Nitrogen Composition of Poultry Litter by NIR

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Introduction

Assessing the nitrogen fertilizer value of poultry litter (PL) relative to chemical sources is frequently based on measurement of total nitrogen. Total N is a poor predictor of field response due to the dynamic nature of organic N. Near Infrared Reflectance (NIR) Spectrometry is a rapid analysis tool that has shown promise in assessing some forms of poultry litter N.

Objectives

1) To develop a calibration for direct measurement of uric acid in poultry litter by NIR.
2) To investigate the potential for NIR as a routine measurement tool for important nitrogen forms in non-dried poultry litter samples with minimal homogenization (~30 s in a food grinder) to preserve characteristics of the bulk material.

Materials and Methods

- Litter samples from operating poultry farms were analyzed in the lab for the following nitrogen components:
- Uric acid-N: 0.1 M sodium acetate extraction; HPLC UV/VIS.
- Total-N: combustion (Dumas Method).
- Ammonium-N: 1 M KCl extraction; gas diffusion conductance.
- Nitrate-N: 1 M KCl extraction; Griess-Ilosvay colorimetric reaction.
- Potentially mineralizable–N: 100 day incubations; nitrate-N as above.
- Each sample was scanned by NIR and partial least squares analysis performed on spectra vs. laboratory measured values.

Figure 1: Poultry litter ready for application
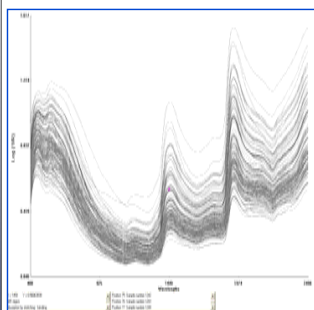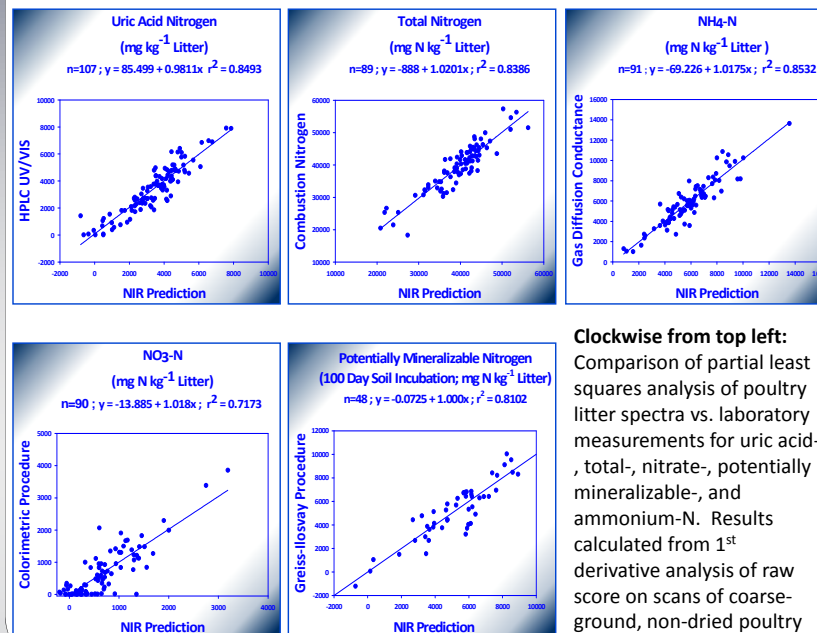
Figure 2: Foss NIRSystems 6500

Figure 3: Overlaid NIR spectra from scans of 150 litter samples

Results

Uric Acid Nitrogen (mg kg^{-1} Litter)
$n=107$; $y = 85.499 + 0.9811x$; $r^2 = 0.8493$
HPLC UV/VIS — NIR Prediction

Total Nitrogen (mg N kg^{-1} Litter)
$n=89$; $y = -888 + 1.0201x$; $r^2 = 0.8386$
Combustion Nitrogen — NIR Prediction

NH$_4$-N (mg N kg^{-1} Litter)
$n=91$; $y = -69.226 + 1.0175x$; $r^2 = 0.8532$
Gas Diffusion Conductance — NIR Prediction

NO$_3$-N (mg N kg^{-1} Litter)
$n=90$; $y = -13.885 + 1.018x$; $r^2 = 0.7173$
Colorimetric Procedure — NIR Prediction

Potentially Mineralizable Nitrogen (100 Day Soil Incubation; mg N kg^{-1} Litter)
$n=48$; $y = -0.0725 + 1.000x$; $r^2 = 0.8102$
Greiss-Ilosvay Procedure — NIR Prediction

Clockwise from top left: Comparison of partial least squares analysis of poultry litter spectra vs. laboratory measurements for uric acid-, total-, nitrate-, potentially mineralizable-, and ammonium-N. Results calculated from 1st derivative analysis of raw score on scans of coarse-ground, non-dried poultry litter samples.

Conclusions

1. This work represents the first known successful calibration for uric acid in poultry litter developed using NIR spectroscopy, demonstrating the potential for rapid routine analysis.

2. This is also the first work to calibrate for several forms of nitrogen important to assessing the fertilizer value of poultry litter using minimally-prepared litter samples. By eliminating drying and fine grinding, volatilization of ammonia is greatly reduced in the lab and the character of the organic fraction is preserved. These results are consistent with other published work on freeze-dried samples receiving a higher degree of homogenization

3. Rapid, direct analysis of uric acid-, NH_4^+-, NO_3^--, potentially mineralizable-, and total-N will improve predictions of poultry litter fertilizer value (short and long term) with respect to chemical fertilizer sources.