Soil Phosphorus Dynamics in Response to Amendment with Poultry Manure

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INTRODUCTION

Increased understanding of the fate of manure phosphorus (P) after soil application is critical for effectively utilizing manures to their full fertilization potential. Poultry manure differs from that of other species in that it contains a large amount of relatively insoluble organic P, particularly in the form of phytic acid (*myo*-inositol hexakisphosphate). This organic P appears as acid-soluble or HCl-P if using the sequential fractionation technique developed by Hedley et al. (1982). Recently our laboratory determined that 31 to 45% of total P from poultry manure was HCl-extractable and of this 23-37% was in organic forms (Dail et al., 2007). This fraction represents a large potential fertilizer resource but is relatively unstudied. Research needs to be conducted on the fate of manure HCl-P upon incorporation into soil.

OBJECTIVE

To utilize sequential fractionation and enzyme hydrolysis to assess short-term changes in P species of two Maine soils after amendment with poultry manure.

MATERIALS AND METHODS

Soils and Manures

Two sieved (2 mm), air-dried Maine soils were utilized for this study:

1) **Newport** (sandy loam, no established soil series designation; coarse-loamy, mixed, frigid, Typic Haplorthod)

2) **Caribou** (sandy loam, fine-loamy, mixed, frigid, Typic Haplorthod)

Selected soil properties

	Sand (%)	pH (1:1)	CEC (Cmol kg^{-1})	P (kg ha^{-1})
Newport	42	5.9	4.6	7
Caribou	51	5.7	7.3	14 .

Poultry manure was collected from a commercial layer hen farm in Central Maine, homogenized, freeze-dried, ground, and stored at -20°C until use. Manure was mixed with pre-incubated bulk soils to provide: **0, 100 or 200 mg manure P kg^{-1} soil** (con, PM100, and PM200). Soil $\pm$ manure (6.5 g DW equivalent) was packed to a density of 1.2 Mg m^{-3} in 50 ml tubes and brought up to 45% gravimetric WFPS and placed at 25°C with aeration every 3 days and WFPS maintained at 45%. Sampling times were 0, 3, 7, 14, 28, 42, 56, 84, and 108 days after incorporation and samples stored at -20°C until analysis.

Sequential extraction

For each sampling period, 1.0 g of soil extracted with 25 ml of deionized H_2O. (22°C, 250 rev min^{-1}) for 1 h. The solution was centrifuged 23,700 x g for 30 min and supernatants passed through a 0.45 µm filter. Using the same procedure, the soil residues were then sequentially extracted by 0.5 M $NaHCO_3$ (pH 8.5), 0.1 M NaOH, and 1.0 M HCl for 16 h each. Extracts were diluted and adjusted to pH 5.0 for enzymatic hydrolysis.

Enzymatic hydrolysis

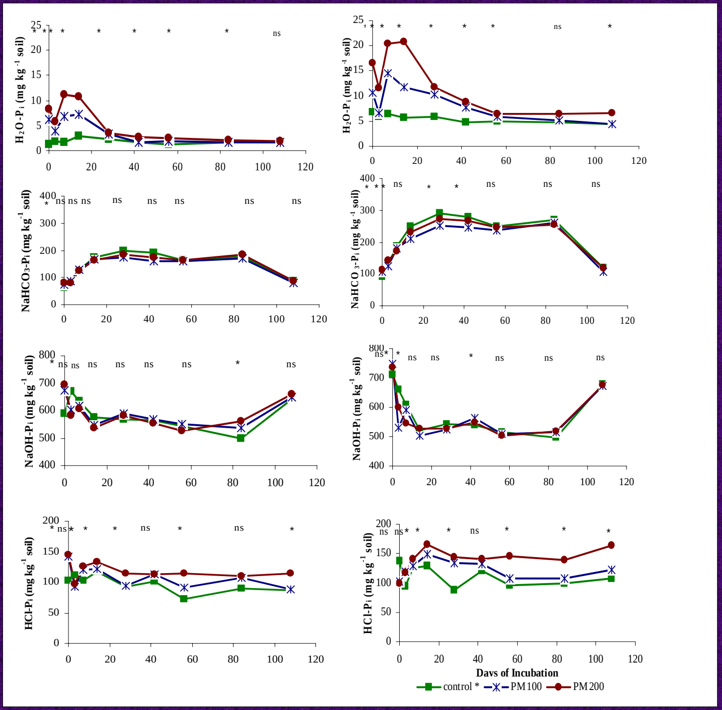
Diluted, pH-adjusted extracts were incubated with 0.25 U each of acid phosphatase (EC 3.1.3.2) type IV-S from potato and 3- phytase from *Aspergillus ficcum* (EC 3.1.3.8) (37°C, 1 h, 250 rev min^{-1}). Controls were included whereby either the enzymes or extracts were omitted.

Phosphorus determination

Inorganic orthophosphate (P_i) was quantified by a modified molybdate blue method. Total P was determined using the same method, following H_2SO_4-potassium persulfate digestion and adjustment to pH 5.0. Organic P (P_o) was estimated as the difference between total P and P_i. The proportion of organic P that was enzymatically hydrolysable (P_{oe}) or nonhydrolysable (P_{ne}) was estimated as the difference between P_i contents in incubation mixtures $\pm$ enzymes. All data are presented as the average of three replicates.

Effect of poultry manure on inorganic P distribution

Newport soil **Caribou soil**



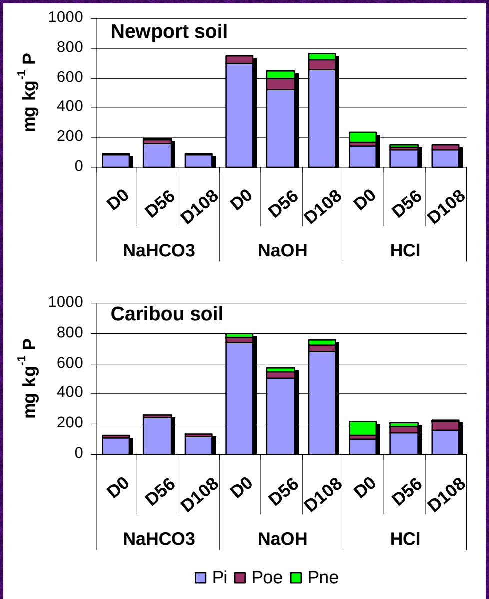
* Indicates significant difference at 0.05 between treatments.

Results and Discussion

Amendment with poultry manure had an overall similar effect in both Newport and Caribou soils, however the intensity was amplified in the coarser Caribou soil. Poultry manure strongly influenced H_2O-P_i at day 0 but this increase was short-term and there was little difference between treatments by day 56. Changes in P forms in $NaHCO_3$ and NaOH extractions were similar for both amended and unamended soils. Concentrations of $NaHCO_3$-P_i increased up to day 108, where a pronounced decrease was observed. Hydroxide-extractable-P_i mirrored $NaHCO_3$-P_i, with an increase of similar magnitude (about 150 mg kg^{-1}) at day 108, implying that a transformation occurred between the two fractions. Transformation of P forms between fractions has been noted previously (He et al., 2004).

Amendment had the greatest overall impact on the HCl fraction, where addition of 200 mg kg^{-1} P increased HCl-P_i in both soils and P_i concentrations remained elevated throughout the incubation.

Overall P distribution with poultry manure amendment (200 mg P/kg)



Examination of the organic P distribution of soils amended with PM200 revealed that the majority of $NaHCO_3$-P_o was hydrolysable in both soils. In Caribou soils, organic P forms in $NaHCO_3$ and NaOH fractions remained relatively stable, while in Newport soils there were changes in both P_{oe} and P_{ne}. The most dynamic change occurred in the organic portion of the HCl fraction. At day 0 there were significant amounts of non-hydrolysable organic P (63 and 92 mg kg^{-1} for Newport and Caribou, respectively) and over the course of the incubation this P either disappeared from the HCl fraction (Newport) or converted to either P_i or hydrolysable organic forms (Caribou).

CONCLUSIONS

- Inorganic P concentration was most affected by manure amendment in the H_2O and HCl fractions
- H_2O-P_i rapidly declined to control levels
- HCl-P_i remained elevated
- Transformations in P forms and fractions occur over time
- The organic component of the HCl fraction represents a significant P source and over time may be converted to more readily available P forms.

REFERENCES

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