Mineralizable N in the Kentucky NRCS Soil Bank Study

Shuang Liu[1], John Graham[2], and Mark Coyne[1]

[1]Department of Plant and Soil Sciences, University of Kentucky, Lexington KY

[2]USDA-Natural Resources Conservation Service, Lexington KY

INTRODUCTION

Soil Quality reflects the capacity of soil to function over extended periods relative to the goals of its users - sustained crop yield in the case of agricultural producers (Snapp and Morrone, 2008). Among the most important soil quality indicators are the amount and availability of soil organic matter. From 2009 through 2012 soil samples were collected across Kentucky by producers participating in individual environmental grants sponsored by the Kentucky Division of Conservation and designed by the USDA-NRCS. As part of those grants, cropping systems were designed to maintain and improve the soil's physical, biological, and chemical properties and to maximize the natural benefits received from them.

Base components of all designed cropping systems were: no-tillage, organic matter on and in the soil surface (plant residues on soil surface/roots in the soil surface), applications of light amounts of animal waste or compost, and maximum plant diversity (cover crop mixtures and crop rotations). Project goals were to maximize soil quality through increased additions of soil C, increased soil pore space, re-establishment of a healthy broad diverse soil microbial food web, and increased soil cation exchange capacity.

One measurement used to determine the success of that effort may be incremental increases in available soil N. We analyzed samples over a four-year period for rapidly mineralizable soil N by anaerobic incubation, and for total mineralizable N in 2011 by long-term aerobic incubation.

SAMPLE LOCATIONS & METHODS

- Sample fields were distributed primarily in central and western Kentucky (Fig. 1). Seven fields have been continuously sampled since 2009 and 9 fields since 2010. Thirty-five individual samples were assessed in 2009, 76 in 2010, and 59 in 2011 and 2012.
- Samples were removed in spring from the plow layer (upper 15 cm of soil), air dried , and sieved prior to analysis.
- Subsamples of sieved soils were sent to the University of Kentucky Regulatory Services Lab for chemical analysis.
- The gravimetric water content was determined in the remaining soil and 5 g distributed into triplicate glass tubes for short term anaerobic mineralization assay as described by Bundy and Meisinger (1994).
- Baseline NH_4^+, NO_3^-, and NO_2^- were determined colorimetrically from samples extracted with 1M KCl. Net mineralization was determined as the increase in N_i with time relative to baseline N_i.
- A long-term aerobic mineralization assay was conducted in 2011. Fifty to 100 g of air dried soil were distributed into triplicate sealable plastic bags, amended to 30% gravimetric water content, and incubated in the dark at 25 C for 31 weeks.
- Baseline NH_4^+, NO_3^-, and NO_2^- were determined by extracting ≈ 5 g soil in 1 M KCL.
- At periodic intervals, ≈ 5 g soil of soil was extracted and inorganic N determined colorimetrically. Net mineralization was calculated as the difference between final and baseline N_i content.

Cooperator	County
RE	Graves
WA	Todd
JMT	Todd
BE	Henderson
BJ	Fayette
JM	Madison
BH	Knox
JT	Bath
MSU	Murray State University
WKU	USDA-ARS/Western Kentucky University

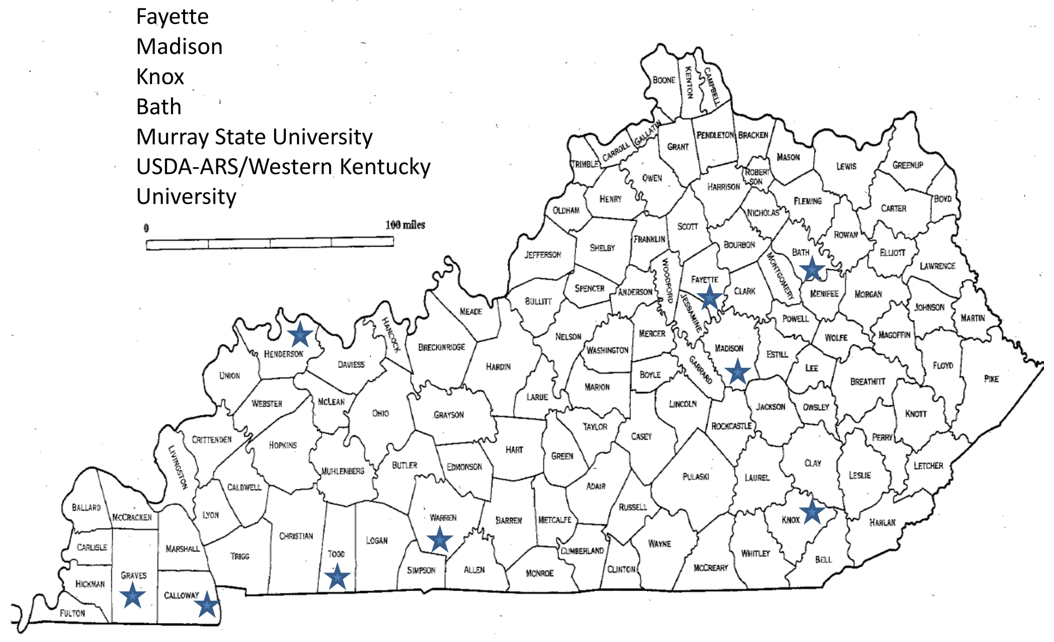

Figure 1. Regional location of sample fields.

RESULTS – ANAEROBIC MINERALIZATION (2009-12)

Between 2009 and 2012 there was a 320% increase in anaerobically mineralizable N from 20 to 84 mg kg^{-1} N_i during the 7-d incubation period (Fig. 2). For the period 2010-2012, when a larger set of samples was included, the increase was 115%, suggesting diminishing returns from the management change with time.

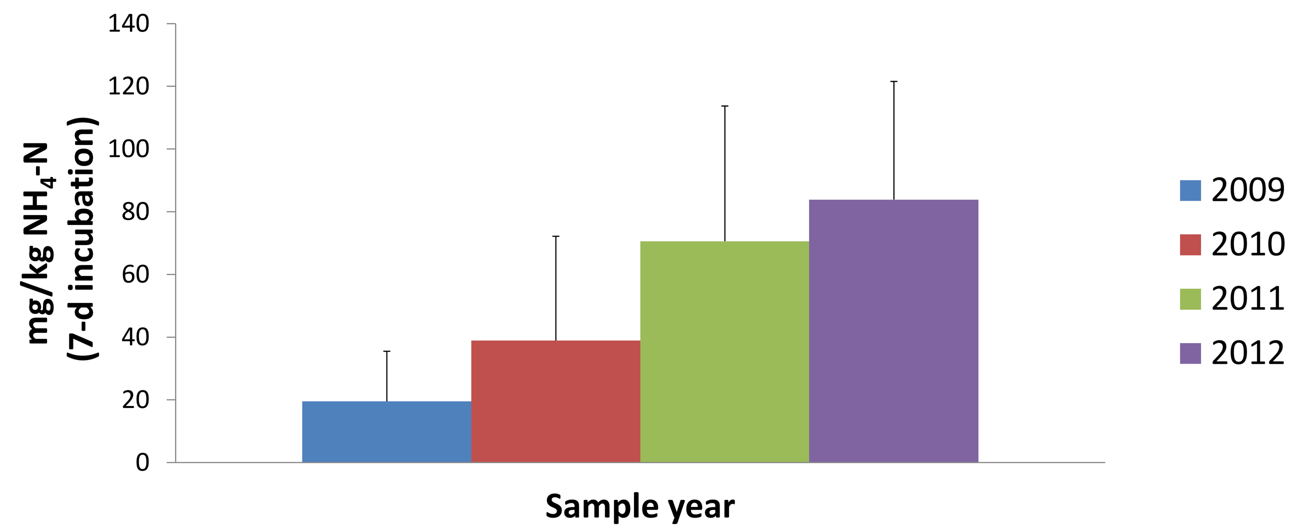

Figure 2. Net N_i released during anaerobic mineralization (2009-2012). N = 26 in 2009 ; N=59 in 2010-2012. Error bars reflect one std deviation of the mean.

Plotted on an individual sample basis, the field sampling initiated in 2009, which primarily represents participating farmer cooperators, suggests that each year the base level of mineralizable N in soil has increased (Fig. 3). The data also suggest increasing returns to the most actively mineralizing sites because between 2009, when the study commenced, and 2012, the slope of the linear regression has increased when samples are ordered on the basis of initial mineralization rates in 2009.

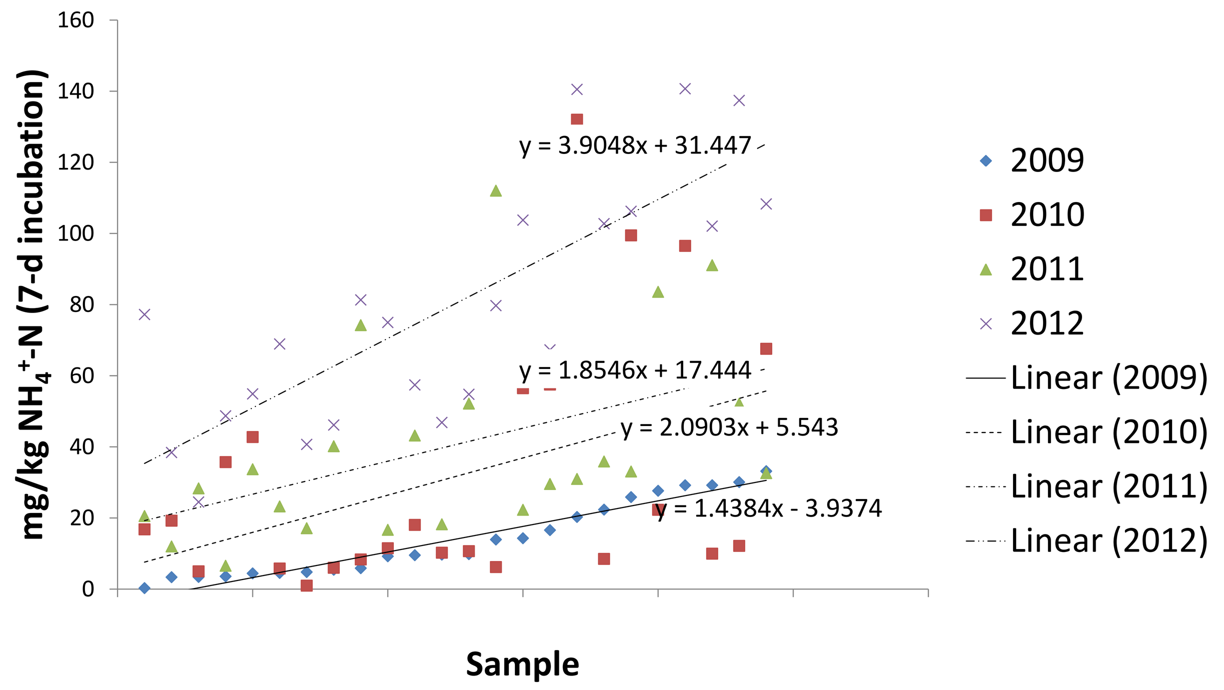

Figure 3. Net N_i released during anaerobic mineralization (2009-2012) for individual samples (N = 23). Samples are ordered based on increasing mineralization rate from 2009 data.

When data from all samples for the last three years are included, the increase in base soil mineralizable N is still apparent, but the soil response to addition of mineralizable N is much diminished after 2010 (Fig. 4).

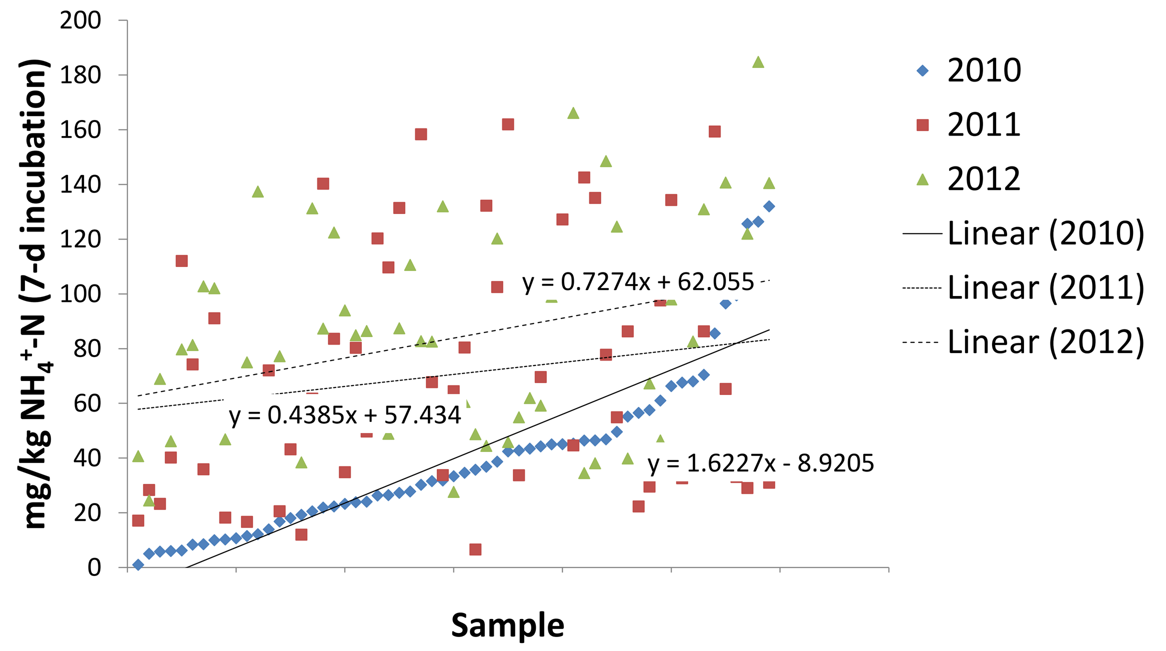

Figure 4. Net N_i released during anaerobic mineralization (2010-2012) for individual samples (N = 59). Samples are ordered based on increasing mineralization rate from 2010 data.

RESULTS – AEROBIC MINERALIZATION (2011)

Aerobic mineralization ranged from 30-230 mg/kg N_i in a two-week period and had a good linear relationship to anaerobically mineralized N_i recovered in a one week period (Fig. 5).

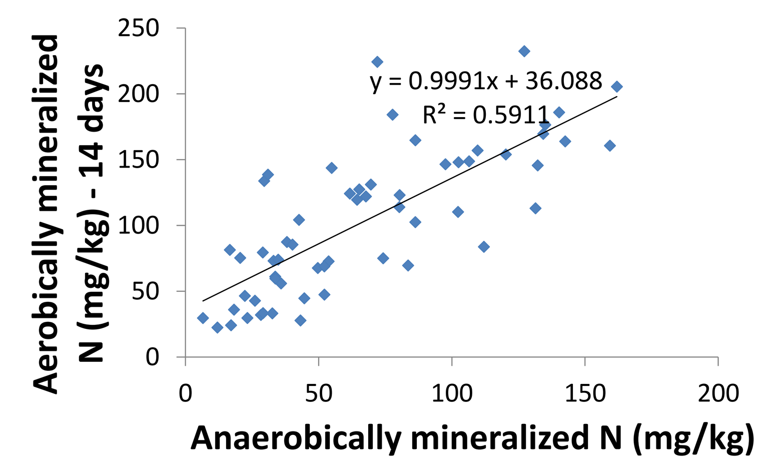

Figure 5. Relationship of rapidly mineralized N determined anaerobically to net mineralized N determined aerobically after a two-week incubation

RESULTS – RELATION TO SOIL PROPERTIES

The relationship between anaerobically mineralizable N or aerobically mineralized N and either total N or total C was best fit to a polynomial function (Fig. 6).

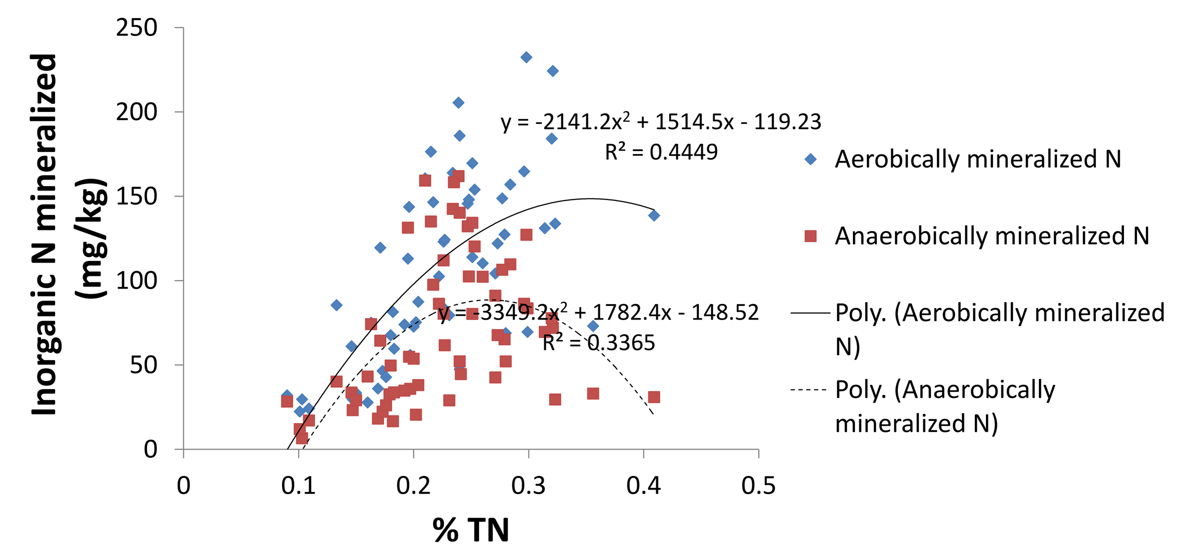

Figure 6. Relationship of total soil N to N_i mineralized aerobically or anaerobically.

CONCLUSIONS

- For cropping systems sampled each year, % total N and % total C increased 26 and 28%, respectively between 2009 and 2011.
- Anaerobically mineralized N increased in one year and increased over 320% from 2009-2012.
- There was a good linear relationship between rapidly mineralizable N and 2-week total aerobically mineralizable N.
- No good relationships existed between anaerobically mineralizable N and basic soil nutrients such as Ca, K, Mg and P.
- Overall, the practices employed in this program appear to be successfully increasing mineralizable soil N with time.

REFERENCES

Bundy, L.G. and J.J. Meisinger. 1994. Nitrogen availability indices. p. 951-984. *In* R.W. Weaver et al., (ed.) Methods of soil analysis, part 2: Microbiological and Biochemical properties. Soil Science Society of America. Madison WI.

Snapp, S.S. and V.L. Morrone. 2008. Soil quality assessment. p. 79-96. *In* S. Logsdon et al. (ed.) Soil Science: Step-by-step field analysis. Soil Science Society of America. Madison WI.

ACKNOWLEDGEMENTS

This research was funded by grants from the Kentucky Division of Conservation, USDA-NRCS, and USDA-FAPRU. S. Liu received financial support of the Department of Plant and Soil Sciences, College of Agriculture, University of Kentucky. The assistance of Dr. Frank Sikora, Regulatory Services Soil Testing Lab, University of Kentucky, faculty at Murray State University and Western Kentucky University, and the USDA-ARS Animal Waste Unit (Bowling Green KY) are appreciated. We also acknowledge the assistance of Ann Freytag and several undergraduate research assistants: Heather Jordan, Olivia Morris, Preston Jones, Joey Van Noy, and Isarapong Norrueang.