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Full Length Research Paper

Phosphorus release potential of PPB enhanced cattle manure in an incubation system

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Abstract

A study was conducted to determine phosphorus (P) release potential of pelletized phosphate blends (PPB) enhanced cattle manure using incubation for two soils in Zimbabwe. The rate of P mineralization for untreated and PPB treated manures was determined using the Bray 1 method on destructive samples (2 g sub-sample) of the soils collected 3, 7, 14, 28 and 42 days after incubation had commenced. The results of the incubation study showed a significant decrease in the amount of P release into solution for the two soils. Results obtained showed net immobilization for both the PPB treated manures and untreated cattle manure for both Buhera and Marenga soils. This means that both untreated manure and PPB enhanced cattle manures have low agronomic potential to effectively restore P status of the P deficient soils for sound crop production. The study confirmed that if rock phosphate is mixed with cattle manure without composting, there is no improvement in P availability and uptake by maize.

Keywords: Agronomic potential, phosphorus release potential, PPB enhanced manure.

INTRODUCTION

Sustainable crop production can be achieved with the use of fertilizer inputs, which are required to restore, supply and maintain soil fertility on depleted soils (Mugwira and Murwira, 1997). Resource poor farmers of most communal areas (CA) of Zimbabwe cannot afford inorganic fertilizers due to escalating costs and poor availability. They rely on organic inputs such as cattle manure to sustain soil fertility (Mokwunye and Bationo, 2002). Given that mineral fertilizers are expensive and farmers' can secure limited quantities, locally available resources such as manures are potential sources of fertilizer for most smallholder farmers (Blackie, 1994). However, manure availability is scarce due to the crop-livestock farming interactions that occur in most smallholder farming systems of Zimbabwe and if available the quality in most cases is of poor. In cases where organic resources are available they can supply no more than 15 kg N t-1 and 1.5 kg P t-1 (Mapfumo and Giller, 2001) and when applied at common rates of 3-5 t ha-1 dry matter depending on availability and generally supply 45-75 kg N ha-1 and 4.5-7.5 kg P ha-1, against a maize major nutrient requirement of N (200 kg ha-1), P (90 kg ha-1) and K (70 kg ha-1). In such a system, the most limiting nutrient will be P, to sustain grain production (Vanlauwe and Giller, 2006).

The P contents of the manures are insufficient to meet requirements for sustained crop production hence, the need to be enhanced with amendments such as PPB that are cheap and locally available. Pelletization of DPR with SSP is a process that confer *in situ* acidulation of the rock and hence the dissolution of DPR in soil (Menon and Chien, 1990). Mixing the amendment PPB with manure also increases the dissolution potential of DPR due to the weak acids produced by the manure. The rate at which the P appears in solution from PR or PR blends (such as PPB) is one of the factors that may affect the rate at which P is transferred from PR to plant root or to soil solid phase (Akande et al., 2005). Therefore, a study of the kinetic dissolution of PPB enhanced cattle manure in soils is needed in order to understand the solubility behaviour of PR blends in soil and infer their agronomic potential and effectiveness. The value of PPB enhanced cattle manure as a soil P amendment can be determined by laboratory dissolution tests. These laboratory tests can be rapid and can be used as a guide in the selection of the amendment to be used in green house or field tests .The laboratory release potential tests works as the baseline determinants of the potential of the PPB enhanced manures to support crop production.

Several methods have been used to measure the extent of dissolution of PR blends in soils. These methods include the fractionation scheme, Bray P, Olsen P and NaOH-P (Chien and Menon, 1995). However, when slowly water soluble fertilizers modified forms of PR have been used, soil tests using acidic extractants overestimate bio-availability of P, whereas alkaline extractants under-estimate it (Sahrawat et al, 1997). Menon and Chien (1990) found that Mehlich extractant over-estimate available P in soils treated with PR amendments while Bray 1 and Olsen tests gave a better measure of P availability. Basing on this fact, the Bray 1 method (Okalebo et al., 2002) was used in this experiment. The objective of this study was to examine the effect of time of incubation on the release of P from plain and PPB enhanced cattle manure in a closed incubation system.

MATERIALS AND METHODS

Soils and manure materials

Two soils, namely Buhera and Marenga soils were used in this study. Buhera and Marenga sites were used so as to assess the impact of different soil texture and different selected soil chemical properties on the agronomic use of cattle manure enhanced with PPB. Initial soil chemical characteristics of the two soils are shown in Table 2.1 and Table 2.2. The two study sites (Buhera and Marenga) have acid soils with Buhera soils being more acidic (with a pH value of 4.4) compared to Marenga (which had pH of 4.9). At both experimental sites the soils were light textured with loamy sands at Buhera and sandy loams at Marenga. Generally, the selected analysed soil fertility parameters were higher for Marenga compared to Buhera, except for Mg where Buhera had a higher value. Micronutrient levels followed the order Fe>Mn>Zn>Cu (Table 2.2) for the two study sites.

Untreated and PPB enhanced cattle manure collected from the two study sites (Buhera and Marenga) were used in the experiment. Tables 2.2 and 2.3 give a summary of the chemical parameters of the manures used. Nutrient contents of both untreated and PPB enhanced manures of the two study sites are shown in Tables 2.3 and 2.4 respectively. Total P values were higher in PPB enhanced manure (0.143 and 0.155 % for Buhera and Marenga sites respectively) compared to plain manures (0.063 and 0.059 ppm) of the two sites. Generally nutrient status of PPB enhanced manures was higher compared to the untreated manures for the two experimental sites (Tables 2.3 and 2.4). The nutrient levels of both manure types followed the order of Ca, K and Mg in descending quantities for both (Buhera and Marenga) sites.

Incubation procedure

Duplicate 200 g of soil samples from Buhera and Marenga study sites were wetted at field capacity for three days before the incubation experiment commenced. This was done to ensure adequate mixing of the manure treatments and the soil later in the experiment. Untreated manure and PPB enhanced cattle manure at a rate of 10 tonnes per hectare were taken as treatments in this study. A mixture of 0.6 g manure amendment (either untreated manure or PPB enhanced cattle manure) and 200 g soil was put in petri dishes. The petri dishes were put in one litre jars and incubated at 28 ^{0}C in the constant temperature room. Treatments were run in triplicate in a completely randomised design. Samples with no manure added were included as controls. The water content was maintained at field capacity by weekly adjustments for all the treatments. Duplicate 2 g of sub-samples for all the treatments were taken at 3, 7, 14, 28 and 42 days after the incubation commenced to determine Bray 1 P.

Soil available P

Available P was determined using the Bray 1 method (0,025 M HCl and 0.03 M NH_4F) as described by Anderson and Ingram (1996). 2 g of air-dried soil was weighed into a plastic container. To this 25 ml of Bray 1 extracting solution was added. The mixture was shaken for 30 minutes on a mechanical shaker. The suspension was filtered through Whatman No. 42 filter paper. The filtrate collected was used for colorimetric determination of P. 10 ml of sample filtrates were pipetted into 50 ml volumetric flasks. To each flask, 5ml of 0.8 M boric acid was added. Ten ml of ascorbic acid-molybdate solution was added. The flasks were filled to the mark with distilled water. They were shaken and left for an hour. When a phosphorus-molybdate blue complex had formed, the absorbances of the solutions were measured at 880 nm wavelength using AAS (Okalebo *et al*., 2002).

Statistical analysis

ANOVAS were performed on data on inorganic P over time using Genstat software. Comparisons of treatment means were declared as significantly different at $P<0.05$.

Table 2.1. Initial soil chemical properties of the experimental sites

Site	Texture	pH ($CaCl_2$)	OC (%)	Avail P (%)	N (%)	Ca (me%)	Mg (me%)	K (me%)
Buhera	Loamy Sand	4.4	0.28	0.007	0.03	0.62	0.18	0.12
Marenga	Sandy Loam	4.9	0.34	0.012	0.05	0.67	0.16	0.14

Table 2:2. Soil micronutrient status of Buhera and Marenga study sites soils.

Site	Fe (ppm)	Zn (ppm)	Cu (ppm)	Mn (ppm)
Buhera	35	8	4	28
Marenga	42	12	7	23

Table 2:3. Nutrient contents of untreated cattle manure for Buhera and Marenga

Site	N (%)	P (%)	K (me%)	Ca (me%)	Mg (me%)	Zn (ppm)	Cu (ppm)
Buhera	0.69	0.063	0.80	1.18	0.14	30	17
Marenga	0.72	0.059	0.77	1.23	0.12	23	14

RESULTS

Phosphorus mineralization patterns of untreated and PPB enhanced manures

The general patterns of P mineralization for the untreated and PPB enhanced cattle manure treatments for Buhera village soils showed a downward trend (Figure 3.1). Manure amended with PPB and untreated cattle manures immobilized P up to 7 days after incubation (DAI); followed by a temporary P mineralization at 14 DAI; then immobilization up to 28 DAI for PPB enhanced manure; whilst up to 42 DAI for untreated manure (Figure 3.1). At 42 DAI manures enhanced with PPB showed slight P mineralization. At the end of the incubation period manure treated with PPB had higher P compared to untreated manure.

Generally the amendments, untreated manure and PPB enhanced cattle manure showed a decline in P concentration from 3 DAI up to 42 DAI for Marenga soil experiments (Figure 3.2). Manure treated with PPB immobilized from 3 DAI up to 42 DAI. Untreated cattle manure showed a temporary mineralization from 3 to 7 DAI, which was followed by immobilization. The control mineralized up to 14 DAI; then P immobilization occurred throughout up to 42 DAI (Figure 3.2). At the end of the incubation experiment P status of untreated cattle manure was higher compared to PPB enhanced cattle manure, with the control having the least P status.

DISCUSSION

Untreated manures and PPB enhanced cattle manures, which had a total P content of less than 0.2 % (Tables 2.3 and 2.4) showed immobilization for the two study sites (Figures 2.1 and 2.2). Floate (1970) noted that organic materials with total P less than 0.2 % show little or no P mineralization. The results seemed to agree with those of Mafongoya *et al* (2000) who found that manures with P content greater than 0.2 % showed net P mineralization compared to leaves that had a total P content less than 0.2 %, which showed prolonged P immobilization. Floate (1960) also showed that P mineralization was correlated with the initial P content of the organic materials. A similar trend was observed in a study by Nguluu *et al* (1996) who concluded that differences in P mineralization in different manures could be partly explained by the soluble P contents. Manures with high soluble P contents mineralize more compared to manures with less soluble P contents that show immobilization or reduced mineralization.

The results obtained in the study showed that the both untreated and PPB enhanced cattle manure treatments used are of low quality, as shown by P immobilization (Figure 2.1 and 2.2). Phosphorus mineralization or immobilization of plant residues or manures depends on the organic P content of the material (Mafongoya et al., 2000). The quality of organic amendment influences the

Table 2:4. Nutrient status of PPB enhanced manure for Buhera and Marenga

Site	N (%)	P (%)	K (me%)	Ca (me%)	Mg (me%)	Zn (ppm)	Cu (ppm)
Buhera	0.78	0.143	0.92	1.24	0.17	37	12
Marenga	0.75	0.155	0.97	1.35	0.15	32	11

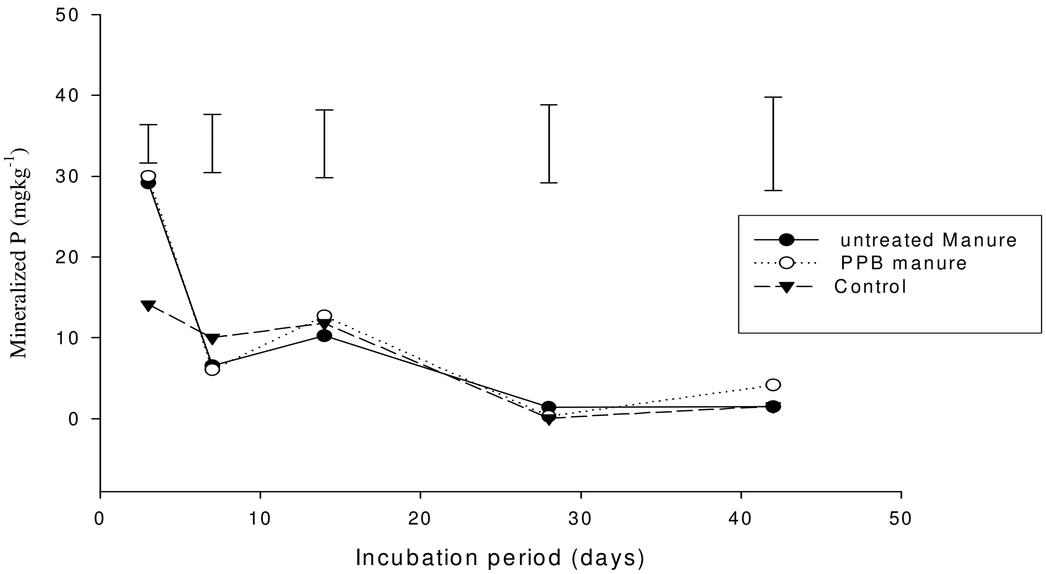

Figure 3:1. Phosphorus mineralization patterns of untreated and PPB treated manures for Buhera soils.

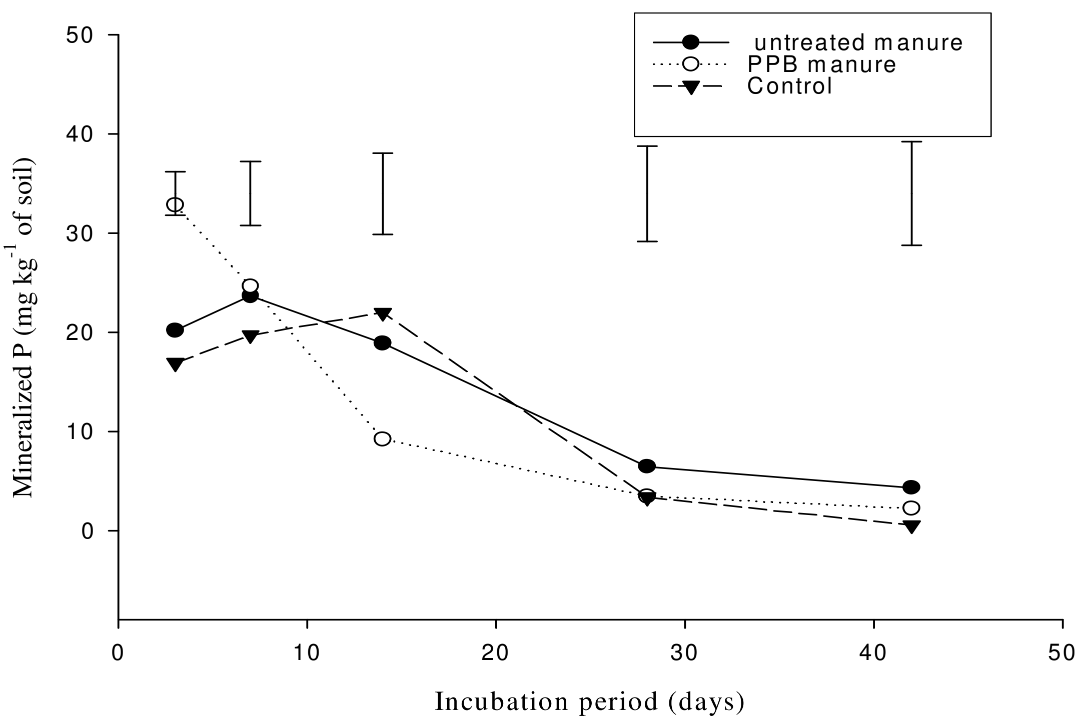

Figure 3:2. Phosphorus mineralization patterns of untreated and PPB treated manures for Marenga soils.

rate of their decomposition and nutrient release. High quality material release nutrients rapidly whilst low quality amendments initially immobilize nutrients, which are later mineralized and made available to crops (Myers et al., 1997). Both untreated and PPB enhanced cattle manure immobilized P for the 56 days in incubation, meaning are of no use in P restoration to the soil on short-term basis. Therefore the PPB enhancement strategy under incubation studies has proved to be of no agronomic use in providing P to the depleted soils of Buhera and Marenga.

CONCLUSION

The value of DPR amendment (PPB) mixed with cattle manure was investigated through dissolution tests under a closed incubation system. Results obtained showed net immobilization for both the PPB treated manures and untreated cattle manure for both Buhera and Marenga soils. This means that both untreated manure and PPB enhanced cattle manures have low agronomic potential to effectively restore P status of the P deficient soils for sound crop production. Therefore time of incubation has a net P immobilization effect on both untreated and PPB treated cattle manure as was shown by this experiment.

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