Improving PSNT Based Sidedress N Recommendations for Corn with Site Specific Factors[1]

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INTRODUCTION

The pre-sidedress soil nitrate test (PSNT) has been found to be a valuable tool for improving nitrogen recommendations for corn grown in humid regions of the country. The PSNT has been especially useful for managing N on farms where organic sources of N, like animal manures are important. This test was proposed by Magdoff et al. in 1984 and has been studied extensively since then (Magdoff et al., 1990; Roth et al., 1992; Fox et al., 1989; Blackmer et al., 1989; Klausner et al., 1993, and Meisinger et al., 1992). Many states have been using some form of the PSNT for several years now.

The basis for the PSNT is taking 12" deep soil samples just before sidedressing (after the spring wet period but before the period of major N demand by corn) and determining the nitrate-N in the soil sample. The results of the test are then used as an index of N availability for corn production and to make N sidedress decisions.

There has been general agreement that the test is most useful for estimating the adequacy of soil nitrogen for optimum corn production. The critical level for response to sidedress N found by most researchers has been remarkably consistent across a wide area. The critical level generally falls somewhere between 20 and 25 ppm nitrate-N. Above this critical level usually no sidedress N is recommended. There is considerably less agreement, however, about what to do when the soil nitrate-N level is below the critical level. Some states use the PSNT levels to make sidedress N recommendations while in other states, when the test level is low, they revert to standard N recommendation systems.

PSNT CRITICAL LEVELS

Critical levels for the PSNT are usually determined from nitrogen response experiments by using the Cate-Nelson approach to partition the data from many experimental sites into responsive and non-responsive populations (Cate and Nelson, 1965). This approach is illustrated in Figure 1 using PSNT calibration data from Pennsylvania. The Cate-Nelson procedure separates the data into these two populations by maximizing the number of data points in the lower left and upper right quadrants. Data points in the upper left and in the lower right quadrants are errors. Points in the upper left quadrant are situations where the test value is below the critical level and a response is expected but is not observed. Points in the lower right quadrant are situations where the test level is above the critical level but a response is observed. A rigorous application of the Cate-Nelson procedure will tend to

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equalize the errors between these two quadrants. However, in practice, critical levels are often adjusted slightly to minimize errors in the lower right quadrant because this is where the recommended amount of N fertilizer would be deficient and thus result in a yield reduction for the farmer. In Pennsylvania this approach of minimizing errors in the lower right quadrant was used and an initial critical level of 25 ppm nitrate-N was established. This critical level is shown as the vertical dashed line in Figure 1.

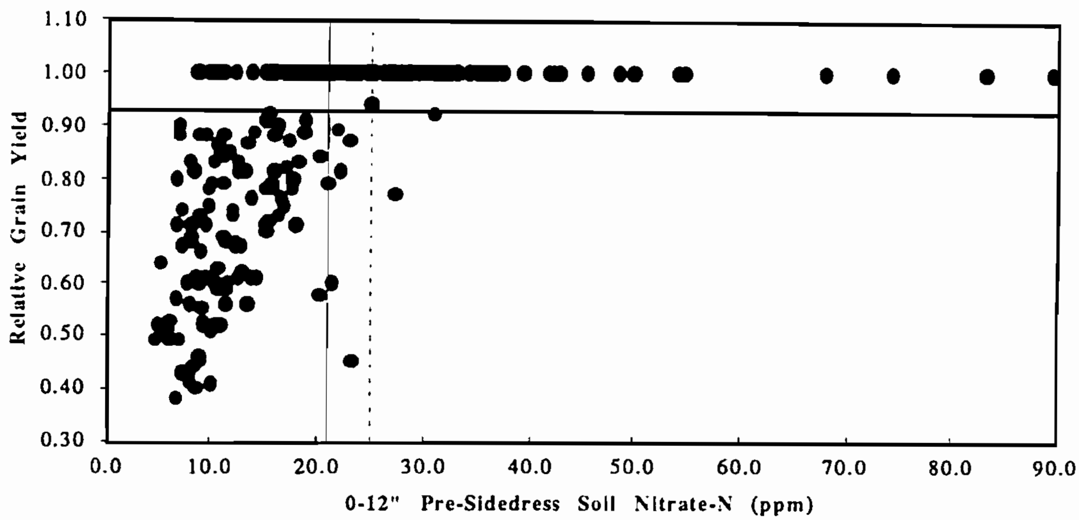


Figure 1. Pre-sidedress soil nitrate test calibration data for Pennsylvania

As was intended with this approach, there are only two points in the lower right quadrant but a relatively large number of points in the upper left. The actual error rates for the 25 ppm NO_3-N critical level are summarized in the first column in Table 1. While this approach succeeded in minimizing the lower right errors it resulted in an overall error rate of almost 25%. As more calibration data was collected and evaluated it became apparent that a lower critical level might be more appropriate. Consequently, the critical level was lowered to 21 ppm nitrate-N. This is the solid vertical line in Figure 1. The error rate for the 21 ppm nitrate-N critical level is given in the second column in Table 1. Note that the overall error rate is reduced almost 10% with only a slight increase in the number of lower right errors. With exception of one point, which would appear to be an outlier, the magnitude of these errors in the lower right quadrant is small, with relative yields over 80% of the maximum achievable yield.

Table 1. Cate-Nelson error rates from 208 PSNT calibration sites in Pennsylvania.

	PSNT Critical Level	
Errors	25 ppm NO_3-N	21 ppm NO_3-N
	-----------% Errors ----------	
Upper left	23.6	12.0
Lower right	1.0	3.4
Total	24.6	15.4

PSNT NITROGEN RECOMMENDATIONS

At PSNT levels below the critical level there is a very poor relationship between the PSNT level and the economic optimum sidedress N recommendation. This is illustrated by the data from Pennsylvania in Figure 2.

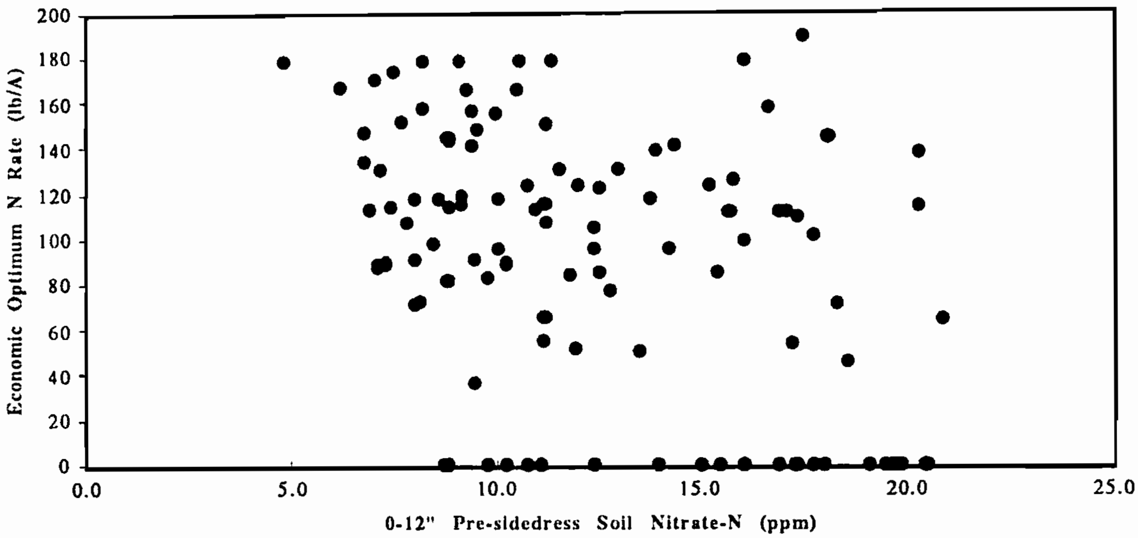


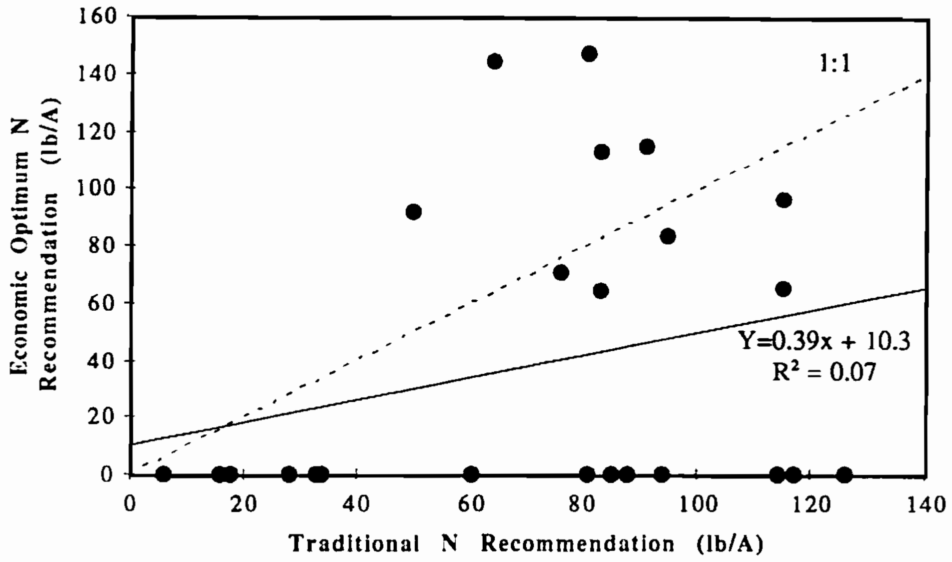
Figure 2. Relationship between PSNT soil test levels and the economic optimum sidedress nitrogen requirement. $R^2 = 0.06$ ns

In spite of this poor relationship between the PSNT level and the economic optimum sidedress N requirement, an attempt was made to use the PSNT level to make a sidedress N recommendation. The recommendations were based on the PSNT level and the expected corn yield and are summarized in Table 2. The rationale behind these recommendations was to call for the normal full rate of N (1 to 1.1 lb. N/bu. expected yield) at low PSNT levels (<10 ppm NO_3-N) and no N above a critical level of 25 ppm NO_3-N. Recommendations were then distributed between these two extremes.

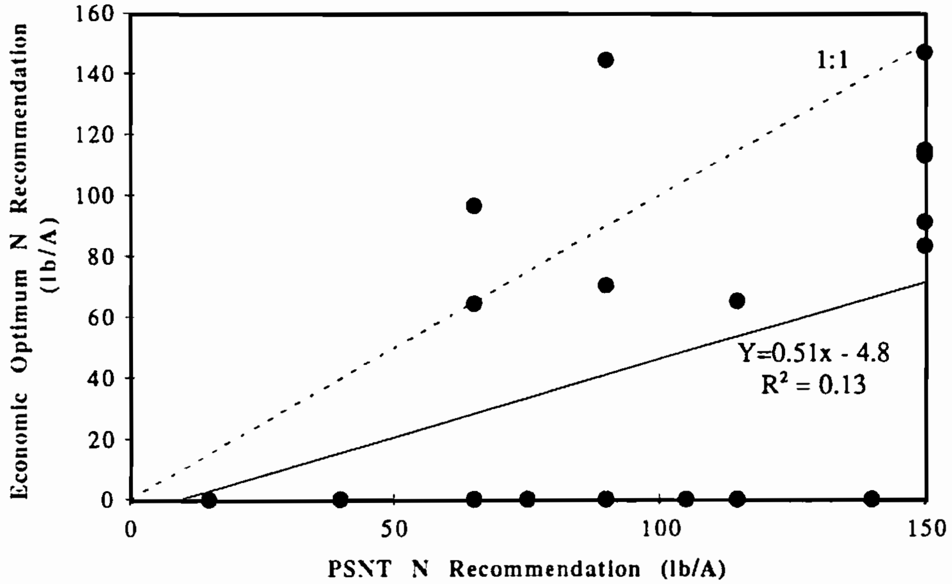
Table 2. PSNT based nitrogen fertilizer recommendations for corn previously used in Pennsylvania.

	Corn Yield Goal (bu/A)				
PSNT Level	100	125	150	175	200
(ppm NO_3-N)	- - - - - - - - - - - - Sidedress N Recommendation (lb/A) - - - - - - - - - - - -				
< 10	100	130	160	190	220
11 - 15	75	100	125	150	150
16 - 20	50	75	100	125	125
21 - 25	25	50	75	100	100
> 25	0	0	0	0	0

The recommendations based on the PSNT were compared to those made using the traditional approach of determining the amount of N required by a corn crop from a base recommendation adjusted for manure and legume credits. Some of this data is shown in Figure 3. When the traditional recommendations are compared to the experimentally



a. Traditional N recommendations



b. PSNT N recommendations

Figure 3. Comparison between traditional and PSNT based N recommendations and experimentally determined economic optimum N rate for sites with PSNT < 25 ppm NO_3-N. The same sites were used in both a and b.

determined economic optimum N rates the R^2 is only 0.07 (Figure 3a). This comparison was made using a selected set of data from sites where there was adequate, valid manure and legume history information to make a recommendation. In actual practice this quality of site history data is the exception rather than the rule. Consequently this 0.07 R^2 probably overestimates the actual relationship in practice. In Figure 3b, the relationship between PSNT based recommendations from Table 2 and actual economic optimum N rates is shown for the same data set. The relationship is still very poor but it is better than with the traditional approach. To help compensate for this poor relationship it was stressed in educational programs that the recommendations based on PSNT results should not be determined solely on the PSNT levels as given in Table 2. These recommendations should be considered as guidelines which should be combined with knowledge of other factors, such as the manure and cropping history, to arrive at a final N recommendation. Unfortunately this part of the recommendation, because of its qualitative nature, was often ignored by farmers and farm advisors. Thus we began to review our accumulated data to determine if we could develop a more quantitative approach to incorporate some of these factors into the PSNT N recommendations.

REVISED PSNT NITROGEN RECOMMENDATIONS

From experience using the PSNT and our knowledge of nitrogen behavior, it appeared that there were several factors that were interacting to influence the recommendation. The most obvious factor influencing nitrogen recommendations is weather. However, this is very difficult to include in a recommendation system. Some other factors such as manure and cropping history and expected yield may be practical to include in the recommendation system. A stepwise, multiple regression analysis that included the PSNT level and these other factors as parameters was conducted. The manure and cropping history were included in the regression as weighting factors influencing the effect of PSNT level on the recommendation. The weighting factors were estimated based on our understanding of the system and then adjusted by trial and error to achieve the best statistical fit to the actual economic optimum data. Specifically, the history is accounted for as the sum of three factors: manure applied since last harvest, any manure applied in the three years prior to the last harvest, and the previous crop on the field. The values selected for these factors are given in Table 4.

Table 4. Values for history weighting factors used to predict economic optimum N recommendations using the PSNT.

Factor	Weighting
Manure since last harvest	None = 1 Any = 5
Manure applied in three years prior to the last harvest	None = 0 Any = 2.5
Previous Crop	Corn = 0 Soybeans = 1.5 Forage legume = 4.5 Other = 0

Regression analysis on the 208 sites using the actual yield, the PSNT test level, and the sum of these history factors resulted in the following regression equation:

$$\text{Predicted EON} = -1.6+0.86 \times \text{actual yield} - 0.713 \times \text{PSNT} \times \Sigma\ \text{History factors} \quad \text{(Eq. 1)}$$
$$R^2 = 0.53$$

While an R^2 of 0.53 is low, when it is compared to the relationship between the actual economic optimum N rate and the economic optimum N rate predicted from the PSNT level only, shown in Figure 3b, it is clear that there is a significant improvement in the recommendations. From this analysis of the accumulated PSNT calibration data, revised recommendations were published by Beegle et al. in 1994. The worksheet for making recommendations with the PSNT is shown in Figure 4. For the worksheet the regression equation was modified algebraically to simplify calculations in the field. The final equation became:

$$\text{N Recommendation} = 1.1 \times \text{expected yield} - \text{PSNT} \times \Sigma\ \text{History factors} \quad \text{(Eq. 2)}$$
$$R^2 = 0.51$$

The equation modification resulted in the coefficients in the history factor being changed by a factor of 1.4. This is why the factors in Table 4 differ from those in Figure 4. Notice that this simplification only reduced the R^2 by 0.02 (Eq. 1 vs. Eq. 2). The recommendations thus become a base recommendation, 1.1 lb. N/A/bu expected yield, which is adjusted downward based on the PSNT level as modified by the history factors. When the calculated recommendation is less than 30 lb/A a recommendation of zero is suggested. This accounts for the observation that this equation tends to over estimate the N requirement. This is a relatively simple and easy to understand N recommendation system.

Yield Factor =	Expected yield	x	1.1			
History Factor =	Manure applied since last harvest	+	Manure applied in three years prior to the last harvest	+	Previous Crop	
Coefficients →	None = 0.75 Any = 3.5		None = 0 Any = 1.75		Corn = 0 Soybeans = 1 Forage Legume = 3.5 Other = 0	
Recommendation =	Yield Factor	– (	History Factor	x	PSNT ppm NO_3-N	)

If the calculated recommendation is less than 30 lb/A, a zero recommendation is suggested.

Figure 4. N recommendation worksheet used to make PSNT based sidedress N recommendations in Pennsylvania.

The predicted economic optimum N rate using this equation is plotted against the actual economic optimum N rate in Figure 5.

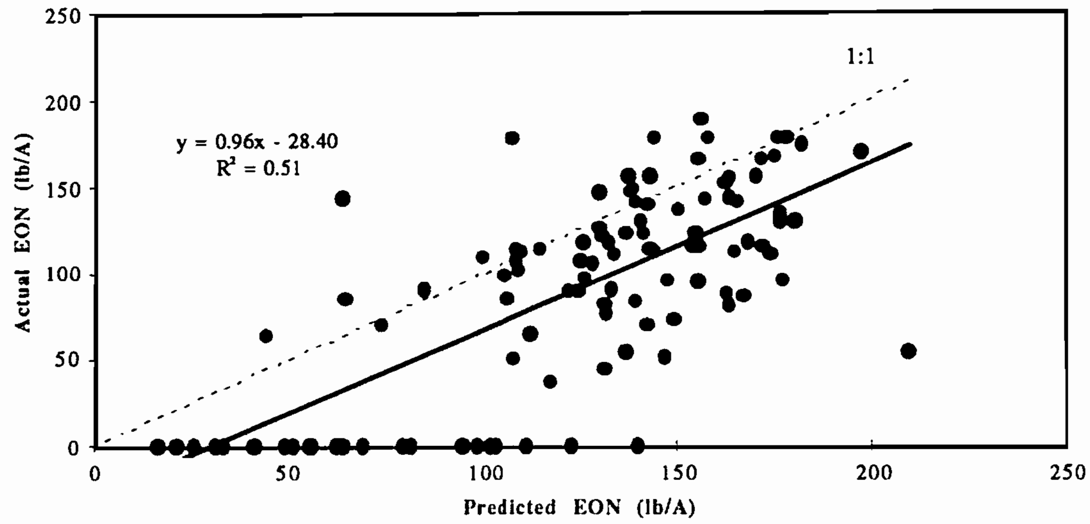


Figure 5. Actual economic optimum N rate vs predicted economic N rate using PSNT, expected yield, and field history.

CONCLUSIONS

One of the biggest problems with the PSNT has been the difficulty in making sidedress N recommendations when the test indicates that a response is likely. However, use of the PSNT to make a recommendation will generally result in a better recommendation than is common with credit based recommendations. This is especially true where there are significant sources of organic N, such as manure, in the system. Modification of the recommendations based on integrating the site specific factors of expected yield and manure and cropping history with the PSNT has been shown to improve the recommendations.

REFERENCES

Beegle, D. B., R. H. Fox, G. W. Roth, and W. P. Piekielek. 1994. Presidedress soil nitrate test for corn. Agronomy Facts #17. College of Agricultural Sciences, The Pennsylvania State University, University Park, PA.

Blackmer, A. M., D. Pottker, M. E. Cerrato, and J. Webb. 1989. Correlations between soil nitrate concentrations in late spring and corn yields in Iowa. J. Prod. Agric. 2:103-109.

Cate, R. B., Jr., and L. A. Nelson. 1965. A rapid method for correlation of soil test analysis with plant response data. Tech. Bull. No. 1. Int. Soil Testing Series. N. C. State Univ., Raleigh, NC.

Fox, R. H., G. W. Roth, K. V. Iversen, and W. P. Piekielek. 1989. Soil and tissue nitrate tests compared for predicting soil nitrogen availability to corn. Agron. J. 81:971-974.

Klausner, S. D., W. S. Reid, and D. R. Bouldin. 1993. Relationship between late spring soil nitrate concentrations and corn yields in New York. J. Prod. Agric. 6:350-354.

Magdoff, F. R., D. Ross, and J. Amadon. 1984. A soil test for nitrogen availability to corn. Soil Sci. Soc. Am. J. 48:1301-1304.

Magdoff, F. R., W. E. Jokela, R. H. Fox, and G. F. Griffin. 1990. A soil test for nitrogen availability in the northeastern United States. Comm. Soil Sci. Plant Anal. 21:1103-1115.

Meisinger, J. J., V. A. Bandel, J. S. Angle, B. E. O'Keefe, and C. M. Reynolds. 1992. Presidedress soil nitrate test evaluation in Maryland. Soil Sci. Soc. Am. J. 56:1527-1532.

Roth, G. W., D. B. Beegle, and P. J. Bohn. 1992. Field evaluation of a presidedress soil nitrate test and quicktest for corn in Pennsylvania. J. Prod. Agric. 5:476-481.

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