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Impact of Clover Incorporation and Ammonium Nitrate Sidedressing on Ammonium, Nitrate and Illinois Soil Nitrogen Test Dynamics over Time

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Introduction

The Illinois Soil Nitrogen Test (ISNT) is a new soil organic N test developed by Kahn et al. (2001) that has been evaluated for use in New York corn systems over the past 6 years. The ISNT, conducted in enclosed incubation units in the laboratory (Klapwyk et al., 2005), was shown to be an accurate predictor of corn N responsiveness for 34 on-farm trials conducted in New York State if the test results were used in conjunction with loss-on-ignition (LOI) organic matter (Klapwyk and Ketterings, 2006). The test reflects past manure N credits but samples should not be taken within 5 weeks after manure application (Klapwyk et al., 2006) to isolate past manure additions and background soil N supply from ammonium N credits associated with just-applied manure. In 2005-2008, an additional 34 N-rate studies were conducted throughout New York State (mostly on-farm trials) to determine the effectiveness of the ISNT and LOI combination in identifying sites that did not need extra N beyond a small (less than 30 lbs N/acre) banded starter. These studies indicated (1) 83% success rate for the test for corn two or more years after alfalfa (Lawrence et al., 2009), and (2) potential for substantial savings in N fertilizer costs for farms with organic N sources. Corn following alfalfa/grass plowdown did not respond to extra N (Lawrence et al., 2008) and ISNT samples taken at sidedress time did not reflect the nitrate-N pool released from sod decomposition (Lawrence et al., 2009). These results suggest that for ISNT results to accurately reflect soil N supply, samples should not be taken within 5 weeks of sod turnover or manure application.

In this study we addressed the question: How do clover plowdown and sidedressing of ammonium nitrate influence ISNT-N results?

Methods

We monitored ISNT-N, ammonium-N and nitrate-N levels on a weekly basis under two contrasting management systems within the "Organic Grain Cropping Systems Experiment" initiated at the Aurora Research Farm in 2005. As part of this experiment, five fertility treatments were implemented in 2005 with two entry points for a soybean-spelt/red clover-corn rotation (http://www.organic.cornell.edu/ocs/grain/index.html). The corn years in the following two systems were sampled in 2007 and 2008:

- System 2: Organic - organically-managed corn planted after one year old (cover crop) clover plowdown.
- System 5: Conventional - conventionally managed corn (starter plus sidedress N); no clover plowdown.

Actual fertility amendments and their date of application are shown in Table 1. The conventional treatment was separated from the randomized block design for the other treatments. Plots were randomly split into two rotation entry points, so that one half of each plot was a year behind in the crop rotation sequence. The plots that were sampled for N dynamics were part of Entry Point A in 2007 and Entry Point B in 2008.

Prior to plowing, we collected samples of above-ground clover biomass in system 2 plots (21 May, 2007 and 21 May 2008). The initial soil sampling round (0-8 inch depth; 12 cores per 120' x 40' plot) occurred prior to plowdown of the clover cover crop on 18 May 2007 and 21 May 2008. The next sampling round occurred at plowdown (22 May 2007 and 22 May 2008) and was followed by 8 additional sampling rounds at weekly intervals thereafter. Corn was planted 23-24 May 2007 and 29 May 2008. The conventional plots were sidedressed 22 June 2007 and 2 July 2008 with 265 lbs/acre of ammonium nitrate (34-0-0). The plots in system 2 received 380 lbs of a dry organic starter fertilizer (2-4-2). The corn in the conventional system was planted with 240 lbs/acre of 10-20-20 starter.

Table 1. Fertility management for two corn years in a rotation study.

2007 Entry Point A		
2 - Organic	Clover plowed down	21 May 2007
	Starter: 380 lbs/acre of dry starter (2-4-2)	23 May 2007
5 - Conventional	Starter: 240 lbs/acre of 10-20-20	23 May 2007
	Sidedress: 265 lbs/acre of 34-0-0	22 June 2007
2008 Entry Point B		
2 - Organic	Clover plowed down	21 May 2008
	Starter: 380 lbs/acre of dry starter (2-4-2)	29 May 2008
5 - Conventional	Starter: 240 lbs/acre of 10-20-20	29 May 2008
	Sidedress: 265 lbs/acre of 34-0-0	2 July 2008

Soil samples were analyzed for ISNT-N in the Cornell Nutrient Management Spear Program (NMSP) laboratory using the enclosed griddle modification of Klapwyk and Ketterings (2005). Soil samples were also analyzed for 2 N KCl extraction of exchangeable nitrate+nitrite and ammonium as described in Mulvaney (1996).

Results and Discussion

In 2007, the clover above-ground dry biomass was 1.6 ton/acre. In 2008, it was 2.4 tons/acre. The year 2007 was a drought year with low corn grain yields (87 bu/acre) while 2008 was a wet year with much higher corn grain yields (165 bu/acre).

In the organically managed system, ISNT-N levels remained stable over time with coefficients of variation of 4.3 and 2.2% for 2007 and 2008, respectively. Such stability would suggest lack of variability in ammonium-N over time, which was confirmed by the ammonium-N data for these two years as well (Figure 1). The difference in total clover biomass between the years was consistent with the height of the nitrate-N peak (just over 60 mg/kg in 2007 versus almost 90 mg/kg in 2008). Clover incorporation increased soil nitrate-N levels over time with the greatest increase occurring after week 3. Peaks in nitrate-N were measured in week 5 showing that the timing of nitrate-N release from clover was very well aligned with the period of highest corn N needs. With weekly sampling, we were unable to detect an accumulation of ammonium-N. These results suggest that for the clover-based system, timing of ISNT sampling is not restricted (i.e. sampling can occur before or after cover crop termination).

In the conventional systems, sidedressing of ammonium nitrate greatly increased soil nitrate-N levels (large increase in nitrate-N between weeks 4 and 5 in 2007 and weeks 5 and 6 in 2008; Figure 1). The ammonium nitrate addition increased ammonium-N levels for 2-3 weeks and this increase was reflected in ISNT-N values after sidedressing, especially in 2008. For the conventional system, across all sampling points, the ammonium-N and ISNT-N content were positively correlated (P=0.0031) whereas in the organic system,

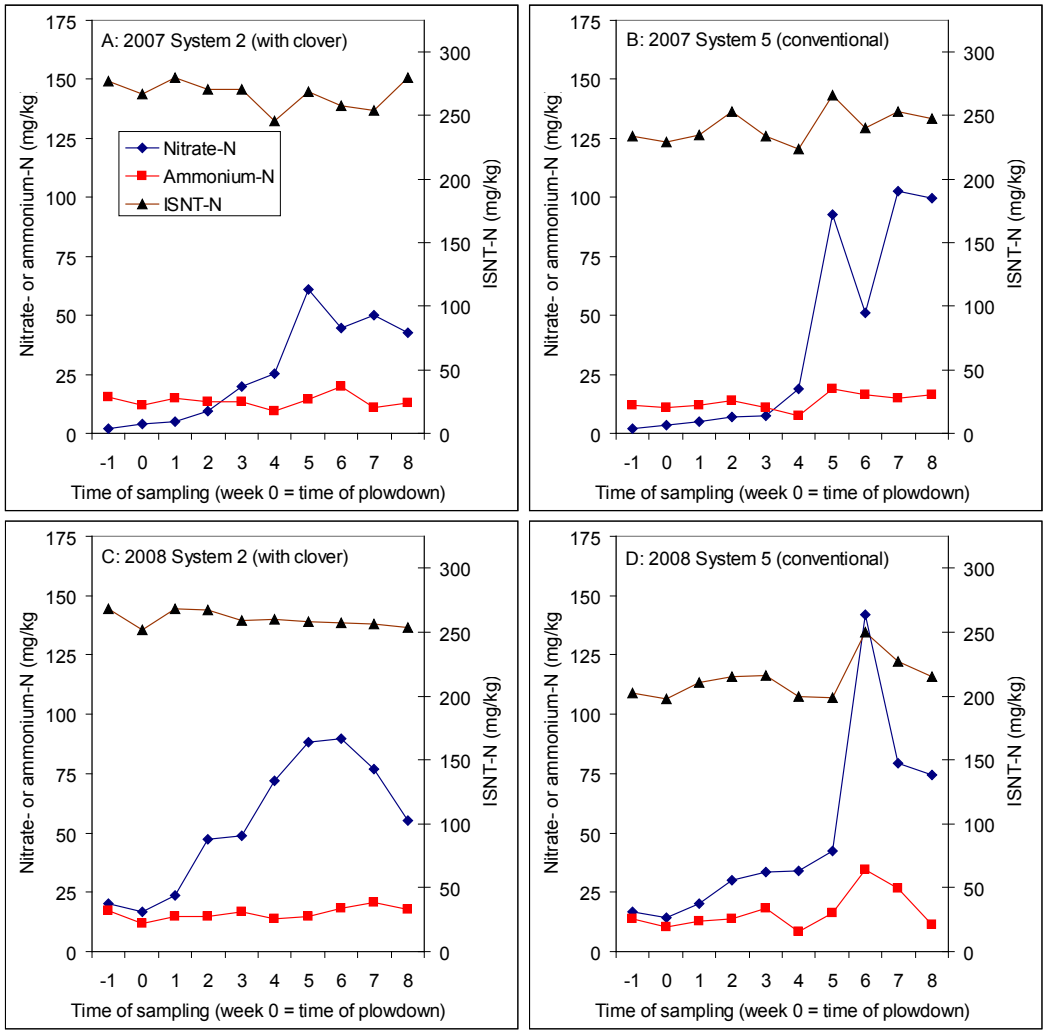

Figure 1: Soil nitrate-N, ammonium-N and ISNT-N following plowdown of clover in system 2 (Organic; A and C) and sidedressing of ammonium nitrate (34% N) in system 5 (Conventional; B and D). Plots in the conventional treatment (system 5) were sidedressed after sampling in week 4 in 2007 and following sampling in week 5 in 2008.

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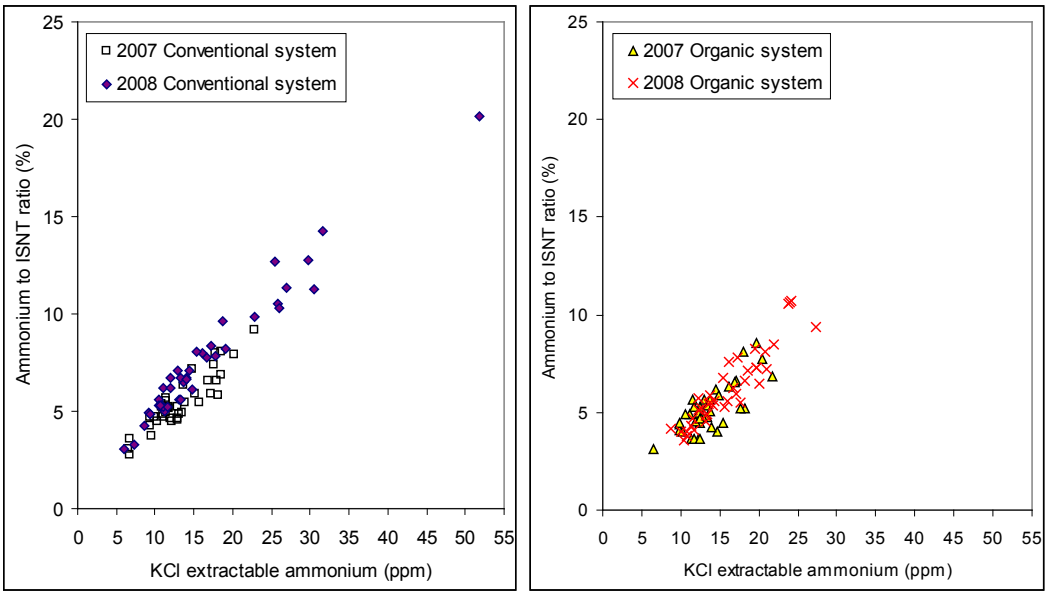

Figure 2: Soil ammonium-N and ammonium-N to ISNT-N ratio for samples collected over eight weeks in organically and conventionally managed systems. Plots in the conventional treatment were sidedressed with ammonium nitrate. In the organic plots, clover was plowed down.

ammonium-N was not correlated to ISNT-N (P=0.2084). This indicates that ISNT-N is not an accurate predictor of soil N supply from mineralization of soil organic matter if samples are taken within 2-3 weeks after addition of an ammonium-containing fertilizer, as at that time, the ISNT-N value reflects both ammonium-N from the fertilizer and soil N supply from mineralization of soil organic matter (Figure 2).

The pre-sidedress nitrate test (PSNT) data for both systems confirm the increase in available N upon incorporation of a clover cover crop; averaged across plots, the PSNT were 20 and 29 ppm where clover had been plowed down in 2007 and 2008, respectively, consistent with the biomass difference between the two years. Both years, the average PSNT for the conventionally managed plots was 11 ppm. Because of the separation in space of the conventionally managed plots, we can not conclude if PSNT values are statistically different between the two treatments but the weekly sampling and the PSNT results of the clover systems do suggest that the clover supplied a considerable amount of N. Comparison of the organic plots in this study with other organic plots in the same experiment that received 1900 lb/acre of 4.0-5.2-2.4 poultry manure compost in addition to the plowed down clover showed no yield increase with compost addition. This suggests that the nitrate-N released from clover decomposition was sufficient to meet the needs of the corn in both years.

Preliminary Observations

Clover incorporation greatly increased the amount of available N for the following crop. Decomposition of the clover resulted in nitrate peaks 5-6 weeks after incorporation, well-aligned with N needs of the corn and showing that clover plowdown is an excellent choice for providing N to corn in organic and conventional production systems. Clover decomposition did not result in ammonium-N accumulation. In contrast, the ammonium-containing fertilizer did increase ammonium-N levels for 2-3 weeks. This increase was measured by the ISNT procedure indicating that ISNT-N results of samples taken within 2-3 weeks after addition of an ammonium containing fertilizer will not reflect soil N supply from soil organic matter only. This study needs to be duplicated at other locations but our preliminary observations are that in cropping systems where N fertility is derived from a clover cover crop, ISNT sampling is not restricted in time, whereas sampling within 2-3 weeks after addition of an ammonium containing fertilizer should be avoided for accurate interpretations of soil N supply with the ISNT.

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For More Information

For more information on the New York State Nitrogen for Corn project and other work, see our project website: http://nmsp.css.cornell.edu/projects/Nitrogenforcorn.asp. You will also find a downloadable spreadsheet on this site that graphically shows the results of the ISNT test. This spreadsheet was recently revised upon suggestions by extension educators, and now includes a multiple field entry form and graph.

Nutrient Management Spear Program
http://nmsp.css.cornell.edu/

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