SOIL TESTING TO GUIDE NITROGEN FERTILIZATION IN MANURED CORNFIELDS

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Land application of animal manures can supply N needed for corn production. The amounts of N supplied, however, vary greatly with source of manure, type of storage, method of application, time of application, rate of application, and weather after application. A major problem is that substantial losses of plant-available N by ammonia volatilization, leaching, denitrification, and/or immobilization frequently occur soon after the manure is applied. Another problem is that it is difficult to determine how rapidly N in the manure becomes available to plants. These problems make it difficult to estimate how much fertilizer N should be applied.

Soil testing for nitrate in the surface foot of soil when plants are 6 to 12 inches tall is gaining acceptance as a tool for assessing fertilizer N needs. The soil test reduces uncertainty in fertilizer N needs because it enables site-specific assessments that reflect any losses or gains in plant-available N that occur before the soils are sampled (Blackmer et al., 1993). The assessments are made early enough that more N can be applied if needed.

Many studies indicate that a nitrate-N concentration of about 25 ppm usually provides a reasonable distinction between soils that do, and do not, need additional N. Relatively few studies, however, have utilized an experimental design that enables direct assessments of the amounts of fertilizer N needed on soils having concentrations of nitrate-N below 25 ppm. The objective of this report is to summarize recent studies to assess the relationship between N fertilizer needs and soil nitrate concentrations found in manured cornfields in late spring. This work was made possible by funding from the Leopold Center for Sustainable Agriculture.

Response trials were conducted in 1992, 1993, and 1994 at a total of 111 sites in 23 Iowa counties on farmers' fields having varied histories of manuring. Manure came from beef units at 22 sites, dairy units at 9 sites, swine units at 55 sites, and poultry units at 9 sites. Sixteen sites received 2 or more forms of animal manure. Of the 78 sites that had been manured for the corn crop studied, 22 were manured in the fall, 24 in the winter, 27 in the spring, and 5 had received applications during 2 or more seasons. Except that fertilizer N was not applied, the cooperating farmers managed the corn in the test areas in accordance with their normal management practices.

Soil samples (0-12 inch depth) were collected when corn plants were 6-12 inches tall. After soils were sampled, ammonium nitrate was topdressed at various rates (0, 30, 60, and 90 lb N/acre) in 4 replications per site. Cornstalk samples were collected from all plots at the end of the season and analyzed for nitrate-N (Blackmer and Mallarino, 1994). Grain yields were measured by hand-picking and adjusted to 15.5% moisture. Relative grain yields, which are a measure of yield response, were calculated; they are yields of nonfertilized plots expressed as a percentage of the average of the highest yielding treatments that were not statistically different within sites.

The 1992 and 1994 growing seasons had above-average rainfall late in the season and produced above-average grain yields. The Spring of 1993 was unusually wet, and this wetness continued throughout the growing season and resulted in below-average grain yields. The results of the studies can be summarized by the following points.

1. Statistical analyses indicated that fertilizer N increased yields at only about one-third of the sites. This demonstrates that manure is a valuable source of plant-available N.

2. No significant yield increases were observed at sites having greater than 25 ppm nitrate-N. This demonstrates that the soil test is a very effective tool for showing where fertilizer N is not needed.

3. Among soils having less than 25 ppm nitrate-N in late spring, mean values for relative yields tended to increase with increases in the soil nitrate concentrations (Fig. 1). This provides direct evidence that the soil test provided meaningful assessments of plant-available N in low-testing soils.

4. Results of the end-of-season cornstalk test showed good agreement with assessments of available N by the late-spring soil test (Fig. 1). The legend in Figure 1 indicates that 250 to 2000 ppm of nitrate-N in the cornstalks is adequate. This range includes the "marginal" category (250-700 ppm) and the "optimal" category (700-2000 ppm). Perfect agreement should not be expected because the end-of-season cornstalk test reflects the effects of weather conditions that could not have been predicted in late spring.

5. Optimal rates of N fertilization tended to decrease with increases in soil nitrate concentrations (Table 1):

90 lb N/acre was needed for less than 10 ppm;
60 lb N/acre was optimal for 10 to 16 ppm;
30 lb N/acre was optimal for 17 to 24 ppm;
0 lb N/acre was most profitable for 25 ppm or more.

This provides direct evidence that the soil test can be used to prescribe rates of N fertilization. The amounts of fertilizer needed seem to be much less than those currently recommended in guidelines for using the soil test (Blackmer et al., 1993).

6. At all rates of application, N fertilization at any fixed rate tended to be a profit-reducing activity under price scenarios often experienced by producers (Table 2). Informal surveys revealed that most producers were applying more than 100 lb N/acre to the manured fields surrounding study areas.

7. Under all reasonable price scenarios, use of the soil test to prescribe N fertilization rates would have substantially increased profits for the producer while decreasing mean rates of N fertilization. This demonstrates clear economic and environmental reasons for using the soil test.

Overall, the results clearly demonstrate that soil testing for nitrate in late spring should be considered an effective method of prescribing N fertilizer needs for manured cornfields. Widespread use of this test would increase profits for producers while decreasing environmental problems associated with agriculture. Current recommendations concerning the amounts of fertilizer N needed on soils having nitrate-N concentrations less than 25 ppm need to be revised to reflect the results of these studies. It is expected that new recommendations based on these studies and data collected in 1995 will be available for the Spring of 1996.

References

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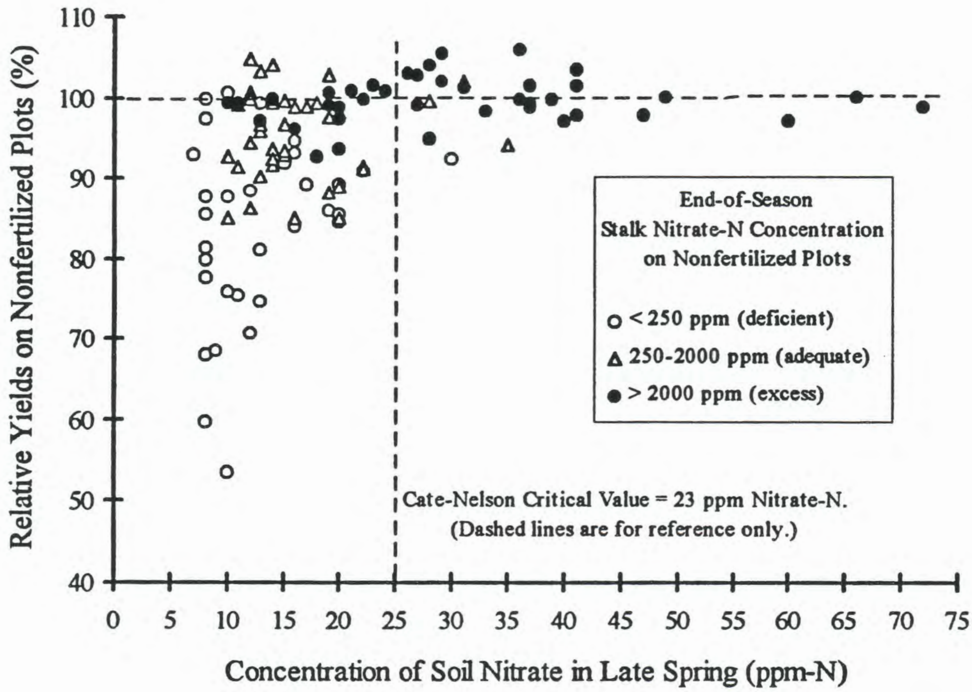

Figure 1: Relationship between concentrations of soil nitrate in late spring and relative yields of nonfertilized plots on 111 manured cornfields, 1992-92.

Table 1. Yields of corn grain observed after fertilizer N was applied to manured soils having various concentrations of nitrate before the fertilizer was applied.

Soil nitrate-N	Yields at various N fertilization rates			
concentration	0 lb N/acre	30 lb N/acre	60 lb N/acre	90 lb N/acre
---ppm---	----------bu/acre----------			
1992				
< 10 (9%) ǂ	122	140	151	154*
10-16 (38%)	154	162	172*	170
17-24 (23%)	165	171*	169	172
25 + (30%)	174*	175	176	175
1993				
< 10 (25%)	90	94	97	100*
10-16 (49%)	102	105*	105	106
17-24 (15%)	109*	111	110	110
25 + (11%)	103*	103	102	99
1994				
<10 (7%)	120	139	156	159*
10-16 (28%)	145	160	168	174*
17-24 (28%)	159	168*	168	171
25 + (38%)	173*	175	175	174
1992-1994				
<10 (13%)	102	112	119	122*
10-16 (39%)	142	146	153*	151
17-24 (22%)	150	155*	155	157
25 + (26%)	163*	165	165	164

* = Treatment that maximized returns to N fertilization, assuming application costs are 2 bu/acre and each 30 lb increment of N costs 2 bu/acre.

ǂ = Percent of total plots in each soil-test category

Table 2. Mean net returns to N fertilization across all soils when fertilizer N was applied using alternative recommendation systems.

Recommendation system	Mean rate of fertilization	Net returns to Added N: Poor+ prices	Net returns to Added N: Good‡ prices
	----lb N/acre----	----$/acre----	
Soil test not used			
0 lb N/acre to all soils	0	0	0
30 lb N/acre to all soils	30	-1.01	2.73
60 lb N/acre to all soils	60	-1.19	8.88
90 lb N/acre to all soils	90	-9.11	5.37
Soil test used			
90 lb N/acre if < 10 ppm, 60 lb N/acre if 10 - 16 ppm, 30 lb N/acre if 17 - 24 ppm, 0 lb N/acre if ≥ 25 ppm	42	3.75	12.46

+ = Assumes a grain price of $2.00/bu, N cost of $0.25/lb and application cost of $2.50/acre
‡= Assumes a grain price of $2.50/bu, N cost of $0.10/lb and application cost of $5.50/acre