Estimating Mineralizable Nitrogen from Organic Materials

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Introduction

In the southeastern United States, compost, poultry litter, and commercial organic fertilizers (made from plant and animal byproducts) are commonly used in vegetable production to supply plant-available nitrogen (PAN). However, due to the high variability in the nitrogen (N) content and composition of these materials, predicting the amount of PAN and the rate of N mineralization from these products is difficult. The ability to accurately predict N mineralization through the use of near infrared spectroscopy (NIRS) would allow for rapid estimations of PAN immediately prior to application, leading to increased precision of application of these products and reduced farmer costs.

Objectives

1. Determine mineralizable N and rate of mineralization from 42 different organic-certified materials (24 commercially available organic fertilizers, 8 composts, and 10 poultry litters).

2. Evaluate NIRS for predicting initial characteristics and rate constants of mineralization of organic-certified materials.

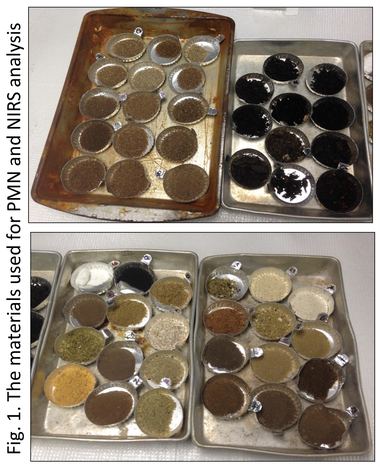

Fig. 1. The materials used for PMN and NIRS analysis

Materials and Methods

PMN INCUBATION

1. Organic materials were characterized for initial water content (drying at 65°C for 48 h), inorganic N (KCl), total C and N (dry combustion) and total elements (acid digestion).
2. Materials were applied at a rate to supply an estimated 75 mg N kg^{-1} of PAN to Cecil Sandy Loam soil at 50% water holding capacity and incubated at 30°C for 99 days. PAN was estimated to be 10%, 40% and 50% of the total N for composts, poultry litters, and fertilizers respectively.
3. Subsamples were taken on d 1, 3, 7, 14, 35, 56, 78, 99 to determine inorganic N (1M KCl, 1:5)
4. Net N mineralization (Net Nmin) was determined for each d by subtracting the d.1 initial inorganic N and fitting the data to a first order exponential model. N mineralization measured in the soil control was then subtracted from the model.
5. Net Nmin (g kg^{-1} material) was fit to first-order kinetics using SAS PROC NLIN:

$$\text{Net Nmin} = i\text{OrgN}\left(1 - e^{-kt}\right)$$

where *i*OrgN is the initial organic N (g kg material), k is the rate constant of mineralization, and t is time (d)

NIRS ANALYSIS

1. Samples were oven dried (65°C), ground, and packed in quartz ring cups.
2. Samples were then scanned using FOSS NIRSystem 6500; 400-2500 nm at 2-nm intervals
3. WinSCAN v 1.50 software (FOSS North America, Eden Prairie, Minnesota) reported reflectance (R) as log (1/R) and was used for statistical analysis.
4. Software used principle component regression for analysis of the spectra to develop calibration and cross validation with initial characteristics, and the rate constant of mineralization.

Results: Net N Mineralized

- Avg Net Nmin % of Total N applied:
  - Composts: -3.5%
  - Poultry litter: 17.0%
  - Fertilizers: 30.8%
- Rate constants (k) varied among materials.
- Very high "k" in blood and feather meal may be due to the high solubility of these products.

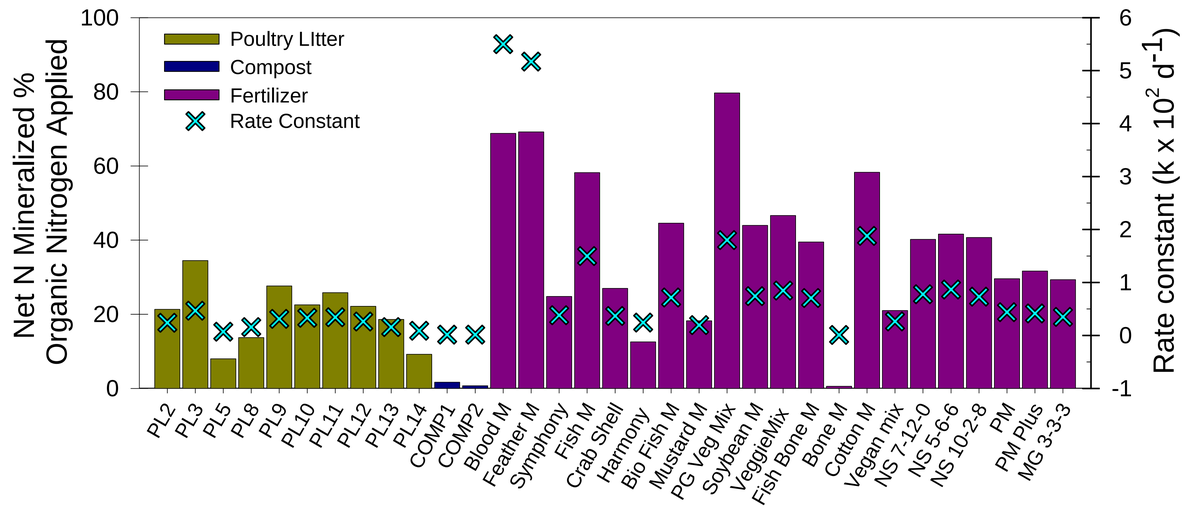

Fig. 2. Net N min from materials (PL=poultry litter, COMP=compost, M=meal) that mineralized and respective rate constants of mineralization determined through first-order kinetics.

Results: NIRS

- NIRS accurately estimated initial material water content, total N and C, organic N as well as the rate constant of mineralization allowing for prediction of mineralizable N using first-order kinetics.
- Net N min calculated using NIRS predicted variables led to a r^2 =0.92 with measured values
- Blood and feather meal values were not estimated well using NIRS and were removed

Characteristic	Mean	SD	RSQ	SECV	1-VR
Water Content g g^{-1}	0.33	0.35	0.86	0.17	0.76
Total C g 100 g^{-1}	35.82	9.67	0.74	7.13	0.49
Total N g 100g^{-1}	4.64	2.50	0.79	1.37	0.70
Organic N g kg^{-1}	40.38	22.66	0.97	10.17	0.79
k x 10^2 d^{-1}	0.51	0.48	0.92	0.42	0.30

Table. 1. NIRS determined mean, standard deviation (SD), r-square (RSQ), standard error of cross validation (SECV), and 1- validation ratio (VR) of selected material characteristics.

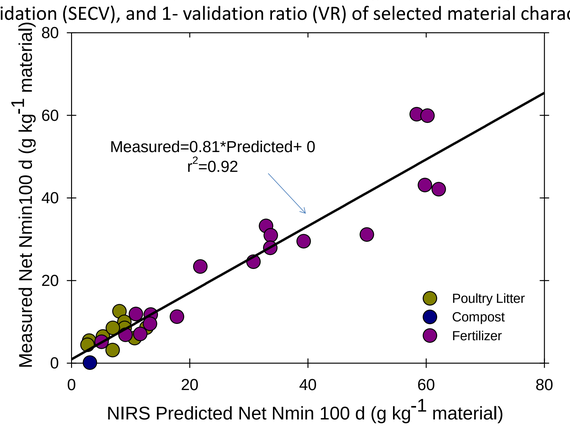

Fig. 3. Predicted Nmin using organic N values and k constants determined through NIRS versus measured Nmin at 99 d

Conclusions

The use of near NIRS allowed for rapid estimates of the initial organic N of the materials (r2=0.97) and the rate constant of mineralization (r2=0.92) when net N mineralization was fit to first-order kinetics for a range of organic materials.

Acknowledgement

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