EVALUATION OF SOIL PROFILE NO_3-N FOR PREDICTION OF N FERTILIZER REQUIREMENTS

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Current N recommendation systems based on yield goal with adjustment for previous legume crop or manure applications have worked well in many situations. In the example given in Table 1, multiplying the 8 year average yield times 1.2 lb N/bushel would result in a recommendation within 20 lbs N/acre of the optimum in 6 of the 8 years. As expected, this system resulted in significant over recommendation in the 1988 and 1989 drought years. While these results provide confidence that the system works well in most years, research and farmer reports of near optimum yield with little or no applied fertilizer N makes one question the system. This is especially true when one determines that lack of expected response cannot be explained on the basis of previous crop, manure application, or poor yield (Table 2). These situations, coupled with economic and environmental concerns require the development of an improved system for determining N needs in the more humid environments of the midwest. A system is needed that would allow farmers to identify those soil conditions where current N recommendation rates should be adjusted.

Soil profile NO_3-N levels are being used to predict nitrogen needs in the more humid areas of the midwest. Iowa has adopted the procedure outlined by Magdoff et al., 1984[1]. Nitrate-N concentrations of soil samples collected from the upper 12 inches of soil when corn is 6 to 12 inches tall are used to set N rates (Blackmer et.al., 1991[2]) A full rate is suggested at test levels below 10 ppm NO_3-N, with an adjusted rate recommended between 11 and 25 ppm NO_3-N. Michigan suggests that farmers reduce N rates by 1 pound for each pound of NO_3-N found in the upper 2 feet of soil in samples taken in late March or early April (Vitosh et al., 1988[3]). Bundy and Malone (1988[4]) have also demonstrated the value of using NO_3-N concentrations in the top 2 or 3 feet of soil in early spring to adjust N rates in Wisconsin.

The objective of the project reported in this paper was to evaluate the accuracy of three systems- namely yield goal, early season NO_3-N concentration, and presidedress NO_3-N concentration- for predicting nitrogen rates necessary for optimum corn production.

Methods and Materials:

Experiments were conducted at 48 sites (data are available for 45 sites for this paper) throughout Illinois over the 1990 and 1991 crop years to evaluate the potential for utilizing a soil NO_3-N test to adjust N recommendations for corn. Ten experiments were also conducted during the 1991 crop year using wheat as the test crop. All sites were selected to provide a range in soil texture, yield potential, previous crop, and manure application.

Soil samples were collected for NO_3-N analysis from each corn site in late

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March/early April at depths of 0-6, 6-12, and 12-24 inches. Nitrate concentrations (ppm) from the upper 24 inches were multiplied by a factor of 8 to estimate NO_3-N content. Samples were also collected for NO_3-N analysis when corn was 6-12 inches tall from the top foot of soil at each location. Individual plots 10 feet (4 rows) x 50 feet were arranged in a randomized complete block design using 4 replications.

Nitrogen was applied at sidedressing at each location at six rates of N evenly distributed from 0 to 100% of normal recommendation in 1990 and from 0 to 125% of normal recommendation in 1991 . The recommended N rate for each site was determined by multiplying the soil's productivity level under high management (Soils of Illinois, 1984[5]) by 1.2 pounds N per bushel minus adjustments for previous crop or manure application. Nitrogen treatments were injected as urea-ammonium nitrate solution (28% N) using a 30-inch knife spacing in 1991 and a 60-inch spacing in 1990.

The center two rows of each plot were thinned to a uniform population shortly after the nitrogen treatments were applied. Ear leaf and grain samples were collected at silking and harvest respectively for N analysis. Grain yield was determined by hand harvesting 20 feet of the center two rows and adjusting the shelled weight to 15.5% standard moisture.

Economical optimum yield was calculated for each location as that point on the quadratic response curve where the slope was equal to a cost:price ratio of 0.08 using $.20/lb N and $2.50/bu corn (Nafizger et al., 1984[6]). The optimum N rate was considered to be zero where there was no significant response to N.

Soil samples were collected in March at depths of 0-12 and 12-24 inches on each wheat site. Six rates of N ranging from 0 to 125 lb N/acre in 25 lb increments were applied using urea as the N source. Individual plots were 10 x 20 feet with four replications at each site. Grain was harvested using a small plot combine from a 5 x 15-foot area from each plot, and yields were calculated based on 13.5% standard moisture.

Results and Discussion:

Soil NO_3-N content in the upper 24 inches of soil ranged from 9 to 300 lbs/acre in 1990 and 4 to 186 lbs/acre in 1991. The highest level of NO_3-N in both 1990 and 1991 was observed at sites where manure was applied the previous fall at over 10 and 5 ton/acre respectively.

While significant (R^2=.50), the relationship between NO_3-N concentrations in the 0-12 inch zone with that in the 12-24 inch zone was not strong. This would suggest that use of the NO_3-N concentration in the 0-12 inch zone to represent content in the upper 24 inches will be of limited value. This would be especially true for those areas where low yields were followed by a wet fall that would result in the movement of carryover N below the upper 12 inch depth, but not out of the rooting zone.

Early June soil NO_3-N concentration in the top 12 inches of soil ranged from 0.3 to 55.4 ppm in 1990 and 1.6 to 51.5 ppm in 1991. The highest level of NO_3-N was observed on sites where manure was applied the previous fall. Of the 48 sites evaluated over the two years, 68% had NO_3-N concentrations less than 10 ppm in the upper 12 inches of soil. When one considers only those fields that did not have manure or a previous legume, 85% had NO_3-N concentrations less than 10 ppm.

Early spring and presidedress NO_3-N concentrations were highly correlated (R^2=0.74). Presidedress concentrations were about 50% higher than the early spring, reflecting the rate of mineralization that occurred between sampling periods.

The relationship between yield obtained on the untreated plot as a percentage of the optimum yield and NO_3-N concentration in the 0-12 and 12-24 inch samples collected in early spring and the 0-12 inch samples collected at presidedress was very low. (R^2=0.08,0.12,0.02 respectively).

Nitrogen needs at 3 of 5 manured sites were accurately predicted to show no response to further N application by all three recommendation systems. One of the two remaining sites had straw manure surface applied the prior year (Table 2: 11) making a representative soil sample difficult to obtain.

Assuming a confidence range of plus or minus 10 lb N/acre, both the current University of Illinois recommendation and the approach suggested by Blackmer et al.[3] would have accurately predicted the optimum rate for 20% of the sites(Table 3 and 4). Subtracting the NO_3-N content (concentration times 8) from the normal recommendation resulted in correct prediction of only 13% of the sites, again assuming a confidence range of 10 lb N/acre. Based on the optimum N rate derived for each location, the three recommendation systems would have resulted in an over recommendation of 67, 57, and 39 lb N/acre respectively for the current University of Illinois recommendation system, the presidedress system (Blackmer et al.[3]), and the early spring system (Vitosh et al.).

This rather poor prediction of N need by all systems may have been due to environmental conditions that resulted in 25 of the 45 sites having yields less than expected for the soil type. In 1990, early planted corn encountered severe stress from excess moisture for several days early in the season at many locations, while in 1991 crop yields suffered from extreme drought conditions at many locations.

No response to applied N was observed at 36% of the sites evaluated. Lack of response in 1990 could be explained in part by the early stress caused by excess moisture at five locations (Table 3: locations 2,13,14,17,19), while the drought of 1991 was likely the reason for lack of response at 7 locations (Table 4: locations 5,8,9,12,14,18,20). The study was repeated in 1991 at three of the sites that did not show a response in 1990. Results have again shown no response to applied N at two of the sites, but they were both under extreme drought stress.

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Table 1. Optimum N rate per unit of land area and per unit of grain harvested derived from results of a N rate study over 8 years of continuous corn at Monmouth, IL.

Year	Optimum N rate lb/acre	lb/bushel
1983	164	1.09
1984	184	1.07
1985	183	1.01
1986	180	1.02
1987	187	1.10
1988	100	1.47
1989	144	1.29
1990	168	0.90
avg.	164	1.12

Table 2. Effect of N rate on corn yield. Monmouth, IL.

N applied lb/acre	Yield (bu/acre)	
	1985	1986
0	118	152
120	183	155
180	190	150
240	183	155

Table 3. Yield goals, No_3-N contents optimum yields and N rates, and N rate recommendations for 18 Illinois sites in 1991.

Location	Previous Crop	Yield Goal	April NO_3-N 0-24"	June NO_3-N 0-12"	Optimum Yield	Optimum N rate	**Recommended N Rate: Ill	**Recommended N Rate: Presid.	**Recommended N Rate: Preplant
			ppm x 8	ppm	bu/A	lb/A	lb/A	lb/A	lb/A
Central									
Piatt-GU	Corn	150	15.6	0.3	177	150	140	180	124
Logan-FA	Beans	163	29.8	6.5	161	212	156	200	125
Logan-BE	Beans	163	16.8	3.2	162	157	156	200	138
Warren-DA	Corn	167	38.8	4.2	160	99	160	200	121
Warren-MO	Beans	167	74.8	5.4	155	92	200	200	125
Iroq.-WE	Beans	140	24.0	2.9	157	98	128	170	104
Iroq.-HU	Corn	150	26.8	7.0	131	168	180	180	153
Iroq.-KI	Beans***	131	300.0	55.4	153	0*	0	0	0
Hends.-GE	Beans	150	22.0	8.3	99	0*	140	180	118
Hends.-RO	Corn	150	23.4	2.0	134	92	180	180	157
Northern									
Will-JJC	Beans	117	49.6	5.7	173	87	100	140	50
LaSalle-BL	Beans	154	45.2	10.5	126	0*	145	150	100
Kendall-KE	Corn	154	45.6	7.9	122	0*	185	190	139
Kane-GU	Beans	152	60.6	14.7	138	0*	142	110	81
Steph.-KO	Corn	123	81.8	12.5	140	0*	148	120	66
Steph.-WE	Beans***	155	91.0	13.3	170	95	136	80	35
Southern									
Effng.-BE	Beans	115	36.0	13.2	157	56	98	80	62
Effng.-DE	Corn	98	42.8	11.9	123	75	118	90	75

*No significant differences among treatment means at P=0.2. In these locations optimum yield equals trial average yield.
**Ill.-University of Illinois, Presid-Presidress NO_3-N Test, Preplant-Preplant $N0_3$-N Test
***Sites with manure applied fall, 1989.

Table 4. Yield goals, NO_3-N contents optimum yields and N rates, and N rate recommendations for 27 Illinois sites in 1991.

Location	Previous Crop	Yield Goal	April NO_3-N 0-24"	June NO_3-N 0-12"	Optimum Yield	Optimum N rate	**Recommended N Rate Ill	Presid.	Preplant
		bu/A	ppm x 8	ppm	bu/A	lb/A	---lb/A---		
Central									
Warren-DA	Corn	160	56.8	5.8	154	0*	192	135	135
War-DU	***Beans	160	87.6	34.1	171	0*	0	0	0
War-EL	Beans	160	28.1	4.4	164	0*	150	135	135
Wdfd-CO	Beans	160	38.7	8.1	182	96	152	135	113
Wdfd-SH	Beans	160	69.8	15.0	83	0*	152	85	82
Logan-FU	Beans	140	42.5	6.8	176	133	128	135	86
Macon-FP	Corn	145	16.8	2.4	100	145	174	135	157
Chpn-HE	Beans	130	25.4	22.0	56	0*	116	20	91
Chgn-KO	Beans	160	32.3	9.0	118	0*	152	135	120
Pike-GA	Beans	145	36.1	4.2	189	102	134	135	98
Northern									
Steph-KE	***Corn	150	67.3	10.8	183	0*	156	125	83
Steph-KO	Corn	150	47.7	6.2	100	0*	189	135	132
Steph-WE	***Beans	140	186.0	51.5	198	0*	0	0	0
Boone-C	Alfalfa	150	25.8	18.8	96	0*	130	45	104
Boone-M	Beans	150	7.2	7.3	113	101	140	135	133
Kane-LO	Beans	150	30.4	4.3	174	80	140	135	110
Kane-PI	Corn	140	28.5	3.6	151	120	180	135	140
Kendall-KE	Corn	150	58.0	8.6	90	0*	180	135	122
Will-JO	Oats	135	19.0	7.1	101	164	162	135	143
Will-MC	Corn	130	17.1	6.1	70	0*	156	135	139

Table 4. Yield goals, NO_3-N contents optimum yields and N rates, and N rate recommendations for 27 Illinois sites in 1991. (continued)

Location	Previous Crop	Yield Goal	April NO_3-N 0-24"	June NO_3-N 0-12"	Optimum Yield	Optimum N rate	**Recommended N Rate		
							Ill	Presid.	Preplant
		bu/A	ppm x 8	ppm	bu/A	lb/A	-----------------lb/A-----------------		
Southern									
Mad-DA	Wheat/Beans	140	3.6	6.5	163	172	143	135	140
Mad-WE	Wheat/Beans	135	23.8	2.7	143	174	137	135	113
Mad-WI	Hairy Vetch	120	21.8	1.6	117	135	94	135	72
Effng-JA	Corn	115	28.0	5.6	136	142	138	135	110
Effng-SC	Corn	115	93.1	7.8	161	0*	138	135	45
Wayne-BR	Corn	115	22.6	10.7	95	0*	138	125	116
Wayne-GL	Wheat/Beans	115	60.3	2.6	71	89	113	135	53

*No significant differences among treatment means at P=0.2. In these locations optimum yield equals trial average yield.
**Ill.-University of Illinois, Presid.-Presidress NO_3-N Test, Preplant $N0_3$-N Test.
***Sites with manure applied fall 1991.

PROCEEDINGS OF THE TWENTY-FIRST

NORTH CENTRAL EXTENSION - INDUSTRY SOIL FERTILITY CONFERENCE

November 13-14, 1991, Holiday Inn St. Louis Airport

Bridgeton, Missouri

Volume 7

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