EFFECTIVENESS OF RECOVERED MANURE PHOSPHORUS AS PLANT FERTILIZER

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Abstract

Phosphorus (P) was recovered from liquid swine manure and poultry litter using new advanced treatment manure processes developed to recover this nutrient from manure. The high P concentration in the recovered P materials indicates that they likely have use as plant fertilizers. A study was conducted under greenhouse conditions to evaluate the agronomic effectiveness of these materials. Recovered P materials from swine manure (RPSM) and broiler litter (RPPL) were compared to commercial triple super phosphate (TSP) using annual ryegrass as the test crop. Treatments were three fertilizer sources and five fertilizer rates (0, 22, 44, 88, and 176 mg P/kg soil). Plant tissues were harvested three times, oven-dried, and acid digested. Soil collected at the end of the trial was extracted using the Mehlich III procedure. Both plant tissue digest and soil extracts were analyzed for P using colorimetric analysis. Plants fertilized with P recovered from swine manure or broiler litter had biomass production similar to TSP but lower P uptake. Soil P tests indicated lower P concentrations for RPPL than for RPSM or TSP. This lower extractable soil P response of RPPL points to possible use as slow release P fertilizer. Further research under field plot conditions and on various soil types will provide necessary data for fertilizer application recommendation.

Key-words: poultry litter, phosphorus recovery, manure, swine, pig.

Introduction

Land application of excessive amounts of manure is an environmental concern in regions with intense livestock production. This situation promotes soil P saturation with subsequent P runoff and potential pollution of water resources. Therefore, effective P management is required to protect surface waters. The use of alternative animal waste management methods that include P recovery from manure gives the opportunity to resolve excess manure P problems on agricultural lands.

Two new treatment methods have been developed to recover P from manure in concentrated solid form. One of these new methods recovered P from liquid swine manure (Vanotti et al., 2007) while the other new process extracted and recovered P from poultry litter (Szogi et al., 2008). Although much of the literature on recovered P from animal manure has been concerned with their production and potential reuse in agriculture, there are very few reports on agronomic effectiveness of recovered P materials. The objective of this study was to evaluate the agronomic effectiveness of P recovered from liquid swine manure and solid poultry litter in comparison to a commercial P fertilizer.
Materials and Methods

The recovered P material from swine manure was obtained from a full-scale wastewater treatment facility located on a 4360-head finisher swine production unit in Duplin County, NC, USA. The wastewater treatment facility consisted of three consecutive modules. In the first module, the manure solids were mechanically separated from the liquid. In the second module, ammonia contained in the separated liquid was biologically converted to nitrogen (N) gas. In the third and final module, soluble P was recovered as calcium phosphate precipitate by increasing the pH with controlled amounts of hydrated lime (Vanotti et al., 2007). Details of the P extraction process are given in Szogi and Vanotti (2008).

A new treatment process, called “quick wash,” was developed for extraction and recovery of P from manure solids (Szogi et al., 2008). The quick wash process consists of three consecutive steps. In step 1, inorganic and organically bound P in litter is converted to soluble-P by rapid hydrolysis reactions using mineral or organic acids. The washed litter residue is subsequently separated from the liquid extract and dewatered. In step 2, P is precipitated by lime addition to the liquid extract forming a calcium-containing P product. In step 3, a flocculant is added to enhance the P content of the product.

A pot study was conducted with annual ryegrass under greenhouse conditions. The soil used in the pot experiment was a sandy-textured paleudults (Uchee sand) with a P content of 1.7 mg kg⁻¹ and pH of 4.9. The soil was limed to raise the pH to about 6.5 prior starting the experiments. Treatments were three fertilizer sources: recovered P from swine manure (RPSM, 26% P₂O₅), recovered P from poultry litter (RPPL, 11% P₂O₅) and commercial triple super-phosphate (TSP) applied at five fertilizer rates (0, 22, 44, 88, and 176 mg P kg⁻¹ soil). Soil was placed in 15-cm diameter pots and annual ryegrass was planted in each pot. Three harvests of plant shoot tissues (19, 34, and 47 d after planting) were made by cutting plants about 2.5 cm above the soil surface. Plant samples were dried at 60°C and then weighed and ground. After the last cutting, three 2.5-cm soil cores were collected from each pot, air dried, and then ground for P analysis. Ryegrass shoot tissues were acid digested and P determined in the digest by automated ascorbic method. Soil P was extracted using the Mehlich III procedure (Tucker, 1992). Statistical analysis was performed using the GLM procedure of SAS (SAS Institute, Cary, NC). The experimental design was a randomized complete block with four replicates.

Results and Discussion

Plants fertilized with RPSM, RPPL or TSP had greater biomass production than the control (Figura 1). Differences in biomass production were not significant among treatments at the P rates of 22, 44, and 88 mg P pot⁻¹. Phosphorus uptake by ryegrass plants was dependent on fertilizer material and rate of application (Figura 2). At the highest application rate, total P uptake was 38.0 mg pot⁻¹ for TSP, 30.4 mg pot⁻¹ for RPM, and 20.2 mg pot⁻¹ for RPL.

Extractable P was lower for RPPL than for RPSM or TSP at the P rates of 88 and 176 mg kg soil⁻¹ (Figura 3). This lower extractable soil P response of RPPL is likely due to its lower solubility. The solubility of RPPL is probably controlled by both insoluble inorganic and organic P fractions of this material. Since the most soluble of
the three materials is TSP, its high response to Mehlich III soil extractant explains the higher P uptake rates (Figura 2). The intermediate P uptake obtained with RPSM is reflected in higher extractable soil P than RPPL but lower than TSP. Therefore, where more readily available P fertilizer is needed, the RPSM material is a better choice. On the other hand, a less readily available P source, such as the RPPL material, is better suited for applications that may require a slow release P fertilizer. These results suggest that both RPSM and RPPL have potential as a fertilizer source without further chemical processing, such as the acid treatment typically used to process rock phosphate for fertilizer manufacture.

Conclusions

Our experimental results indicate that the two tested P materials recovered from livestock manure may have different uses depending on its origin and solubility. The recovered P materials from liquid swine manure and poultry litter both have the potential as a fertilizer source without further chemical processing into other P materials, such as the acid treatment typically used to process rock phosphate for fertilizer manufacture. Further research under field plot conditions and on various soil types will provide necessary data for fertilizer application recommendation of these two P materials.

References


**Figure 1.** Effect of fertilizer material and P rate on ryegrass biomass. RPSM, phosphorus recovered from swine manure; RPPL, phosphorus recovered from poultry litter; TSP, triple superphosphate. Difference between two means is not significant when the difference is smaller than the least significant difference (LSD$_{0.05} = 0.6$ g pot$^{-1}$).

**Figure 2.** Effect of fertilizer material and application rate on total P uptake by ryegrass. TSP, triple superphosphate; RPSM, phosphorus recovered from swine manure; RPPL, phosphorus recovered from poultry litter. Standard error bars are shown when their size was larger than that of the symbol.

**Figure 3.** Mehlich III extractable phosphorus concentration remaining in the soil after 47 days of ryegrass growth as affected by fertilizer material and application rates. TSP, triple superphosphate; RPSM, phosphorus recovered from swine manure; RPPL, phosphorus recovered from poultry litter. Standard error bars are shown when their size was larger than that of the symbol.