in savings of about 86 million dollars on N-fertilizers which is equivalent to about 4.3 million barrels of crude oil (at $20 per barrel) in energy terms.

ENVIRONMENTAL IMPACT

The main objective of this research was to demonstrate and investigate the impacts of agricultural activities within a watershed (nitrogen management and tillage) on the loss of N to the surface and groundwater resources through tile drainage, and to improve the efficiency of N use by decreasing the N leaching losses. This could be achieved either by making split N-applications to increase the plant uptake and/or by reducing the rate of N-applications. Therefore, the results of this study will be useful in developing efficient management practices for the nitrogen fertilizer to improve the quality of our water resource systems (and thus the environment).

PUBLICATIONS

Kanwar, R.S., J.L. Baker, and D.G. Baker. 1988. Tillage and split N-fertilization effects on subsurface drainage water quality and corn yield. TRANSACTIONS of the American Society of Agricultural Engineers 31(2): 453-460.

Kanwar, R.S. 1988. Loss of nitrogen fertilizers from cropland and their impacts on water quality. In: Proceedings of the 15th European Regional Conference on Agricultural Water Management, International Commission on Irrigation and Drainage, Dubrovnik, Yugoslavia.

Kanwar, R.S. 1989. Effect of tillage systems on the variability of soil-water tensions and soil-water content. TRANSACTIONS of the American Society of Agricultural Engineers 32(2): 605-610.

Baker, D.G., and R.S. Kanwar. 1989. Tillage effect on variability of soil nitrate. Paper presented at the 1989 ASAE International Winter meeting, New Orleans, LA. ASAE Paper No. 892504.

Sanoja, J., R.S. Kanwar, and S.W. Melvin. 1990. Comparison of simulated and measured tile outflow and water table elevations for two Iowa soils using DRAINMOD. TRANSACTIONS of the American Society of Agricultural Engineers (In Press).

OUTREACH

Several visitors from Finland, Russia, Hungary, and U.S. were taken to the field site for observation of the monitoring network for drainage water quality.

A field day was organized on June 15 which was attended by more than 40 Iowa State University researchers and Administrators. Several engineers from the DNR and USGS also attended this field day. Another field day was organized on August 15, 1989 to show these plots to the Iowa Seed Association members when more than 70 people attended.

Several press releases were issued during the period of this project.

BUDGET

Salaries and Wages	$5,598.94
Benefits	107.64
Equipment	0.0
Supplies	2,817.81
Travel	1,248.73
Other	2,026.88
Total	$11,800.00