A NITROGEN SOIL TEST FOR CORN

M.A. Schmitt and G.W. Randall
Extension Soil Scientist and Soil Scientist
University of Minnesota
St. Paul and Waseca, Minnesota

In the past decade, many states have started including a soil test when making N recommendations. In order for a soil N test to be useful, it must provide information that is not known or incorporated when making N recommendations without a test. If a test does not provide explainable, quantifiable information, the test loses its usefulness.

In Minnesota, a fall/spring preplant N test has been used in the western tier of counties, which have lower rainfall than the rest of the state, for many years. However, a soil N test is now being recommended for the remainder of the state, primarily to identify non-responsive sites. The test being implemented is a spring, preplant, 2-foot, nitrate-N test for corn. This test is not recommended following alfalfa.

The objective of this paper is to provide some of the rationale and experimental data used in selecting the parameters of this test.

PROCEDURES

Sixty locations were selected from 1989 through 1992 to conduct calibration/correlation experiments regarding an N test for corn. These locations had an array of previous crops, with a predominance of corn and soybeans. The sites were primarily on farmer-cooperator fields throughout south-central, southeastern, and east-central Minnesota.

The correlation phase of the project involved collecting soil samples and grain yields from plots at each site. Soil samples were collected approximately two weeks before planting, two weeks after planting when the first leaf was emerging, and five weeks after planting when the corn was 6-12" tall. Samples were collected to a depth of four feet in one-foot increments at all sampling times. Samples were analyzed for nitrate-N, ammonium-N, and phosphate-borate extractable hydrolyzable N.

At each site, several N fertilizer rates were applied to plots so that a calibration of the soil test values and response to fertilizer could be evaluated compared to a prediction model based on the soil test parameter and relative grain yields.

RESULTS AND DISCUSSION

N form

When developing an N test, it is essential to know which N form best relates to a crop response. While nitrate-N is the standard for N testing programs in the U.S., there are reasons to consider ammonium-N and hydrolyzable-N. If an ammonium-based fertilizer is applied to cropland before the sample is taken (i.e. spring preplant N with a soil N test to be taken in late May), ammonium-N may be a significant factor to take into account.

Table 1 lists nitrate-N and ammonium-N concentrations in plots that received preplant fertilizer N applications. Significant amounts of nitrate-N and ammonium-N are measured at the emergence sampling time in amounts proportional to the fertilizer rate. However, when correlating relative grain yields to N forms at various sampling times and depth, the coefficients from using ammonium-N and hydrolyzable-N are much poorer compared to using nitrate-N (Table 2).

Hydrolyzable-N may provide useful data in crop systems that have manure and legumes because of the organic N added to the system. Nonetheless, hydrolyzable-N, although at times well correlated to grain yields, was not consistent in this study (Table 2).

When developing predictive models relating soil test values to grain yield, it is clear that nitrate-N is the preferred N form to measure (Table 3). Thus, while ammonium-N and hydrolyzable-N may be very important N forms in supplying N to crops, they are not as useful in developing predictive models.

Sampling Depth

Current soil sampling depths for nitrate-N throughout the U.S. range from 6 inches to 6 feet. In evaluating depths, it is important to consider the source of nitrate-N (i.e. residual N or recently mineralized N). There must also be a balance between science and practicality; a deeper sampling depth should be recommended only if it provides additional information.

Based on the data in Table 1, it was concluded that preplant fertilizer N does cause elevated nitrate-N concentrations in the second foot. Using predictive models for nitrate and comparing sampling depths at the preplant and emergence sampling times, the model fit is better for the 2-foot sample compared to the 1-foot sample (Table 3). At the preplant sampling time, the 3-foot model does not provide a better fit compared to the 2-foot model.

Sampling to a depth of two feet combines the improved predictability of the data and the feasibility of acceptance by those taking soil samples. Sampling to one foot might not include enough information whereas sampling to three feet does not include substantial additional information compared to two feet.

Sampling time

The sampling time recommended for a test is extremely important due to the effect of N transformations on the data obtained and its consequences. An early season test will most likely measure residual, or carryover, nitrate from the previous year, whereas a test taken during the growing season would include some recently mineralized N along with some possible residual N. Nitrate-N changes among the three sampling times evaluated provide evidence of the mineralization of organic N (Figure 1). Thus, the issue of legume and manure credits as part of an N recommendation could be complicated by the use of an in-season test.

If the soil N test is to be used in making a fertilizer recommendation, it is implied that a fertilizer application will need to be made after taking the test. Thus, samples collected after the corn is planted will require a sidedress, topdress, or fertigation N application. Yet, for many crop producers and fertilizer dealers, this situation is not ideal. In contrast, if the soil test is intended only to provide feedback regarding N sufficiency, an in-season test does not have a perceived disadvantage compared to a preseason test.

Using the predictive models in Table 3, the different sampling times can be judged relatively. For a 2-foot sampling depth, model fits for the emergence (V1) and 6-12" corn (V4) are equivalent (0.61 and 0.62). The preplant model fit is 0.50. All three sampling times have similar error rates when predicting N response of the models to actual data.

In evaluating a) the data, b) the implications of sampling time on subsequent fertilizer applications, and c) the issue of crediting legumes and manures, the preplant sampling time was selected for Minnesota.

SUMMARY

At this time, Minnesota is recommending a spring preplant, 2-foot soil nitrate test for corn N recommendations. The calibration of this test is not finished; a temporary critical value of 175 lb nitrate-N is being used to identify non-responsive sites.

Preplant soil nitrate-N amounts near 175 lb/acre can be associated with one (or more) of three scenarios: 1) low rainfall in the previous year or two resulting in lower yields than planned, 2) manure has been applied regularly for some time, and/or 3) continuous corn being grown with excessive amounts of N being applied.

A major Midwest drought in 1988 has had a large impact on the results of the this study. Fertilizer N rates that provided the highest yield at each location were, on average, much lower in 1989 than in other years (Table 4). Figure 2 depicts the inverse relationship between preplant nitrate-N and rainfall in the latter half of the previous growing season. In general, less rainfall in the previous summer and fall was associated with more residual nitrate-N measured the following spring.

A soil N test can easily be confounded with the validation of N fertilizer responses. While the 1989 data might have suggested that the standard N fertilizer rates were too high, the information provided by soil testing explained the lack of responses. Soil testing can also serve different objectives--fertilizer recommendations and/or fertilizer sufficiency feedback--and it is important to acknowledge which objective is to be met.

Table 1. The effect of time and depth of soil sampling on nitrate-N and ammonium-N concentrations from preplant fertilizer applications averaged across all sites, 1989-1991.

Sampling Time	Sampling Depth	Preplant N applied (lb N/A) 0 NO_3-N	0 NH_4-N	60 NO_3-N	60 NH_4-N	150 NO_3-N	150 NH_4-N
	- ft -	- - -	- - -	- - lb N/A - -	- - -	- - -	- - -
1-2 leaf	0-1	38	25	67	28	112	39
(V1)	1-2	26	13	38	14	49	16
	0-2	64	38	105	42	161	55
6-12" tall	0-1	35	31	59	32	98	35
(V4)	1-2	27	19	35	19	51	20
	0-2	62	50	93	51	149	55

Table 2. Correlation coefficients of three N forms measured as affected by sampling time and depth correlated to relative grain yields of plots receiving no fertilizer N, 1989-1991.

Sampling Time	Depth	Nitrate-N	Ammonium-N	Hydrolyzable-N
	-ft-	- - -	- - r[1/] - -	- - -
Preplant	0-2	0.487	-0.010^{NS}	0.125^{NS}
	0-3	0.495	0.001^{NS}	0.155
1-2 leaf	0-1	0.561	0.258	0.205
(V1)	0-2	0.615	0.270	0.192
6-12" tall	0-1	0.529	0.225	0.167
(V4)	0-2	0.506	0.285	0.163

[1/] All coefficients are statistically significant at the 95% confidence level except those designated with an NS.

Table 3. The effect of sampling time, sampling depth, and N form on linear-plateau models with relative grain yields as the dependent variable, 1989-1992.

Sampling Time[1/]	Sampling Depth	N Form	R^2[2/]	Critical Value	Error Rate
	-ft-			-lb N/A-	-%-
PP	0-2	**NO_3-N**	0.50	122	30
PP	0-2	**NH_4-N**	NF[3/]	--	--
PP	0-2	**Hydrol-N[2/]**	0.12	210	54
PP	**0-1**	NO_3-N	0.35	70	36
PP	**0-2**	NO_3-N	0.50	122	30
PP	**0-3**	NO_3-N	0.49	220	39
V1	**0-1**	NO_3-N	0.46	60	29
V1	**0-2**	NO_3-N	0.61	192	24
PP	0-2	NO_3-N	0.50	122	30
V1	0-2	NO_3-N	0.61	192	24
V4	0-2	NO_3-N	0.62	186	31

1/ Abbreviations for sampling time are: PP, preplant; V1, 1-2 leaf corn; V4, 6-12" corn.
2/ Phosphate-borate extractable hydrolyzable N.
3/ The data did not statistically fit a model.

Table 4. Frequency of optimum fertilizer N rates from all sites except where alfalfa was the preceeding crop.

Optimum N rate[1/]	1989	1990	1991
- - -lb N/A- - -	- - - - -number of	sites- - - -	
0	7	3	0
30	_[2/]	_[2/]	3
60	3	6	2
90	1	4	3
120	1	1	3
150	1	0	1
180	1	0	0

1/ The optimum N rate is defined as the lowest N rate in the highest t-grouping when using FLSD.

2/ The 30 lb N/A rate was not used in 1989 and 1990.

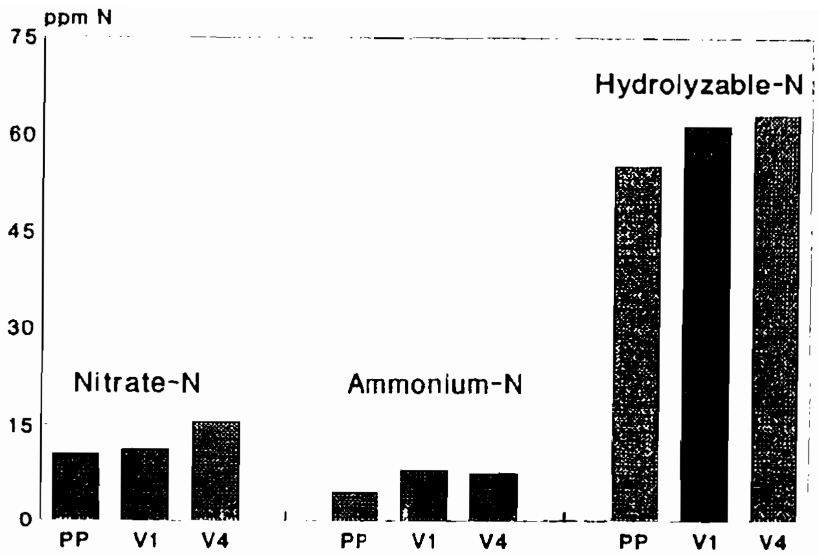

Figure 1. The effect of sampling time on N concentrations from sites in southeast MN, 1989-1991.

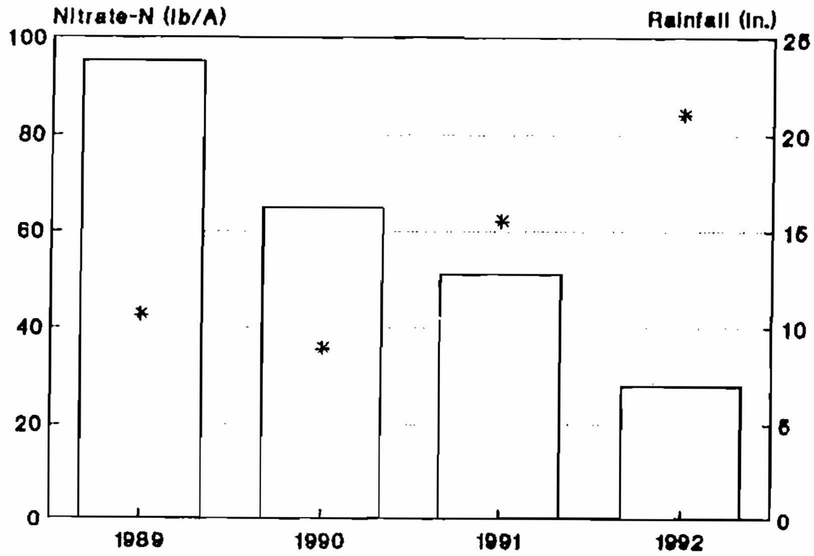

Figure 2. Spring, preplant, 2-foot nitrate-N values and the previous year's rainfall (*) from July through October.

PROCEEDINGS OF THE TWENTY-SECOND

NORTH CENTRAL EXTENSION - INDUSTRY

SOIL FERTILITY CONFERENCE

November 18-19, 1992, Holiday Inn St. Louis Airport

Bridgeton, Missouri

Volume 8

Program Chairman and Editor:

Ray Lamond
Department of Agronomy
Throckmorton Hall
Kansas State University
Manhattan, KS 66506