Increasing Rates of Gross Nitrogen Mineralization in Diversified Midwestern Cropping Systems

IOWA STATE UNIVERSITY
Department of Agronomy

William Osterholz*, Michael Castellano, Javed Iqbal, Matt Liebman
*wosterho@iastate.edu

Introduction

Gross N mineralization is the total amount of nitrogen transformed by microbes from labile soil organic N (SOM-N) to NH_4^+. Agroecosystems that achieve increased rates of gross N mineralization could potentially:

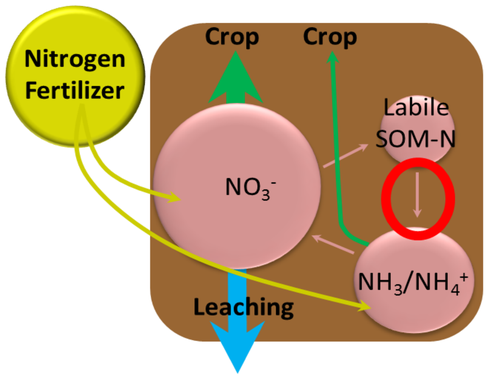
- Supply sufficient N to meet crop demand without depending on large fertilizer inputs and associated pools of inorganic N (NO_3^- and NH_4^+).
- Reduce N losses to the environment by reducing large inorganic N pools.

Conceptual Model

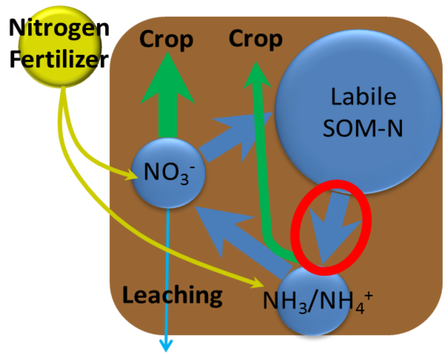
Gross N mineralization rates should be greater in agroecosystems with large labile SOM pools, which can be favored by high organic matter inputs, such as manure and legumes.

Additionally, crop yields could be increased in systems with high gross N mineralization as N availability would be more stable.

Low Gross N Mineralization

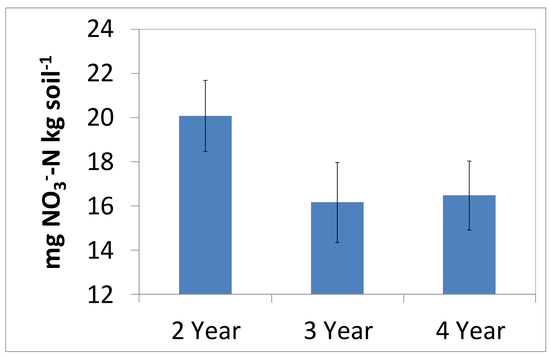


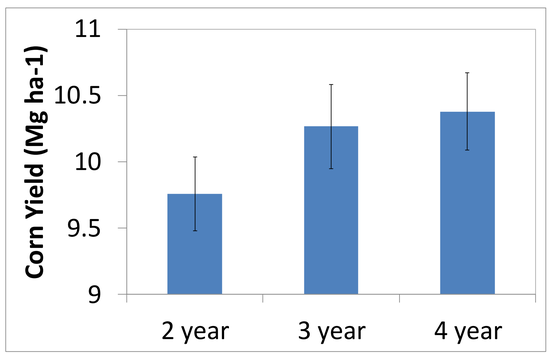
High Gross N Mineralization



Data from the Marsden Farm cropping systems experiment in Iowa supports the conceptual model:

- Inorganic N pool size is greater in simple rotations than diverse rotations with manure and legumes.
- Despite smaller N pool size, corn yields are higher in more diverse rotations.





2 year = corn-soy, 3 year = corn-soy-oat/clover + manure, 4 year = corn-soy-oat-alfalfa + manure.

10 year means, error bars = SE.

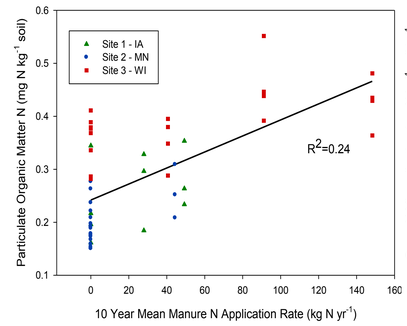
Study Objective

We tested the gross N cycling rates conceptual model by examining the relationship between manure application, particulate organic matter N, and gross N mineralization rates.

Measurements were taken on soil samples from three long-term cropping systems experiments in Iowa (Marsden), Minnesota (VICMS), and Wisconsin (WISCT). Cropping systems in each experiment vary in diversity and N fertility sources. Soil samples were taken from corn plots in fall 2012, 0-20 cm depth.

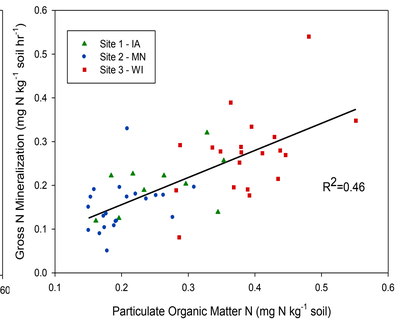
Results

Hypothesis 1: POM-N concentrations will be higher in agroecosystems with greater organic N inputs.



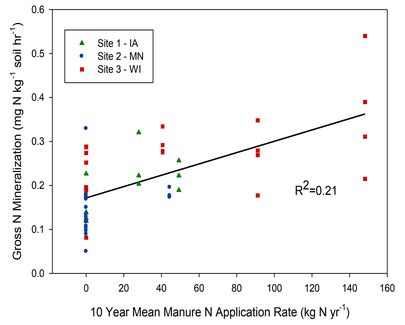
POM-N concentrations were greater with increasing rates of manure N application (p=0.0001).

Hypothesis 2: Gross N mineralization will be higher in agroecosystems with large POM-N concentrations.



Gross N mineralization was greater when POM-N concentrations were larger (p=0.004).

Hypothesis 3: Gross N mineralization will be higher in agroecosystems with greater organic N inputs.



Manure application was significantly positively correlated with gross N mineralization rate (p=0.02).

Conclusions

- Manure application increased POM-N, gross N mineralization was positively correlated with POM-N, therefore manure application may increase gross N mineralization rates.
- Cropping system management can have a large impact on POM-N concentrations and gross N mineralization rates.
- Agroecosystem design can improve supply of N to a growing crop through organic N inputs, which may reduce N losses to the environment.
- Future work will focus on further characterization of the relationship between labile SOM fractions and gross N mineralization in agroecosystems. Additionally, we will investigate how increased rates of gross N cycling can impact crop N availability and N losses to the environment.

Acknowledgements

Funding was provided by the Iowa State University Agronomy Department, the Leopold Center for Sustainable Agriculture, and the Binational Agricultural Research and Development Fund.

References

Cambardella, C., and E. Elliot. 1992. Particulate soil organic-matter changes across a grassland cultivation sequence. Soil Science Society of America Journal 56: 777-783.

Coulter, J., C. Sheaffer, D. Wyse, M. Haar, P. Porter, S. Quiring, and L. Klossner. 2011. Agronomic performance of cropping systems with contrasting crop rotations and external inputs. Agronomy Journal 103: 182-192.

Drinkwater, L., and S. Snapp. Nutrients in Agroecosystems: Rethinking the management paradigm. Advances in Agronomy 92: 163-186.

Hart, S., J. Stark, E. Davidson, and M. Firestone. 1994. Nitrogen mineralization, immobilization, and nitrification. *In* J. Bigham (ed.) Methods of Soil Analysis, Part 2. Microbiological and Biochemical Properties. SSSA.

Liebman, M., L. Gibson, D. Sundberg, A. Heggenstaller, P. Westerman, C. Chase, R. Hartzler, F. Menalled, A. Davis, and P. Dixon. 2008. Agronomic and economic performance characteristics of conventional and low-external-input cropping systems in the central corn belt. Agronomy Jounal 100: 600-610.

Posner, J., M. Casler, and J. Baldock. 1995. The Wisconsin integrated cropping systems trial: Combining agroecology with production agronomy. American Journal of Alternative Agriculture 10: 98-107.