Illinois Soil Nitrogen Test Evaluation
2006-2007 Final Project Report

John Sawyer, Associate Professor
Daniel Barker, Assistant Scientist
Department of Agronomy
Iowa State University
jsawyer@iastate.edu
dbarker@iastate.edu

Introduction

The Illinois Soil Nitrogen Test (ISNT) was developed several years ago at the University of Illinois by researchers in the Department of Natural Resources and Environmental Sciences. The ISNT is a routine soil N test based on the assumption that the amino sugar-N fraction of soils is important for determining supply of crop available N from soil (Mulvaney et al., 2001). The ISNT laboratory procedure does not directly measure amino sugar-N content of soil, but instead is designed to measure N liberated from soil heated for five hours with dilute alkali (sodium hydroxide) solution (Khan et al., 2001). The test does not include nitrate as do some other N tests, but is expected to measure exchangeable ammonium and a fraction of soil organic N. The theory behind the ISNT is to extract a specific component of organic N from soil collected prior to planting and N application that reflects the amount of N mineralized in a growing season to plant available forms (converted to inorganic ammonium and nitrate). The test was developed to detect sites that are non-responsive to N fertilizer application. Initial development of the test was with 0-12 inch depth soil samples collected prior to corn planting (late March to early April). In Illinois, the critical concentration value of the ISNT that indicates if a site will be responsive or non-responsive has been reported at 250 ppm for 0-12 inch depth soil samples (Mulvaney, 2006). This critical concentration, or a relationship to N response, could not be duplicated by research conducted in Iowa (Barker et al., 2006a; 2006b) or across the Midwest (Laboski et al., 2006; Osterhaus et al., 2008). The ISNT test has not been calibrated to adjust N application rate.

This project is designed to evaluate corn response to applied fertilizer N and directly compare ISNT values to yield increase from applied N. One objective is to determine the ability of the ISNT to predict N fertilizer response in Iowa soils. A second objective is field calibration of the ISNT and use for estimation of economic optimum N rate.

Materials and Methods

Sites were located on seven Iowa State University research farm fields in 2006 and 2007 (Northwest Research Farm - Sutherland, Northern Research Farm – Kanawha, Northeast Research Farm – Nashua, Southeast Research Farm – Crawfordsville, Armstrong Research Farm – Lewis, and Agronomy Farms – Ames). These sites represent major corn production areas and predominant soils in Iowa. Two sites were located on the Agronomy Farms each year, one with (Ames Swine Farm, AmesSF and Ames Dairy Farm, AmesDF) and one without a manure application history. All other sites had no history of manure application. The crop grown in the previous year was soybean at all sites. Information regarding the past management practices (crop grown, tillage, manure application) was collected for each site and used to assist in selecting field sites and for evaluating N response. No N fertilizer as MAP, DAP, starter, or animal manure was applied the fall before or during the study year. Corn management practices such as hybrid, tillage system, and weed and insect control were chosen by the farm manager.

Plot size varied from six to eight rows wide by 50-ft in length for each trial site. Nitrogen fertilizer rates were a no-N control, 40, 80, 120, 160, and 200 lb N/acre applied as urea broadcast and incorporated prior to planting at Sutherland, Kanawha, and Nashua each year and at Crawfordsville in 2007; ammonium nitrate broadcast on the soil surface shortly after planting at Lewis both years, Crawfordsville in 2006, and the Ames sites in 2007; and calcium ammonium nitrate broadcast on the soil surface shortly after planting at the Ames sites in 2006. To allow for direct comparison of N response and ISNT by replicate, the no-N zero and 160 lb N/acre rates were positioned side-by-side in each replicate. Nitrogen rates were replicated four times in a randomized complete-block design at each site.

Soil samples were collected from the 0- to 6 inch and 6- to 12 inch soil depths from the no-N control plot in each replication in April prior to planting (early spring), early June when corn was approximately 6- to 12 inches tall (late spring), and fall after harvest. Twelve cores were collected per sample. No early spring soil samples were collected from the Sutherland site in 2006. Samples were dried in a forced-air oven at room temperature and ground to pass through a 2-mm sieve. Soil was analyzed for ISNT using the procedure outlined by Mulvaney (2006). To obtain estimated ISNT values for the 0-12 inch depth, the values for the 0-6 and 6-12 inch depth were averaged. Routine soil tests for pH, P, K, and organic matter were determined by the Iowa State University Soil and Plant Analysis Laboratory.

Corn grain yield was determined by combine harvest of the middle rows of each plot, with yield adjusted to 15.5% moisture. Relative grain yields for each site were calculated by dividing grain yield of the no-N control by maximal yield determined from a regression model fit to yield response at each site. Economic optimum N rate (EONR) was determined from the same regression model, and calculated at the 0.10 N fertilizer to corn price ratio ($/lb N:$/bu corn). Percent grain yield response to applied N was calculated by subtracting the no-N control yield from the grain yield at EONR, and dividing by the no-N control yield. Increase in grain yield was calculated by subtracting the no-N control yield from the yield at the 160 lb N/acre rate. This yield increase was directly compared to the ISNT for each replicate.

The SAS system version 9.1 was used for statistical analyses of all data (SAS, 2003). Yield response to applied N at each site was analyzed in a stepwise process. First, significance of N rate was determined using PROC GLM as main effect of N rate or contrast of no-N vs. applied N. If not significant ($p > 0.10$), the site was classified as non-responsive to applied N. If significant, regression models were fitted using PROC NLIN. If the models had a similar coefficient of determination (R^2), and had a significant fit ($p \leq 0.10$), then quadratic-plateau or quadratic equations were selected in preference to linear-plateau or linear models. Otherwise, the model with a significant fit and largest R^2 value was chosen. The response fit was also visually inspected against yield at each N rate to confirm the appropriate choice of model. A linear regression model was used to compare ISNT values with response to applied N, grain yield increase to applied N, EONR, and total soil N.

Results and Discussion

All sites were N responsive in 2006 (grain yield significantly increased from applied fertilizer N), and all sites in 2007 except the Ames site. For each site, Table 1 gives the yield with no N applied (check yield), yield and N rate at the EONR, yield and N rate maximal response to applied N, and percent yield increase at the maximal response.

The traditional approach to investigate calibration of a soil test is to compare relative yield against soil test values. For the six sites with early spring preplant ISNT results, Fig. 1 shows the relationship between ISNT and site relative grain yield. The equivalent ISNT value for the 0-12 inch depth shown in Fig. 1 was calculated as the average of the 0-6 and 6-12 inch depths. Fig. 2 shows the same relationship for the late spring 0-6 inch depth samples, which were collected at all sites. Both figures clearly indicate no relationship between ISNT value and relative grain yield, indicating no potential for calibration of the test.

The original procedure used by Mulvaney et al. (2001) to indicate the relationship between the ISNT and N response was to plot the ISNT vs. percent yield increase to the EONR. This relationship is shown in Fig. 3 for the early spring ISNT with the 0-12 inch equivalent depth. Using this approach shows no relationship between ISNT and yield increase to applied N. The proposed ISNT critical concentration of 250 ppm for early spring preplant 0-12 inch depth soil samples (Mulvaney 2006) does not work for these sites as many of the sites had an ISNT at or above 250 ppm and also had large response to applied N. The same holds true for the relationship between ISNT and EONR (Fig. 4), that is, the ISNT value cannot be used to adjust N application rate. Even with a very high ISNT value (approximately 450 ppm), the grain yield response to N and required N application rate (EONR) was quite large (Figs. 3 and 4). Serious error in N application would occur if the ISNT were used to evaluate N need at that site. Using the proposed 250 ppm critical value would have resulted in a suggestion for no N application, which would have resulted in a 30 bu/acre yield loss.

One criticism (Mulvaney et al., 2006) of using the traditional approach of site-mean relationships between ISNT values and N responses from replicated plots for soil test calibration is the averaging across blocks or replicates – thus ignoring spatial variability in soil properties and crop yield response to N within sites. To investigate the possibility of spatial variability within trial sites affecting the effectiveness of traditional calibration methods, the zero N rate (check) plots were situated side-by-side with the 160 lb N/acre rate plots. This allows direct comparison by replicate of the yield difference between the two N rates and the ISNT value from soil at the same location. This relationship is shown in Figs. 5 and 6 for the early spring preplant 0-6 and 6-12 inch depth soil samples. Clearly there is no relationship between the ISNT and yield increase to applied N, and further documents the lack of predictability of the ISNT for determining expected corn response to applied N or adjusting N application rate.

An identified problem with the ISNT is the direct relationship with total soil N (Barker et al., 2006b; Laboski et al., 2006; Osterhaus et al., 2008), and hence total soil organic carbon and soil organic matter due to the relatively constant relationship between soil organic carbon and N. A high correlation ($R^2 = 0.91$) between total soil N and the ISNT occurs for the sites in this study as well (Fig. 7). This indicates the inability of the ISNT to estimate a specific soil organic N fraction, and indicates the ISNT can do no better than routine tests for total soil N or soil organic matter in predicting corn grain yield response to added N.

Summary

The first and second year evaluation of the ISNT in this project indicates the same results as found previously in Iowa by Barker et al. (2006a; 2006b), in Wisconsin by Osterhaus et al. (2008), and across the Midwest by Laboski et al. (2006). The ISNT is not predictive of corn response to applied N, is not predictive of adjustment in N application rate, is not calibrated for Iowa soils, and ISNT values are a constant fraction of total soil N.

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Table 1. Corn grain yield response to applied N, 2006-2007.

	No-N Check	Economic Response[2]		Maximal Response[3]		Yield
Site	Yield[1]	N Rate	Yield	N Rate	Yield	Increase[4]
	bu/acre	lb N/acre	bu/acre	lb N/acre	bu/acre	%
			2006			
Ames	149	127	221	141	222	48.3
AmesSF	144	105	169	140	170	18.8
Nashua	188	108	218	130	219	16.7
Kanawha	135	159	200	186	202	49.6
Sutherland	139	72	156	98	157	13.3
Crawfordsville	137	152	193	183	195	41.7
Lewis	193	118	238	140	239	23.8
			2007			
Ames	137	0	137	0	137	0.0
AmesDF	169	166	238	193	239	41.2
Nashua	143	91	202	100	202	41.1
Kanawha	101	100	179	107	179	77.1
Sutherland	104	140	165	161	166	60.6
Crawfordsville	140	84	191	92	192	36.5
Lewis	117	145	192	163	193	65.3

[1] Yield with zero applied N.

[2] Economic optimum N rate (EONR) and yield at EONR calculated at a 0.10 N:corn price ratio (example $0.30/lb N and $3.00/bu corn).

[3] Nitrogen rate and yield at maximum response to applied N from the fitted response equation.

[4] The percent yield increase from applied N at the maximal response above the no-N check.

Fig. 1. Relative corn grain yield and ISNT values for 0-12 inch depth early spring preplant soil samples, 2006-2007.

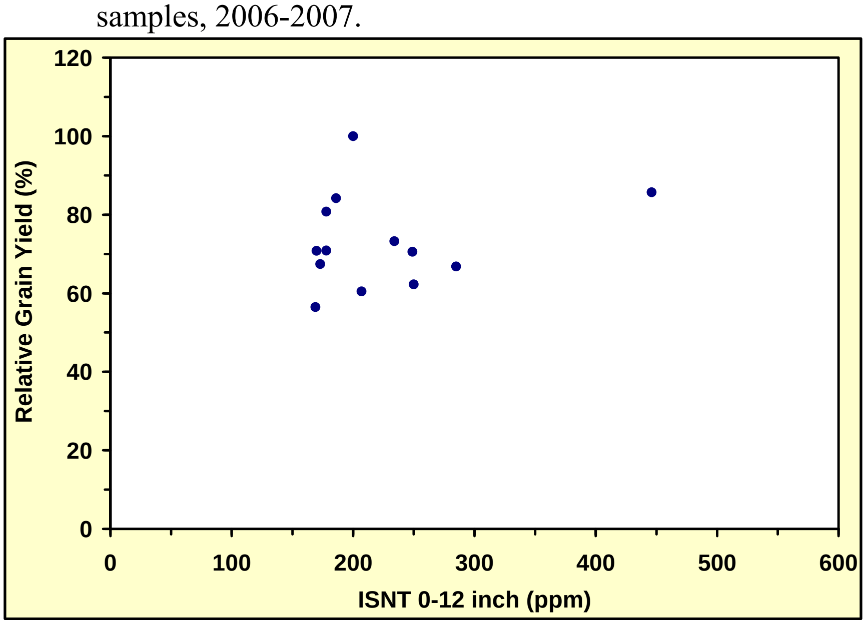

Fig. 2. Relative corn grain yield and ISNT values for 0-6 inch depth late spring soil samples, 2006-2007.

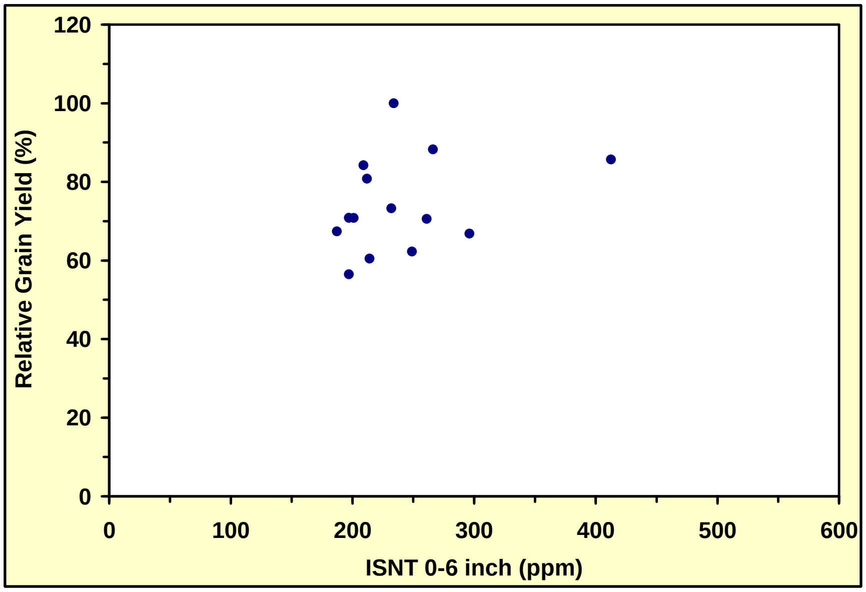

Fig. 3. Corn grain yield response to applied N and ISNT values for 0-12 inch early spring preplant soil samples, 2006-2007.

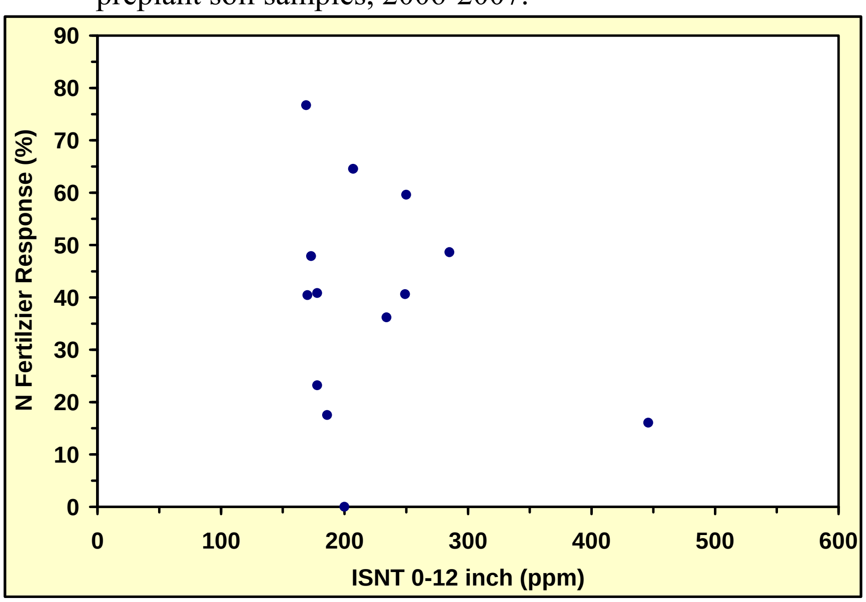

Fig. 4. Economic optimum N rate (EONR) at a 0.10 price ratio ($/lb N:$/bu) and ISNT values for 0-12 inch early spring preplant soil samples, 2006-2007.

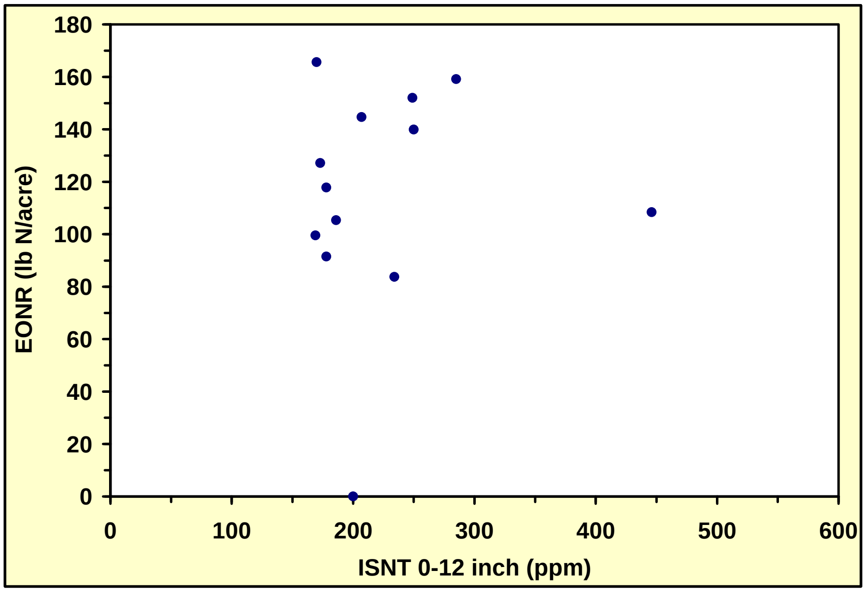

Fig. 5. Corn grain yield increase (from zero N to 160 lb N/acre) and ISNT values for 0-6 inch early spring preplant soil samples by replicate, 2006-2007.

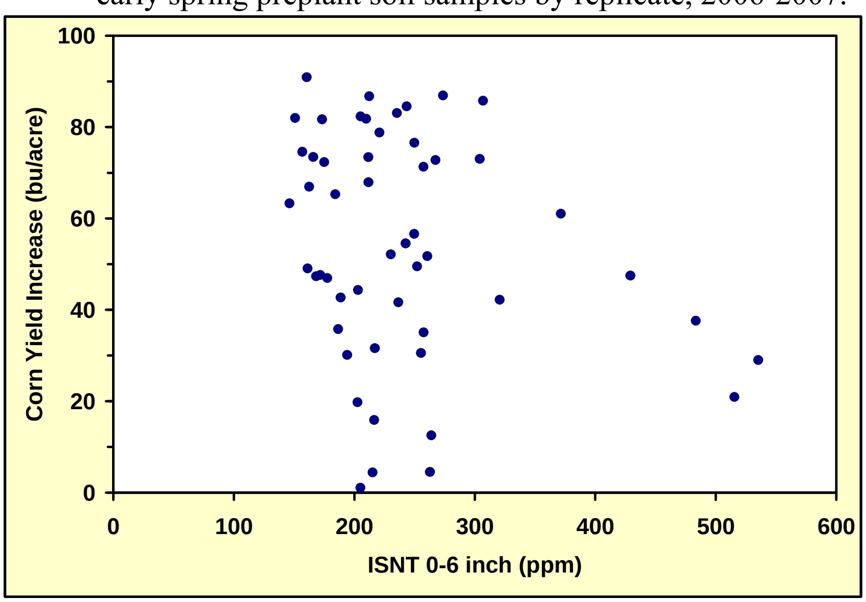

Fig. 6. Corn grain yield increase (from zero N to 160 lb N/acre) and ISNT values for 6-12 inch early spring preplant soil samples by replicate, 2006-2007.

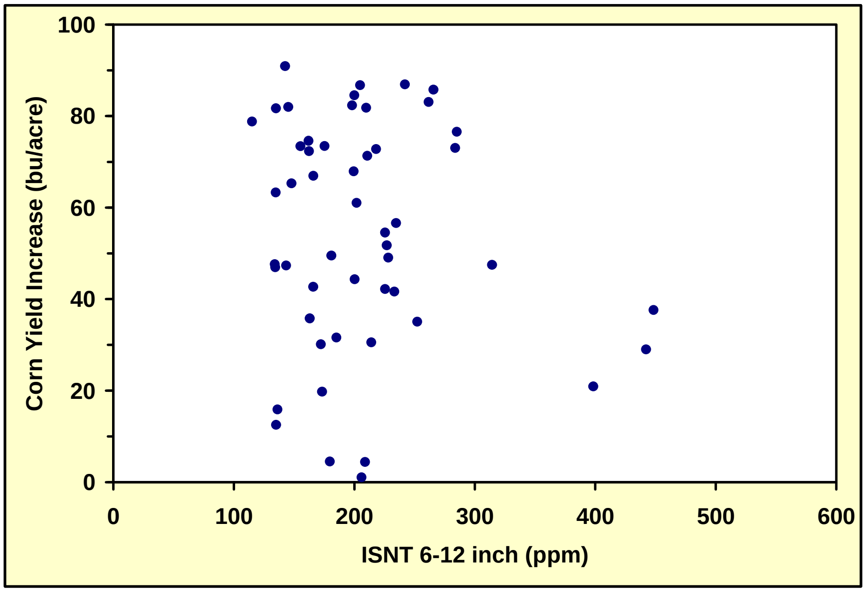

Fig. 7. Total soil N and ISNT values for 0-6 inch early spring preplant soil samples, 2006-2007.