ILLINOIS NITROGEN SOIL TEST FOR SUGAR BEETS AND CORN IN MICHIGAN

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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 mg N kg^{-1} for a 0.3-m 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.

At various scientific meetings over the past year, researches have raised concerns about the INST. These concerns stem from: the difficulty in obtaining adequate recoveries of N from a glucosamine standard; the impact of relatively small temperature differences on results; and the ability to quickly and easily perform the INST on a routine basis.

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 report on the challenges surrounding successful execution of the laboratory procedure and: 2) To provide initial results of the field calibration studies.

Methods and Materials

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 H_2SO_4 instead of the recommended 0.01 M H_2SO_4 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. Prior to use, the glucosamine was either dried in a desiccator or an oven.

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 mg N kg^{-1}, then the samples are rerun. The amount of N recovered from the standard soil is being tracked to obtain a mean and standard deviation.

Field Methods

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 235 kg N ha^{-1} (34 kg ha^{-1} increments) was sidedressed as urea at the four true leaf stage with four replications at each site. In 2003, the total amount of N applied in six treatments ranged from 0 to 225 kg N ha^{-1} (45 kg ha^{-1} increments). 45 kg ha^{-1} of urea was applied in a 5 cm x 5 cm 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 0.9 m in 0.3-m increments and to 0.3 m prior to sidedressing. All samples were analyzed for nitrate, while the INST was determined on the upper 0.3 m samples. Additionally, 0.15 m 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:
% sucrose * % clear juice purity * yield Mg ha^{-1} * 1000 kg Mg^{-1} = RWSA kg ha^{-1}. RWSA was regressed on rate of N fertilizer applied using a quadratic plateau model. The optimum N rate and RWSA was calculated as the join point and plateau of the model, respectively. In 2002 at two locations, the data did not fit a quadratic plateau model. At these locations a linear model with zero slope best fit the data; thus, the optimum N rate was 0 kg ha^{-1}. The response of RWSA to N fertilization was calculated as 100*((optimum RWSA – check plot RWSA)/check plot RWSA)).

Corn: Three and 11 field locations were selected in 2002 and 2003, respectively, for calibration of the INST for corn production in Michigan. Anywhere form 5 to 8 N rates were applied ranging from 0 to 280 kg N ha^{-1} in four replications. Soil samples were taken preplant and presidedress to 0.3 m in the control plots and analyzed for INST and nitrate. 0.15-m soil samples were taken preplant in the control plots and analyzed for P, K, Ca, Mg, pH, and organic matter. Grain yield was measured. Yield was regressed on rate of N fertilizer applied using a quadratic plateau or linear plateau model. The optimum N rate and yield was calculated as the join point and plateau of the model with the lowest residual sum of squares. The response of yield to N fertilization was calculated as 100*((optimum yield – check plot yield)/check plot yield)).

INST analysis was performed at the University of Illinois for the 2002 samples and at Michigan State University for the 2003 samples.

Results and Discussion

Laboratory

Initially we were unable to perform the INST analysis repeatably by following the methods in earlier versions of the Technical Note. However, after a graduate student spent several days at the University of Illinois labs, we were able to obtain repeatable data, though some problems still exist. It is crucial to follow every detail perfectly.

One of the largest problems we were having was related to maintaining 49°C throughout the 5 hour diffusion process. To achieve a stable temperature, it was necessary to cover an HVAC vent in the lab and redirect airflow away from the area where the griddles were located.

While at the University of Illinois lab, the INST was run on a Michigan soil several times to obtain a baseline. This soil, using that baseline, has become our standard soil. To obtain more consistency in the INST value for the standard soil, that soil was crushed with a mortar and pestle after being ground to pass a 2-mm sieve. The INST performance on duplicate runs of the standard soil over time is shown in Figure 1. Duplicate analyses on a given date are less than 5 % different from one another 80 % of the time. Differences between 5 and 7 % are found 20 % of the time.

Even though the INST values for the standard soil are consistently within the range found at the University of Illinois lab, recovery of N from glucosamine using the INST procedure is less than desirable. Nitrogen recovery from glucosamine on several dates is provided in Figure 2. The best recovery is 95 %. Initially the solution was made from oven dried glucosamine. Later dessicator dried glucosamine was used. Drying the glucosamine in a dessicator as the Technical Note instructs did not improve N recovery. It is currently unknown what steps may be taken to improve N recovery.

Field

As most 2003 field locations are not harvested at this time, only partial data is presented. Figure 3 shows the response of RWSA and yield to N fertilization for sugar beet and corn, respectively, in relation to INST values. In 2002, there were two sugar beet locations that did not positively respond to N fertilization. At these two sites, the INST was > 225 mg N kg^{-1}. At the non responsive sites, INST was < 200 mg N kg^{-1}. This preliminary data set suggests that there may be a threshold somewhere between 200 and 225 mg N kg^{-1} that would signal when sugar beets will not respond to additional N. It may be likely that the INST threshold value for sugar beets is less than the 250 mg N kg^{-1} threshold proposed for corn in Illinois, because late season N mineralization reduces sugar content and increases impurities in the beet, both of which reduce

RWSA. The greatest INST value for the 2003 sugar beet locations is 174 mg N kg^{-1}. Based on 2002 data, it is predicted that all 2003 sites will respond positively to N fertilization.

For corn, all 2002 locations and one 2003 location that has been harvested to date were responsive to N fertilization (Figure 3). At this point, there is too few data to evaluate how well the INST may perform in Michigan for corn. The greatest INST value for corn plots not yet harvested is 244 mg N kg^{-1}. Based on Illinois criteria, it is likely that all will be responsive to N fertilization.

For the 2002 sugar beet locations, the 0 – 0.3 m preplant INST values were correlated to organic matter in a 0 – 0.15 m 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 9 of the 11 corn locations in 2003. There was a significant correlation ($r = 0.79$) between the 0 – 0.3 m preplant INST value and organic matter at 0 – 0.15 m (Figure 4). 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). There is one case in this data set where organic matter content was 4.3 % and the INST was 174 mg N kg^{-1}. This point appears as an outlier in Figure 4. The yield data for this location is not yet available. However, it may be a case similar to one cited by Hoeft et al. (2002). Overall the data in Figure 4, suggest that the INST is mimicking a measurement of organic matter.

Conclusions

Preliminary data with sugar beet suggests that the INST should continue to be pursued. Identifying non responsive sugar beet fields will improve farm profitability and environmental quality. However, 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 by more cost effective though perhaps not as accurate as the INST.

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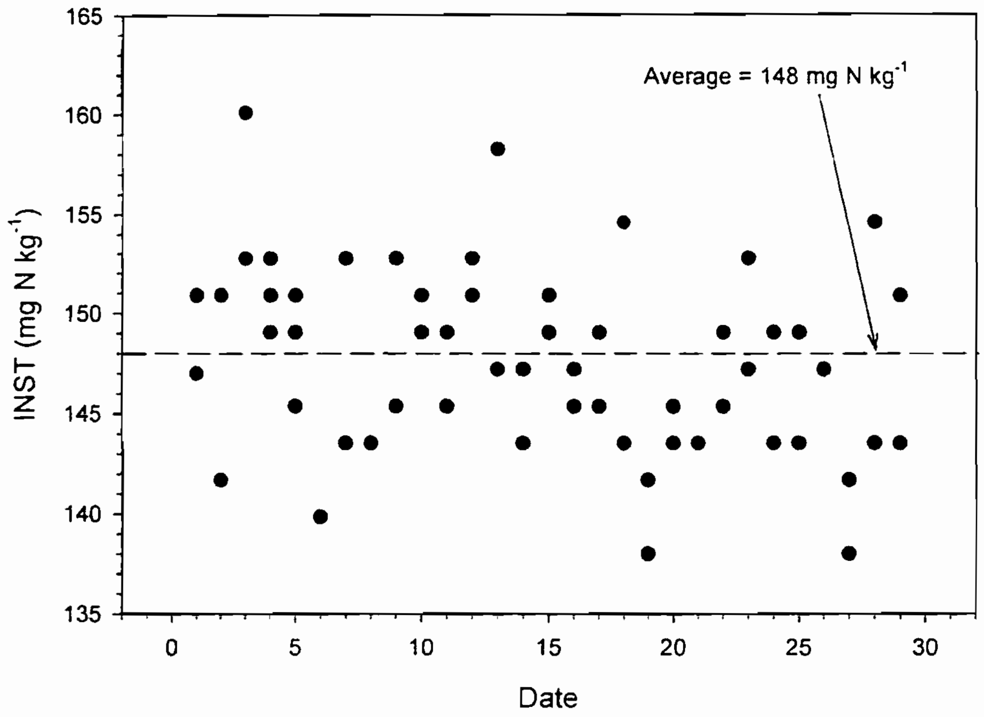
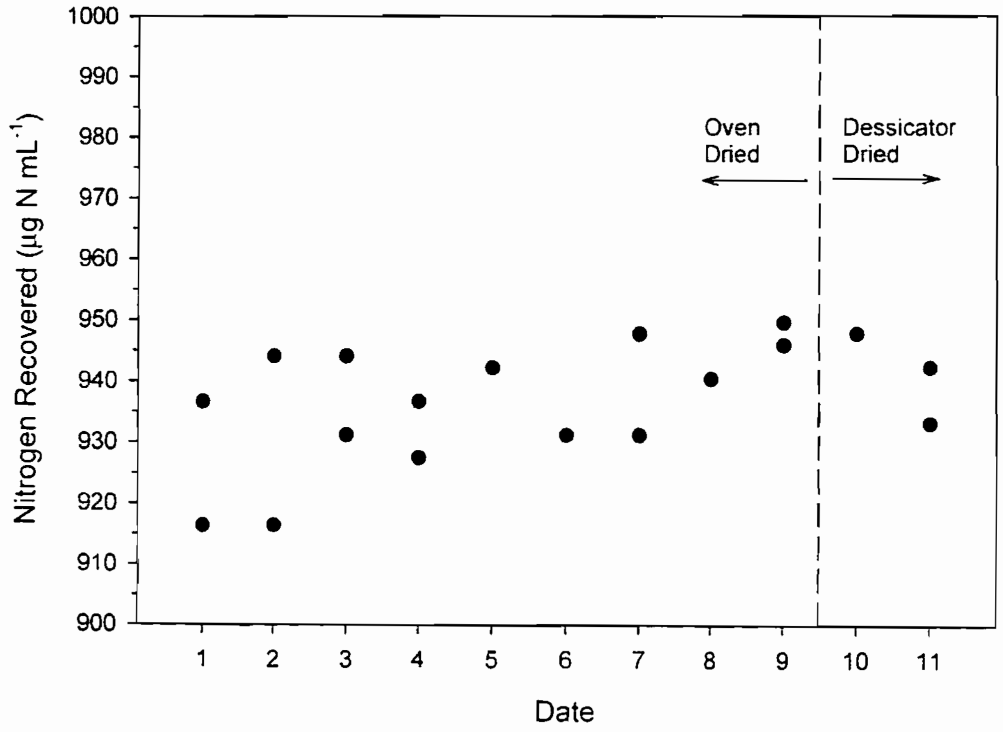


Figure 1. Performance of INST on a standard soil over several dates.



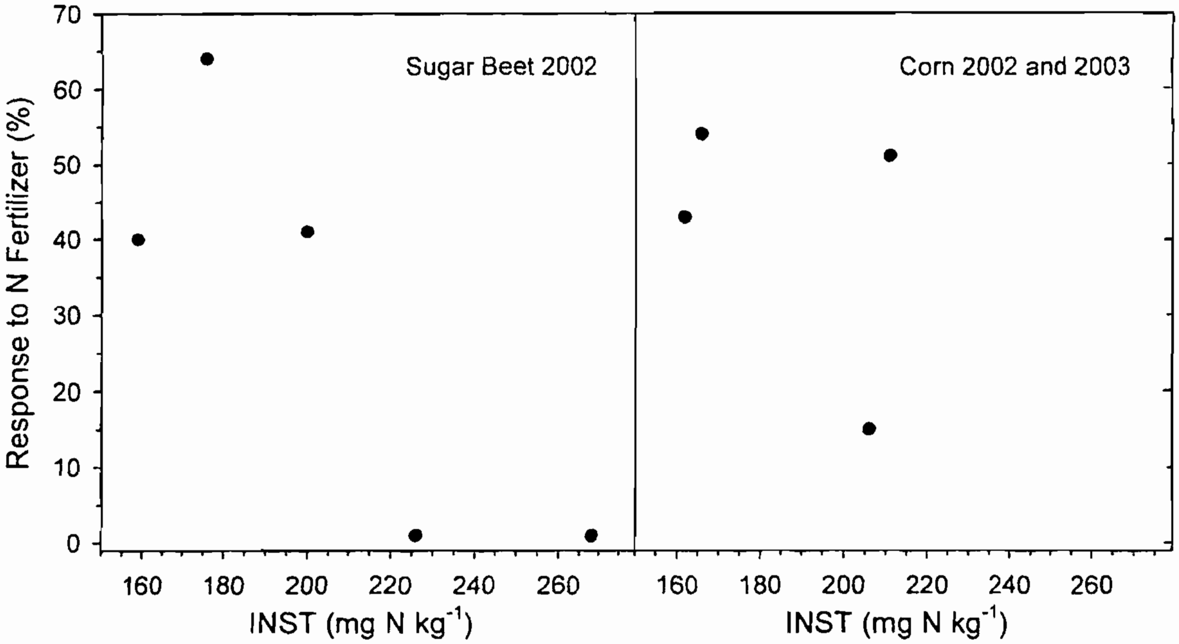


Figure 2. N recovered from a standard glucosamine solution. 100 % recovery = 1000 μg N mL^{-1}.

Figure 3. Response of recoverable white sugar per acre and yield to N fertilization for sugar beet and corn, respectively, in relation to INST values.

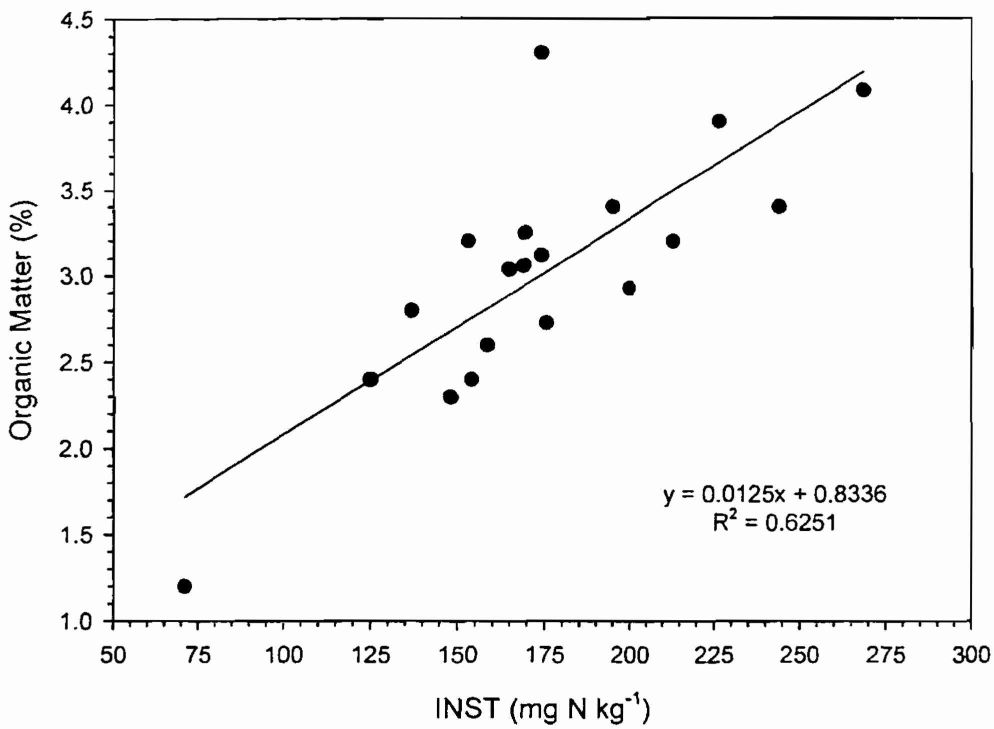


Figure 4. Relationship between INST and organic matter for all 2002 and 2003 sugar beet locations and 9 of 11 corn locations in 2003.

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