NITRATE SOIL TESTING
CORRELATION AND CALIBRATION,
EASTERN CORN BELT

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Current economic and environmental concerns have increased the interest in developing methods to help manage nitrogen (N) fertilizers as efficiently as possible. There is a concern that fertilizer N that remains in the soil following harvest may be leaching below the root zone of crops and eventually ending up in groundwater. Agronomists throughout the corn belt are actively evaluating methods to manage N fertilizer as efficiently as possible.

N FERTILIZER RECOMMENDATIONS

Nitrogen fertilizer recommendations are currently made by multiplying a farmer's expected yield goal times an empirically derived constant that is an estimate of the amount of N required to produce a bushel of corn. The factor used in Iowa is 1.22 (Voss and Killorn, 1988). This can be expressed mathematically by the equation:

$$N_f = 0 + 1.22*YG$$

N_f is the N requirement (lb/a),
YG is the yield goal (bu/a).

N_f is then modified to account for N from other sources, such as a previous legume crop, an application of manure, or N contained in an N-P-K fertilizer.

While the equation is mathematically consistent, it is not agronomically consistent unless two assumptions are made. The first is that the farmer has a realistic yield goal. This effectively places an upper limit on the equation. Second, the equation, as written, indicates that if no N is applied there will be no yield. Since this isn't true, we must assume that the N fertilizer requirements are larger than year to year variations in the N supplying capacity of the soil (Olsen and Kurtz, 1982). This allows us to ignore the intercept of the line (which is defined as 0 in the equation above).

The data in Table 1 are average yields observed when no N was applied in a study conducted near Beaconsfield in south-central Iowa. The range is from 21 bu/a in 1983 to 150 bu/a in 1981. Clearly, year to year variation in the N supplied by the soil can be quite high. This variability is probably largely due to changes in the amount of residual and mineralized N supplied by the soil.

Table 1. Yield of continuous corn where no N was applied over several years at Beaconsfield, Iowa. (data from G. Benson)

1980	1981	1982	1983	1984	1985
----------	----------	----------	bu/a ----------	----------	----------
52	150	45	21	48	79

The effect of not being able to anticipate the ability of the soil to supply N to a crop can be seen in Table 2. These data are from a study conducted state-wide by Killorn et al. in 1987. The study sites were located in farmer's fields and consisted of rates of N, from 0 to 180 lb N/a applied either preplant or sidedress, and one rate that simulated the cooperator's N management program. The data are the average of 4 replications. Optimum economic yields were calculated from equations generated by regressing yields on rates of N fertilizer, and the optimum N fertilizer rate was calculated from the same equations once optimum economic yield had been determined. State-wide it required approximately 70 lb N/a to attain optimum economic yields in 1987. These data indicate that the soil supplied a significant quantity of N. In fact, average yield where no N was applied was 145 bu/a (data not shown). The average fertilizer rate used by the cooperators was 160 lb N/a. As shown in the fourth column in Table 2, the average over-application was 90 lb N/a.

Table 2. Comparison of optimum and cooperator's N fertilizer rates in a state-wide study conducted in Iowa in 1987.

Site	Optimum	Cooperator	Difference
	----------	lb N/a ----------	----------
3	60	135	-75
11	80	130	-50
12	40	200	-160
17	70	160	-90
18	70	160	-90
19	100	180	-80
Ave.	70	160	-90

It must be noted that all the cooperators were applying N fertilizer at rates consistent with reasonable yield goals. The reason for the magnitude of the over-application was the lack of the current recommendation system to account for the amount of N that will be supplied by the soil.

N INDICES

The search for suitable indices for estimating available N in soils has been in progress for some time (Magdoff, et al., 1984). There are three primary categories of N indices:

1. Biological tests, which consist primarily of incubation of soil samples to estimate the amount of N that will mineralize during the growing season,

2. Direct measurement of N fractions, especially nitrate (NO_3^-), and

3. Inorganic N released from soil upon treatment with chemicals.

The biological studies are time consuming, and can be difficult to run. Category 3, is an attempt to get the same information as the biological tests in a shorter time. There are several of these procedures that are correlated with one another, however, they tend to have little predictive value in terms of N fertilizer requirements in many situations.

Direct measurement of NO_3^- is being used in the low rainfall areas of the western United States. However, because of the mobility of NO_3^- in soils, it has been difficult to obtain reliable calibrations in the more humid corn-belt. This is due primarily to the unpredictability of rainfall and its effects on NO_3^-.

CURRENT RESEARCH ON N SOIL TESTS

Researchers in eastern corn belt states are currently investigating different ways to estimate how much N a soil will supply in a given year. There are two basic approaches, calibrating an index, or measuring nitrate nitrogen (NO_3-N) and reducing the fertilizer recommendation on a one-for-one basis. The specifics differ from state to state. The information contained in the following discussion came from conversations with Extension Soil Fertility Specialists in the various states, and from published materials.

Illinois

Nitrogen fertilizer recommendations are based on the grower's yield goal multiplied by a standard factor. There is no current correlation/calibration research for an N soil test.

Indiana

Nitrogen fertilizer recommendations are based on the grower's yield goal multiplied by a standard factor. There is no current correlation/calibration research for an N soil test.

Iowa

Researchers in Iowa are currently evaluating several different indices. Correlation data developed by Blackmer, et al. (1989) indicate that the index developed by Magdoff, et al. (1984) shows promise in the state (Figure 1). Nitrate-N concentration is determined on a 0-12" soil sample that is collected when the plants have reached the V3 to V4 growth stage (3 to 4 leaf collars visible on the stalk) which normally occurs in early June. If the soil sample contains 21 ppm NO_3-N or more, no fertilizer is required. If the sample tests less than 21 ppm NO_3-N fertilizer is recommended on a pro-rated scale.

ppm NO_3-N in Soil	Recommendation (lb N/a)
≤ 10	1.2 x Yield Goal
11-12	0.8(1.2 x Yield Goal)
13-15	0.6(1.2 x Yield Goal)
16-18	0.4(1.2 x Yield Goal)
19-20	0.2(1.2 x Yield Goal)
≥ 21	0

The test was offered for the first time this past spring. The Iowa State University Soil Testing Laboratory received over 800 soil samples. Sixtyfive percent of them tested in excess of 21 ppm NO_3-N. Information sheets received with the samples indicated that most of those that tested in excess of 21 ppm NO_3-N had already been fertilized with at least a portion of what the grower anticipated would be required. The correlation data currently applies only when no N fertilizer (except that in a low analysis starter) or manure was applied prior to taking the samples, or where such applications were broadcast. Further research is required in fields where N fertilizer has been band applied, ie. anhydrous ammonia or banded manure. A field test kit is being developed by Dr. Alfred Blackmer in cooperation with Hach Chemical that will allow growers to test their soil themselves. The kit should be available in the spring of 1990. Calibrations will be refined with the results of on-going research.

Michigan

Nitrogen fertilizer recommendations based on a 2' soil sample (0-1' plus 1-2') were offered this past spring. The correlation/calibration data are discussed in the paper by Dr. M. Vitosh elsewhere in this proceedings.

Minnesota

Nitrogen fertilizer recommendations based on soil tests have been offered for some time for the western portion of the state. Recommendations based on soil tests are now available for the entire state. Research is currently in progress to develop calibration data for the eastern portion of the state.

Missouri

Nitrogen fertilizer recommendations based on soil tests were available this past year. The recommendations are based on a sample taken in one foot increments to two feet (or to a root restricting layer). The amount of NO_3-N in the sample is deducted on a one-for-one basis from the fertilizer recommendation. The samples must be collected after April. The recommendations will be refined using the results of numerous on-going research projects.

Ohio

Nitrogen fertilizer recommendations based on soil tests are not currently available. Research is currently in progress to evaluate the 1' soil index (Magdoff, et al., 1984) and a test kit for in-field analysis.

Wisconsin

Nitrogen fertilizer recommendations based on a soil test were available this past year. The recommendations are based on the amount of NO_3-N in the top 2 or 3 feet of soil before planting (Bundy and Malone, 1988). Correlation data are shown in Figure 2. A background NO_3-N value (either 40 or 50 lbs N/a) is subtracted from the results of the soil analysis. The remainder is subtracted from the standard corn N recommendation. If the initial profile NO_3-N is less than 200 lbs N/a, a minimum N recommendation of 50 lbs N/a is given. A zero recommendation is given if the initial test value is more that 200 lbs N/a. Finally, the recommendation is adjusted for manure and legume credits.

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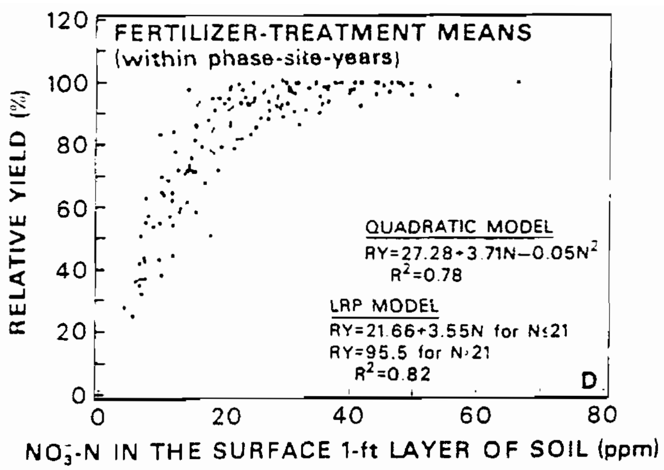

Figure 1. Relationship between corn yield and concentrations of nitrate in the soil when corn plants are in the V3 to V4 growth stage (From Blackmer et al., 1989)

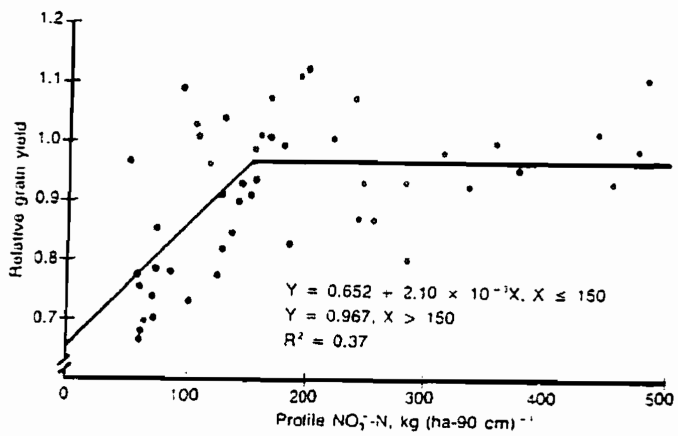

Figure 2. Relationship between relative grain yield and profile nitrate nitrogen at three locations in Wisconsin, 1984 (From Bundy and Malone, 1988).

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