Evaluation of the Illinois Soil Nitrogen Test in the North Central Region of the United States

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Over the past few years, there has been a lot of interest in the Illinois Soil Nitrogen Test (ISNT); particularly as fertilizer prices have increased, everyone is looking for the best way to fine-tune their nitrogen (N) management program. The ISNT was initially developed as a means to identify fields where corn would not respond to the addition of N fertilizer using N response studies in Illinois (Khan et al., 2001).

Other researchers have since evaluated the ISNT in other geographic regions. It was shown to predict potentially mineralizable N in a 24-week laboratory incubation (Sharifi et al., 2007) using soils from New Brunswick, Quebec, Manitoba, Saskatchewan, and Maine. However, other soil tests, such as total soil N, were more highly correlated with potentially mineralizable N than was the ISNT. Klapwyk and Ketterings (2006) compared the ability of the ISNT and pre-sidedress nitrate test (PSNT) to predict sidedress N response in corn silage production in New York. They confirmed that the PSNT is a good predictor of sidedress N response and found that ISNT alone was not. However, ISNT combined with organic matter concentration did provide an adequate predictor of the probability of sidedress N response. In North Carolina, Williams et al. (2007b) found that the ISNT could predict economic optimum N rate (EONR) and N fertilizer response in corn for mineral soils only. In a follow-up study, the ability of the ISNT to predict EONR increased substantially when sites were separated into well or poorly drained classes (Williams et al., 2007a).
Very poorly drained soils, which had the highest ISNT values with approximately average EONR, were excluded from the analysis because the authors felt that the high humic matter concentrations might be affecting the ISNT threshold levels. Because both studies (Williams et al., 2007a, 2007b) lacked nonresponsive sites, the validity of the ISNT critical level proposed by Khan et al. (2001) could not be evaluated.

In contrast, separate studies in Iowa (Barker et al., 2006) and Wisconsin (Osterhaus et al., 2008) found that the ISNT was not predictive of the EONR for corn and could not be used to separate responsive from nonresponsive sites. In fact, in these studies, using the ISNT critical threshold proposed by Khan et al. (2001), would result in many responsive sites being categorized as nonresponsive and many nonresponsive sites being declared responsive. Both of these studies found that the ISNT was measuring a constant fraction of total soil N and was not sensitive to mineralizable N.

A subsequent study with 102 N response sites in Illinois found that the ISNT had an overall failure rate of 20.6% and incorrectly identified 6.0% of the nonresponsive sites (nonresponsive sites were identified as being responsive, results in overapplication of N fertilizer) and 27.5% of the responsive sites (responsive sites were identified as nonresponsive, results in yield loss from under fertilization) (Mulvaney et al., 2005). The researchers hypothesized that ISNT failures may have resulted from a limitation to soil N mineralization or crop N utilization caused by moisture stress, weed competition, soil fertility limitation, quality/quantity of carbon inputs, or corn plant population. However, they did acknowledge that experimental data to substantiate these hypotheses were not collected. Incorrectly classifying responsive sites as nonresponsive could have a large negative economic impact to farmers as yield losses from underfertilization would have occurred and would result in their losing confidence in the test. Fully understanding factors affecting ISNT performance is essential to providing farmers with criteria for successful use of the test.

Recently, researchers from the North Central region compiled data from 96 N rate studies in Iowa, Illinois, Michigan, Minnesota, Nebraska, and Wisconsin that were conducted from 2001 to 2004. The goal of these studies was to evaluate the performance of the ISNT over a broad range of soils representing various drainage classes and climates, along with various previous crops, manure history, irrigation, and tile drainage. This research is being published in the July–August 2008 issue of *Agronomy Journal.* The specific objectives were to assess the effectiveness of the ISNT for:

1. predicting fields where corn will not respond to additional N fertilizer,
2. estimating optimum N fertilizer application rates, and
3. estimating mineralizable soil N.

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Results

The regional research confirmed previous results in that the ISNT measured on a 0- to 6-inch sample was very strongly correlated to the ISNT value of a 0- to 12-inch sample. The relationship between ISNT and EONR was explored (Fig. 1). Though statistically significant, the relationship between ISNT and EONR is not strong enough to use the ISNT as a practical means to predict the amount of N needed for a crop as evidenced by a low $R^2$ and a wide range (often greater than 100 lb N/acre) in EONR for most ISNT values. Additionally, ISNT values above the critical level of 230 ppm N proposed by Khan et al. (2001) are associated with sites with both zero and high N requirements. Khan et al. (2001) used N fertilizer response ([(maximum yield – yield with no N)/yield with no N] expressed as a percentage) to develop the ISNT critical level. In the present study, there was no correlation between ISNT and N fertilizer response (Fig. 1). Even though there were several nonresponsive sites in this data set, no ISNT critical level could be determined that would separate sites with large or small N fertilizer response.

The ISNT for sites with a previous crop of soybean was significantly greater than where corn or dry bean was the previous crop. In addition, the ISNT was significantly greater for poorly drained sites compared with all other drainage classes. Because previous crop and soil drainage class impact ISNT, the data were evaluated to determine if either of these site characteristics could improve prediction of EONR with INST. The ISNT could not be effectively calibrated for the determination of EONR using either or both previous crop and soil drainage class.

Critical levels of soil tests (soil test level above which no yield response to the added nutrient is expected) are often established by plotting the soil test value against the relative yield. Relative yield is calculated as the yield with no N applied divided by maximum yield and is expressed as a percentage. There was no relationship between relative yield and ISNT (Fig. 2). Furthermore, the 230 ppm ISNT critical level was evaluated for its failure rate with regard to identifying responsive and nonresponsive sites on the basis of relative yield above and below the critical level. TYPE A failure rates were defined as sites with an ISNT value >230 ppm and a relative yield <90 % and represent failures where underfertilization would occur. For all sites with an ISNT value >230 ppm, the TYPE A failure rate was 76.1 %. TYPE B failure rates were defined as sites with an ISNT ≤230 ppm and a relative yield ≥90 % and represent failures where overfertilization would occur. For all sites with an ISNT value ≤230 ppm, the TYPE B failure rate was 14.0 %. For all 96 site-years in the study, there was an overall (TYPE A and TYPE B) failure rate of 43.8 %. Relative N uptake can be considered an in situ index of the relative amount of N that was available to a crop.
from all sources (net soil N mineralization, residual inorganic N, precipitation, or irrigation water). It is calculated as the N uptake where no N was applied divided by the N uptake at the highest N rate and expressed as a percentage. There was no relationship between ISNT and relative N uptake or the amount of early-season N mineralization (presidedress nitrate – preplant nitrate), suggesting that the ISNT is not measuring mineralizable and crop available N.

The ISNT was strongly correlated to soil organic matter across a wide range of soil organic matter levels at the sites studied. Using data reported by Klapwyk and Ketterings (2006), we determined that the ISNT was also strongly correlated to organic matter in New York soils. In the present study, ISNT was strongly correlated to total soil N and seems to be measuring a relatively constant fraction of total soil N (Fig. 3). In work published by Khan et al. (2001) and Klapwyk and Ketterings (2005), the ISNT was also correlated to total soil N (Fig. 3), although those authors did not explore that relationship. Based on the slope of the regression line, the ISNT is measuring 14.7% of total soil N when all data sets are combined, with a range from 13.5 to 16.4% for the individual data sets. By comparison, the ISNT was 15.0, 13.5, and 12.6% of total soil N as reported by Barker et al. (2006), Marriott and Wander (2006), and Osterhaus et al. (2008), respectively. Thus, the ISNT is apparently measuring a constant fraction of total soil N for a wide range of soils rather than the readily mineralizable fraction of soil organic N as would be required to assess the soil’s contribution to the available N supply.

Conclusion

In conclusion, the ISNT was not a good predictor of relative yield or N fertilizer response in the North Central region and did not provide reliable estimates of EONR. Additionally, the ISNT was unable to differentiate responsive from nonresponsive sites. The overall failure rate for the ISNT in this 96 site-year study was 43.8% with the majority of the test failures as TYPE A failures where sites predicted as nonresponsive were found to need substantial N fertilizer additions. Subsetting the data based on previous crop or drainage class did not improve the ability of the ISNT to predict EONR. Results of this work indicate that the ISNT is not a useful predictor of N fertilizer need because it is measuring a constant fraction of total soil N rather than a specific fraction of mineralizable N as evidenced by the lack of a correlation between ISNT and relative N uptake. Based on results of this multistate project, the ISNT is not suggested for use in adjusting corn N rate applications in the North Central Region (Corn Belt) of the United States.


References