EFFECT OF RESIDUAL PROFILE NITRATE ON CORN RESPONSE TO N FERTILIZATION IN WISCONSIN

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Research in several Great Plains and Western states has shown that crop yield response to fertilizer N is closely related to the amounts of residual nitrate in soil profiles. Based on this work, nitrogen fertilizer recommendations in these low-rainfall areas are adjusted to reflect the contribution of residual nitrate to the total crop nitrogen requirement. Use of residual profile nitrate data in development of N fertilizer recommendations has received much less research attention in the higher rainfall areas of the Midwest, such as Wisconsin, due to the increased probability of nitrate loss through leaching or denitrification. Moreover, it is generally assumed that residual nitrate in soils of the humid Midwest is too transient to permit reliable use of residual nitrate data for prediction of crop N fertilizer requirement. However, work in several states has shown that significant amounts of residual nitrate accumulate in some Midwestern soils and that crop response to N fertilization is affected by the amount of residual nitrate in these soils.

If N fertilizer application rates can be reduced on soils with high residual nitrate content without affecting crop yield, N fertilizer costs in crop production could be reduced and the risk of nitrate loss from these soils to groundwater could be lowered. Currently, little progress has been made in development and evaluation of procedures for adjustment of N fertilizer recommendations for soil residual nitrate content in the higher rainfall areas of the Midwest. The objectives of our work are to: (1) determine the effect of residual nitrate in soil profiles on corn N fertilizer requirements in Wisconsin; and (2) develop a procedure for prediction of N fertilizer requirements for corn based on soil residual nitrate content.

Materials and Methods

Field studies were initiated in 1983 at University of Wisconsin Experimental Farms at Lancaster (Fayette silt loam), Madison (Ringwood silt loam) and Arlington (Plano silt loam) to determine the effects of a range of soil residual nitrate contents on corn yield response to applied N. Soils selected for these experments were well drained and typical of soils widely used for corn production in Wisconsin.

At each location, fertilizer N was applied at rates of 0, 120, 240 and 360 lb N/acre before planting in 1983. Nitrogen treatments were arranged in a randomized complete block design with four replications. Above-optimum N fertilizer rates were used in 1983 to produce a wide range of soil residual nitrate contents for use in subsequent experiments. In 1984, the original plots were split, and N rates of 0, 70, 140 and 210 lb N/acre were applied to each 1983 N treatment. Fertilizer N was applied broadcast as ammonium nitrate, and the N treatments were incorporated by plowing.

Adapted corn varieties were planted in May each year, and all plots received 150 lbs/acre of 6-24-24 starter fertilizer in a 2 x 2 inch placement at planting. Conventional herbicide and soil insecticide treatments were used in all experiments. The effects of residual and applied N treatments on corn grain and silage yield were determined each year.

Soil samples were taken from all plots in April before application of N treatments and at the end of the growing season (October) each year. All plots were sampled in 1-foot increments to a total depth of 3 feet at Lancaster and 4 feet at Arlington and Madison. Sampling depth at Lancaster was limited to 3 feet by a layer of stones in the soil profile. Soil samples were placed in polyethylene bags and stored at -10^{o}C. Before analysis, soils were dried at $30-35^{o}$C in a forced-air dryer and ground to pass a 2-mm screen. Nitrate and exchangeable ammonium were determined by automated analysis of 2M KC1 soil extracts.

Results and Discussion

Initial residual profile nitrate contents before application of N fertilizer treatments in 1983 were 185, 128, and 72 lb N/acre at Arlington, Madison, and Lancaster, respectively. Corn grain yields in 1983 were not increased by N fertilization at the Arlington and Madison locations where soil residual nitrate contents were high, but grain yields were significantly increased by applied N at the Lancaster site.

Soil residual nitrate content determined at the end of the 1983 growing season showed that the amount of residual nitrate in soil at all experimental locations increased as the rate of fertilizer N applied to corn in 1983 was increased (Table 1). Measurements of residual nitrate at the same locations in the spring of 1984 usually showed some loss of residual nitrate during the period between growing seasons. However, substantial amounts of residual nitrate remained in soil profiles at all locations in the spring of 1984, and the amounts of nitrate found were directly related to the rate of fertilizer N applied during the 1983 growing season (Table 1). Variability of residual nitrate measurements was very high as indicated by the coefficients of variation (cv) shown in table 1.

Accumulation and retention of residual nitrate in soils is greatly influenced by the amount and timing of precipitation because water movement through the soil profile and soil moisture content affect nitrate loss through leaching and denitrification. precipitation relative to normal at the three experimental sites for the periods between profile nitrate measurements is shown in table 2. average total precipitation for the may through september period is about 18 inches and total annual precipitation is about 30 inches at all locations.

In 1984, the effects of various residual nitrate levels established by the 1983 N fertilizer treatments on corn yield response to applied N were studied at three locations. At Lancaster, where residual nitrate levels ranged from 57 to 189 lb N/acre, corn yields were significantly increased by applied N at the lowest residual nitrate level, and yields were maximized at the 70 lb N/acre fertilizer rate (Table 3). Corn yields were not significantly increased by applied N at residual nitrate levels of 104, 148 or 189 lb N/acre, but a trend toward response to added N is apparent at the 104 lb N/acre residual nitrate level. Similar results obtained at Madison indicated that corn yields were increased by applied N at a residual nitrate level of 69 lb n/acre. No response to applied N was observed at soil residual nitrate contents of 130 lb N/acre or more. Corn yields were not significantly increased by applied N at Arlington where soil residual nitrate levels ranged from 106 to 442 lb N/acre (Table 4).

The effects of 1983 and 1984 N treatments on the amounts of residual nitrate in soil profiles at the end of the 1984 growing season for the Arlington site are illustrated in Table 5. An analysis of variance performed on this data indicates that the amounts of residual nitrate found after the 1984 growing season were significantly ($p = 0.05$) affected by both 1983 and 1984 N rates. Similar results were obtained at the Lancaster and Madison locations.

Several approaches were evaluated to describe the relationship between corn grain yield and soil residual nitrate content found in our work. A significant quadratic relationship between relative grain yield and residual nitrate-N (0-3 ft) was found when data for these parameters from all locations were combined. The r^2 value (0.284) for the equation ($y = 0.718 + 0.002\ x - 0.000004\ x^2$) is significant at the $p=0.001$ level. This low r^2 value is at least partly due to the large number of non-responsive points from the Arlington and Madison experiments. When similar regression techniques were applied to data from the Lancaster experiment where yields varied substantially with soil residual nitrate content, the r^2 value for the equation ($y = 0.448 + 0.00538\ x - 0.000013\ x^2$) was 0.765***.

Use of the SAS NLIN model (SAS user's Guide, 1982) permitted identification of the residual nitrate level above which no yield increase is likely. Results from this method indicated that corn yield is maximized at profile (0-3 ft) residual nitrate contents of 143 lb N/acre.

Summary

Field studies conducted on well drained silt loam soils in wisconsin showed that accumulation of residual nitrate in soil profiles increased with increasing rates of applied N. Significant amounts of residual nitrate were retained in these soils during the period between growing seasons.

The amounts of residual nitrate in soil profiles before planting markedly affected corn yield response to applied N, and a significant relationship was found between corn yield in the absence of applied N and soil residual nitrate content. Data from experiments conducted in 1984 indicate that corn yield response to N fertilization is not likely on soils with spring residual nitrate contents above 143 lbs N/acre in a 3-ft. soil profile.

Results obtained in this study indicate that adjustment of N fertilizer rates based on soil residual nitrate content may have potential for improving N fertilizer recommendations for corn on some Wisconsin soils.

Table 1. Effect of nitrogen fertilizer application rate on residual nitrate-N in soil profiles at amounts of three locations in fall 1983 and spring 1984.

	Residual nitrate-N [1/]					
	Arlington		Madison		Lancaster	
1983 Spring	Fall	Spring	Fall	Spring	Fall	
N rate	1983	1984	1983	1984	1983	1984
	lb N/ acre					
0	136	106	54	69	47	57
120	265	172	226	130	83	104
240	381	225	373	340	171	148
360	576	442	421	478	319	189
CV (%)	27	32	56	49	50	39

[1/] Values reported are total nitrate N in 4-ft. soil profiles at Arlington and Madison and in 3-ft. soil profiles at Lancaster.

Table 2. Precipitation relative to normal during the periods between profile nitrate measurements.

Time Interval	Departure from normal (inches)		
	Arlington	Madison	Lancaster
May-Sept., 1983	-0.27	-1.57	-1.07
Oct., 1983 - Apr., 1984	+3.18	+2.71	+1.51
May - Sept., 1984	+0.33	+2.09	-2.25

Table 3. Effect of applied N and residual nitrate on corn grain yields. Lancaster, Wis., 1984.

	1983 N rate lb/a			
	0	120	240	360
1984 N rate	Grain yield[1/]			
lb/a	bu/a			
0	100	121	129	137
70	129	141	138	137
140	140	130	121	148
210	133	144	142	139
$LSD_{(0.05)}$	15	NS	NS	NS
Residual NO_3^--N (lb/a) (0-3 ft.), Spring 1984.	57	104	148	189

1/ CV for yield = 8.2%

Table 4. Effect of applied N and residual nitrate on corn grain yields. Arlington, Wis., 1984.

	1983 N rate lb/a			
	0	120	240	360
1984 N rate	Grain yield[1/]			
lb/a	bu/a			
0	150	136	149	149
70	154	164	159	138
140	160	156	159	153
210	153	151	147	157
$LSD_{(0.05)}$	NS	NS	NS	NS
Residual NO_3^--N (lb/a) (0-4 ft.), Spring 1984	106	172	225	442

1/ CV for yield = 8.3%

Table 5. Effect of 1983 and 1984 N rates on residual nitrate in soil profiles. Arlington, Wis., fall 1984.

1984 N rate	1983 N rate, lb/a			
	0	120	240	360
lb/a	---------Residual NO_3^--N, lb/a[1/]---------			
0	64	67	75	72
70	78	77	115	121
140	121	149	128	188
210	217	255	210	258

1/ Total residual NO_3^--N in 0-4 ft. soil profile; CV for residual nitrate = 25%.

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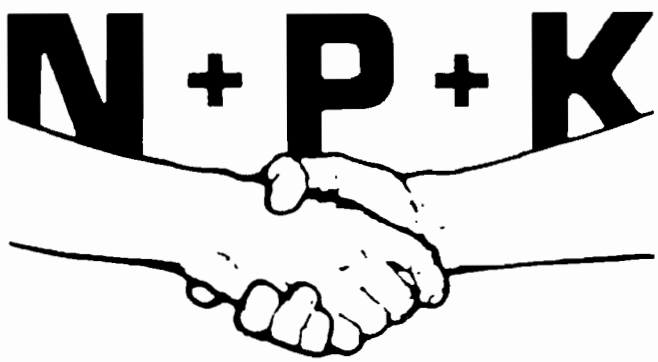

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OCTOBER 30-31, 1985

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