Spatial Variability of Illinois Soil Nitrogen Test Results in New York Soils

Kulbhushan Grover[1], Scott Grandt[2] and Quirine Ketterings[2]

[1]Plant and Environmental Sciences, New Mexico State University, Las Cruces, NM

[2]Nutrient Management Spear Program, Animal Science Department, Cornell University, Ithaca, NY

Introduction

The Illinois Soil Nitrogen Test (ISNT) was developed to assess soil N release potential. In research in New York State, the ISNT, with critical value adjustments based on organic matter derived by loss-on-ignition (LOI), was 84% accurate in predicting corn (*Zea mays* L.) responsiveness for 2nd or higher year corn (Lawrence et al., 2009). For implementation of an ISNT-based N management system, it is important to understand the spatial and temporal variability of the ISNT and its effect on sampling distribution for accurate measurements of this pool of soil organic N.

Objectives

- Evaluate the accuracy of soil sampling protocols (number of samples per field) during the growing season and after harvest, with and without manure application.
- Quantify implications of a change in spatial and temporal variability for ISNT results.
- Determine the 95% confidence interval and probability of obtaining a mean within the 95% CI as impacted by sampling intensity.

Methods

- **Site:** Two 4-ha corn fields selected on a dairy farm in central NY with soil type of silt loam.
- Manure application: Field 1: no manure; Field 2: 110 Mg ha^{-1} in fall.
- **Soil sampling:** 150 samples/field (0-20 cm) in July and Nov. (Fig. 1A). Regular grid sampling 20 m lag distance classes (Fig 2).
- **Soil analyses:** LOI-OM, ISNT–N according to Khan et al. (2001) with the enclosed-griddle modification (Klapwyk and Ketterings, 2005; Fig. 1B).

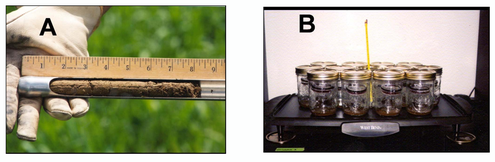

Fig. 1. A. Soil sampling (A) and Lab Analysis (B) for ISNT-N.

- **Statistical analyses**
  - Descriptive statistics using PROC MEANS of SAS.
  - Spatial dependence with semi-variograms using GS+ Software.
  - Best fit model (linear, spherical, exponential, or Gaussian) using GS+ based on the residual sum of squares (RSS).

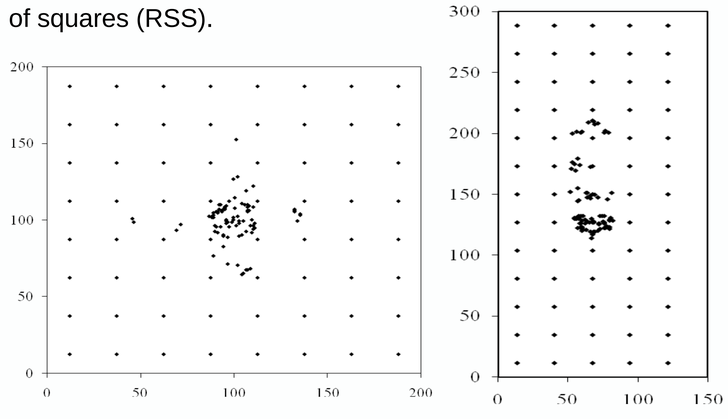

Figure 2. Soil sampling schemes for spatial and seasonal variability assessment of corn fields in NY.

Results

Table 1. Descriptive statistics of ISNT-N for two fields with and without manure†.

	Field 1 (No manure)			Field 2 (Manure)		
	Summer	Fall	% change	Summer	Fall	% change
	ISNT-N					
	mg kg^{-1}			mg kg^{-1}		
Mean	306	290	-5*	286	287	0
Std Dev	46	45	0	39	40	2
Minimum	207	198	-4	190	192	1
Maximum	406	412	1	363	412	13

† Significance of the difference between the summer and fall seasons was calculated using a two-tailed, paired T test.

Table 2. Best-fit models† for the ISNT-N semi-variograms of two fields.

ISNT-N		Model	Nugget	Sill	Range	r^2	RSS
			mg kg^{-1}		m		
Field 1	Summer	Exponential	0.03	1.4	113.1	0.87	0.15
	Fall	Exponential	0.36	1.4	152.4	0.81	0.13
Field 2	Summer	Exponential	0.24	1.6	236.7	0.75	0.48
	Fall	Exponential	0.56	1.4	260.7	0.70	0.23

† The best fit model was based on 150 samples taken per sampling round per field.

Descriptive statistics

- **Field 1:** The mean ISNT-N value of Field 1 decreased by 5% from summer to fall sampling, reflecting a decrease in readily available N pool (Table 1).
- **Field 2:** The ISNT-N was not impacted by sampling time, suggesting the manure addition compensated for a decline in ISNT-N due to N mineralization (Table 1).

Spatial and temporal variability

- **Field 1:** The variogram range for ISNT-N increased by 35%, while r^2 decreased by 15% from summer to fall in the Field 1. The nugget increased 12-fold while sill did not change from summer to fall.
- **Field 2:** Range decreased by 29% from summer to fall. The r^2 did not change considerably, while the RSS decreased by 56% from summer to fall. Nugget increased by 2.5-fold, while sill decreased from summer-fall.

Table 3. Average confidence interval (and the probability of obtaining an estimate within the 95% confidence interval†) as a function of number of subsamples taken in two 4-ha corn fields. Field 2 received manure 2 wk before sampling.

		Number of samples per 4-ha field										
		3	5	10	15	20	25	30	35	50	60	All
		ISNT-N										
		mg kg^{-1} (% probability)										
Field 1	Summer	48 (35)	35 (45)	28 (53)	23 (68)	20 (83)	18 (81)	16 (91)	15 (97)	12 (100)	12 (100)	11 (100)
	Fall	46 (32)	34 (45)	28 (62)	23 (69)	19 (80)	17 (80)	16 (89)	15 (97)	13 (100)	12 (100)	11 (100)
Field 2	Summer	39 (30)	33 (40)	24 (50)	20 (73)	17 (86)	15 (89)	14 (92)	13 (98)	11 (99)	10 (100)	10 (100)
	Fall	38 (36)	34 (40)	24 (59)	19 (74)	18 (87)	16 (89)	14 (89)	13 (94)	11 (99)	10 (100)	10 (100)

† The 95% confidence interval was calculated using 25 meter grid sampling of the field and 300 randomly selected sets of samples were taken to determine the average confidence interval for each sample size.

Sampling simulation

- The smallest CI for ISNT-N obtained was 10 mg kg^{-1} (summer and fall) (Table 3).
- Increasing the number of subsamples from 1 to 30 reduced the 95% CI from ±13 (16%) to ±5 (6%) (summer or fall) for both fields (Table 3).
- There was a 89-91% probability that the mean of 30 subsamples was within the 95% CI of the field versus 30-35% for compositing 3 subsamples in the summer, and 32-36% for 3 samples in fall (Table 3).

Preliminary Conclusions

- At a minimum 30 samples per 4-ha field (3 subsamples per acre) were needed to obtain a confidence interval within 10% of the population mean with >90% probability.
- The number of samples required was same for both summer and fall sampling and independent of manure application when applied in the fall.

References Cited

- Khan, S.A., R.L. Mulvaney, and R.G. Hoeft. 2001. A simple soil test for detecting sites that are nonresponsive to nitrogen fertilizer. SSAJ. 65:1751–1760.
- Klapwyk, J.H., and Q.M. Ketterings. 2005. Reducing analysis variability of the Illinois soil nitrogen test with enclosed griddles. SSAJ. 69:1129–1134.
- Lawrence, J.R., Q.M. Ketterings, M.G. Goler, J.H. Cherney, W.J. Cox and K.J. Czymmek (2009). Accuracy of the Illinois Soil Nitrogen Test (ISNT) in predicting N responsiveness of corn in rotation. SSAJ. 73: 303-311.

Acknowledgements

This research was funded by federal formula funds. For further information on ISNT work in New York, contact Quirine Ketterings, Nutrient Management Spear Program, Department of Animal Science, 323 Morrison Hall, Cornell University, Ithaca NY 14853. (qmk2@cornell.edu).