

MICHIGAN PROSPECTS FOR USING THE ILLINOIS N SOIL TEST

Carrie A.M. Laboski¹

Introduction

In Michigan the presidedress nitrate test (PSNT) (Magdoff et al., 1984) is used to adjust nitrogen (N) recommendations for corn and sometimes sugar beet. Many growers do not use the PSNT because the presidedress soil sampling time does not conveniently fit into their operation. Preplant nitrate tests do not provide a good estimate of plant available N because of the relatively wet weather conditions during Michigan springs. Another drawback to the PSNT is that it tends to recommend N on soils which have manure histories and are non-responsive to N fertilization.

The Illinois nitrogen soil test (INST) measures a portion of amino sugar-N and provides an estimate of N that may become available during the growing season (Mulvaney et al., 2001). The University of Illinois is suggesting that when the INST is greater than 250 ppm N for a 1-foot soil sample, corn will not respond to fertilizer N in central or northern Illinois (University of Illinois Technical Note 02-01 (rev. d)). Soil samples for the INST may be taken prior to planting. A preplant soil test that may be used to determine non-responsive fields would likely see wider adoption in Michigan than the PSNT.

Two studies have been started in Michigan to calibrate the INST with the optimum N fertilizer rate for corn and sugar beet. The objectives of this paper are: 1) To provide initial results of the field calibration studies; 2) To discuss differences in results between laboratories.

Methods and Materials

Field Methods

Corn: Three and nine field locations were selected in 2002 and 2003, respectively, for calibration of the INST for corn production in Michigan. Anywhere from five to eight N rates were applied ranging from 0 to 250 lb N/acre in four replications. Soil samples were taken preplant to 2 or 3 ft in 1-ft increments. Nitrate was measured in both samples and INST was measured in the 1' sample only. Samples were also taken prior to sidedressing to 1 ft in the control plots and analyzed for nitrate. 0-6 inches soil samples were taken preplant in the control plots and analyzed for P, K, Ca, Mg, pH, and organic matter. Grain yield was measured. Return was calculated as: (yield x \$2.00/bushel) – (N applied x \$0.20/lb N). Return was regressed on the rate of N fertilizer applied using a quadratic plateau or linear plateau model. The economic optimum N rate (EONR) and return was calculated as the join point and plateau of the model with the lowest residual sum of squares. Yield at the EONR was calculated. The economic response of yield to N fertilization was calculated as $100 \times [(\text{optimum yield} - \text{check plot yield})/\text{check plot yield}]$.

Sugar beet: Five field locations in each of 2002 and 2003 were selected to assess sugar beet response to N fertilization. In 2002, eight N rates from 0 to 210 lb N/acre (30 lb N/acre increments) was sidedressed as urea at the four true leaf stage with four replications at each site.

¹ Assistant Professor and Soil Fertility Extension Specialist, Dept. of Crop & Soil Sciences, Michigan State University, 580 Plant & Soil Sciences Building, East Lansing, MI 48824

In 2003, the total amount of N applied in six treatments ranged from 0 to 200 lb N/acre (40 lb N/acre increments). 40 lb/acre of urea was applied in a 2 x 2 band at planting, the remaining N was sidedressed as urea at the four true leaf stage. Soil samples were taken in the control plots prior to planting to a depth of 3 ft in 1-ft increments and to 1 ft prior to sidedressing. All samples were analyzed for nitrate, while the INST was determined on the upper 1' samples. Additionally, 0-6 inches soil samples were taken in the control plots prior to planting and analyzed for P, K, Ca, Mg, pH, and organic matter. Yield, sucrose content, and clear juice purity were determined. Recoverable white sugar per acre (RWSA) was calculated using the formula:
$$\text{Yield} \times (((\% \text{ sucrose} \times 18.4) - 22) \times (1 - (60 / (\% \text{ clear juice purity} - 3.5)))) / 0.4$$
RWSA was regressed on rate of N fertilizer applied using a quadratic plateau or linear plateau model. The optimum N rate and RWSA was calculated as the join point and plateau of the model, respectively. The response of RWSA to N fertilization was calculated as $100 \times ((\text{optimum RWSA} - \text{check plot RWSA}) / \text{check plot RWSA})$. RWSA is an economic parameter because growers are paid on extractable sugar yield not root yield and over application of N reduces sucrose content and increases impurities.

Laboratory Methods

The basic methods and equipment used are contained in University of Illinois Technical Note 02-01 (rev. d). Specific details and deviations follow.

Equipment: 1) Two mason jar lids were placed under the two back legs of the griddle to increase the incline along the shorter dimension of the griddle. 2) Titrations were performed manually with a 5-mL (0.01-mL graduations) microburet with the endpoint determined by pH measurement.

Reagents: 1) The boric acid indicator solution was titrated with 0.006 M H₂SO₄ instead of the recommended 0.01 M H₂SO₄ to make manual titrations easier.

Procedure: 1) The griddle is plugged into a timer which turns on 2.5 hours before the jars are to be placed on the griddle. Prior to placing the jars on the griddle, the temperature of 100 mL of water in a jar in the center of the griddle must be stable at 49°C. 2) After the sample has been treated with 2 M NaOH the jar is gently swirled for 5 seconds keeping the bottom of the jar in contact with the laboratory bench at all times. This is done to provide consistency in mixing and minimize soil adherence to the wall of the jar.

The accuracy of the procedure for recovering amino sugar-N was tested by extracting N from a standard glucosamine solution as per the Technical Note.

Two griddles are used each day samples are run. The second griddle contains the same samples and standards as the first. Twelve jars are placed on the griddle. One jar always contains 100 mL of water for measurement of temperature. Another contains a standard soil. The remaining 10 jars may contain soil samples or glucosamine. On a given day, if the N recovered in duplicate samples differs by more than 10 ppm, then the samples are rerun. The amount of N recovered from the standard soil is being tracked to obtain a mean and standard deviation.

INST analysis was performed at the University of Illinois for the 2002 samples and at Michigan State University for the 2003 samples. Several 2002 samples were also run at a private laboratory. Comparisons between laboratories are provided.

Results and Discussion

Field

Figure 1 shows the response of corn and sugar beet to N fertilizer in 2002 and 2003. The relationship that one would like to see is where as the INST increases the percent response decreases such that above a threshold value (or range) the percent response is zero. The University of Illinois threshold is 250 ppm. The data for corn in Figure 2 does not suggest that such a relationship exists. There are four locations which had an INST < 160 ppm and a response less than 20 %. If the Illinois relationship were to hold true, one would have expected that these locations would have had a greater INST value considering how low the response was. It must be noted that over the two-year study period, all locations were responsive to N fertilizer application.

The data in Figure 1 for sugar beet shows a relationship between percent response to N fertilizer and the INST that is closer to what one might expect if the INST will be predictive of non-responsive locations. Of the 10 locations, three were non-responsive to N fertilizer. Two of these non-responsive locations had INST values greater than all of the responsive sites. One non-responsive site had a relatively low (169 ppm) INST value. So even though there were non-responsive sugar beet locations, the INST is not doing a very good job differentiating responsive and non-responsive sites.

For the 2002 sugar beet locations, the 1-ft preplant INST values were correlated to organic matter in a 6" sample with a correlation coefficient of 0.96 (data not shown). Thus, organic matter and INST data were compiled for all 2002 and 2003 sugar beet locations and the nine corn locations in 2003. There was a significant correlation ($r = 0.79$) between the 1-ft preplant INST value and organic matter from a 6-inch sample (Figure 2). The range in organic matter from 1.2 to 4.3% is representative of soils that are cropped in Michigan. The University of Illinois feels that the INST is measuring amino sugar-N and is not another measure of organic matter because they found soils with similar high organic matter contents where one was responsive and the other non responsive (Hoeft et al., 2002). Overall the data in Figure 2, suggest that the INST is mimicking a measurement of organic matter.

Because a significant relationship between the INST and organic matter was found, the percent response to N fertilizer was plotted against organic matter (Figure 3). The relationships between percent response and organic matter are different between the two crops. For corn, as organic matter increased the percent response to N fertilizer increased; while for sugar beet the percent response decreased as organic matter increased. The relationship for sugar beet might be expected in that if a soil has a greater organic matter content it will likely mineralize more N over the growing season, thus decreasing a crop's responsiveness to applied N fertilizer. Using organic matter, there was a clear though small differentiation between responsive and non-responsive sugar beet locations. The relationship for corn is unexpected. It is likely that the one location with 4.3% organic matter is skewing the relationship. At this site, the INST was relatively low where one might expect a greater response to N fertilizer, and, in fact, the response was 74%. This site may be similar to the ones described by Hoeft et al. (2002).

Laboratory

Figure 4 shows the INST values for samples that were run at a private laboratory and the University of Illinois. Overall the private laboratory reported greater INST values. With the exception of a few samples with larger INST values the difference between samples in ppm was similar over the range in INST values. The relative percent difference between samples was

calculated as $100 \times ((\text{University of Illinois value} - \text{Private Lab value}) / \text{University of Illinois value})$. For 40% of the samples, the difference between laboratories is < 10%; and for 25% of the samples, the difference is > 20% (Figure 5). These results show that even though laboratories are following quality assurance and quality control protocol, there may be significant variability in the INST results. This suggests that a relatively narrow INST threshold range between responsive and non-responsive may be inadequate to accommodate for differences between laboratories.

Conclusions

Preliminary data for the INST do not look very promising. However more data are needed. For corn, locations that are non-responsive to N fertilizer need to be found. For sugar beet, the relationship between the INST and organic matter needs to be investigated further. If the INST is mimicking organic matter in all but a few cases, adjusting N rates based on organic matter may be more cost effective though perhaps not as accurate as the INST.

The inter-laboratory variability found in the INST is not acceptable for any type of soil test, particularly where the decision is to use N fertilizer or not. Thus, research needs to continue related to the robustness of the INST.

References

- Hoef, R.G., R.L. Mulvaney, and S.A. Khan. 2002. Update on the Illinois N Test. *In* North Central Extension-Industry Soil Fertility Conference. Nov. 20-21, 2002. Des Moines, IA. Vol 18:92-101
- Magdoff, F.D., D. Ross, and J. Amadon. 1984. A soil test for nitrogen availability to corn. *Soil Sci. Soc. Am. J.* 48:1301-1304.
- Mulvaney, R.L., S.A. Khan, R.G. Hoef, and H.M. Brown. 2001. A soil organic nitrogen fraction that reduces the need for nitrogen fertilization. *Soil Sci. Soc. Am. J.* 65:1164-1172.
- University of Illinois, Department of NRES. 2002. The Illinois soil nitrogen test for amino sugar-N: Estimation of potentially mineralizable soil N and ^{15}N . Technical Note 02-01.

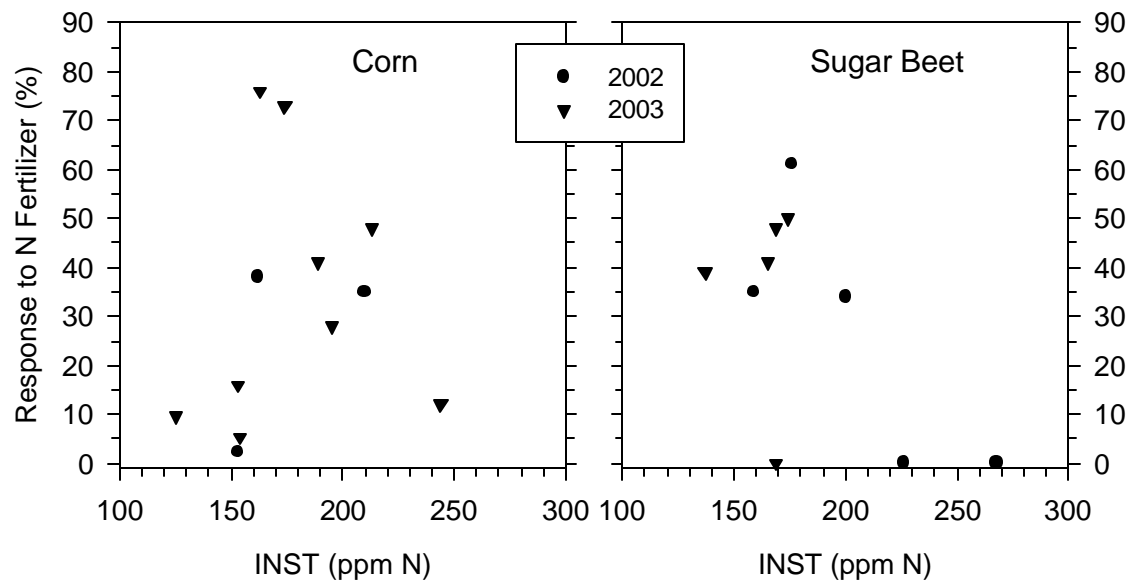


Figure 1. Response of corn and sugar beet to N fertilizer v. INST value.

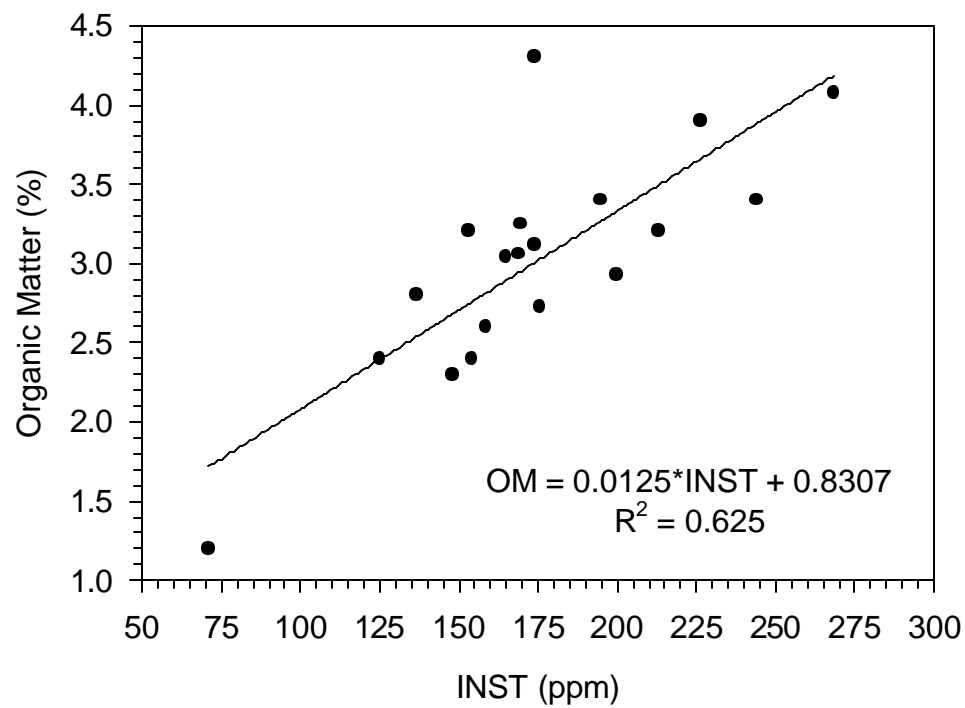


Figure 2. Relationship between organic matter and INST.

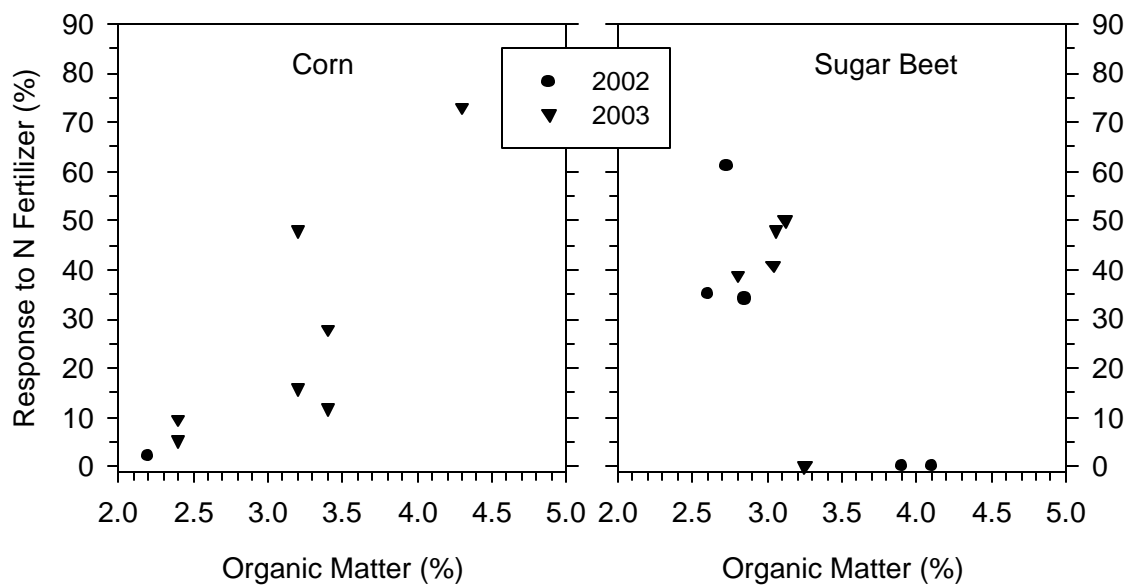


Figure 3. Response of corn and sugar beet to N fertilizer v. soil organic matter content.

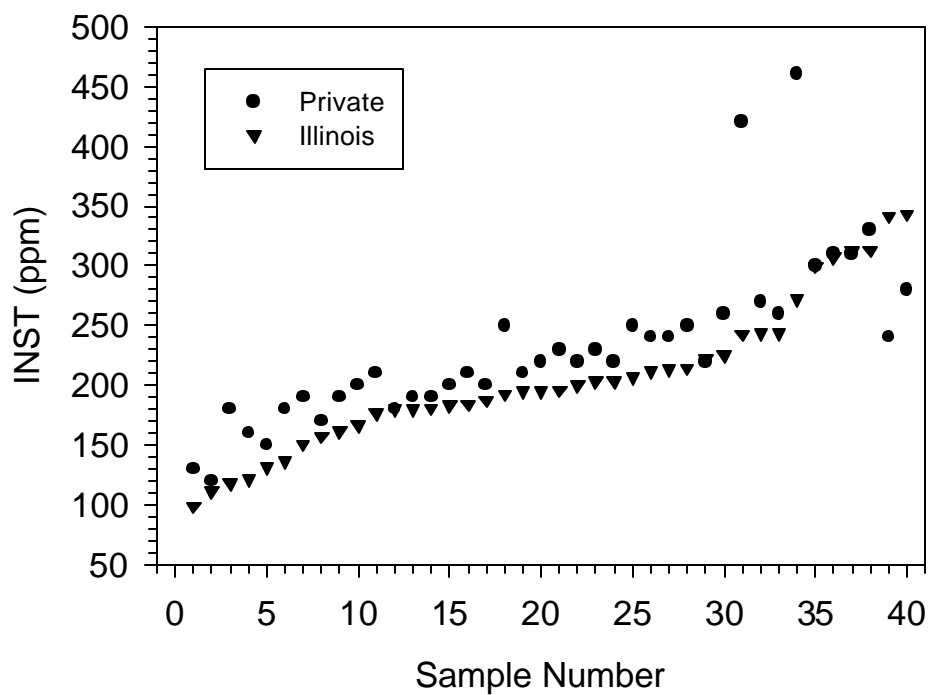


Figure 4. INST values for 40 samples run at a private laboratory and the University of Illinois.

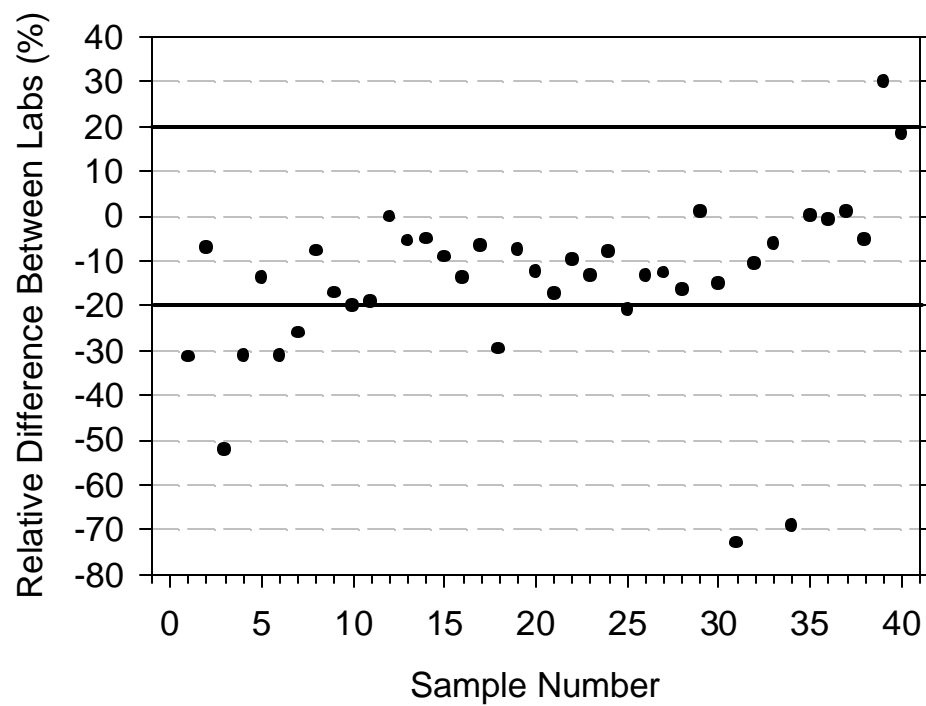


Figure 5. Relative percent difference between INST results from two laboratories.