The effect of a microbial inoculant on release of phosphorus from different organic amendments in an ultisol

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ABSTRACT

The availability of phosphorus (P) in acid soils is comparatively less compared to other macro-nutrients. However, to obtain high crop yields on acid soils high amount of P is required. Thus, it is vital to determine the influence of different kinds of organic amendments on phosphorus (P) availability in acid soils. The major objective of this study was to quantify the P availability in presence of different organic amendments with or without a microbial inoculant in an acidic Ultisol. The soil samples were obtained from a forested area dominated by Mahogany trees (*Swietenia macrophylla*) in the Faculty of Agriculture, University of Ruhuna. The soil samples werepre-incubated for two weeks prior to the introduction of treatments. Eight treatments were arranged in a Completely Randomized Design with four replicates: (i) soil + 10 T/ha level of compost (SC), (ii) soil + 10 T/ha level of compost + 500 L/ha level of inoculants (SCI), (iii) soil + 5 T/ha level of green manure (SG) (iv) 5 T/ha level of green manure + 500 L/ha level of inoculants (SGI), (v) soil + 100kg/ha Urea (SU) (vi) 100kg/ha Urea+ 500 L/ha level of inoculants (SUI) (vii) soil + 500 L/ha level of inoculants (SI) (viii) control soil (S). The P availability was assessed using Olsen method at the end of the incubation experiment conducted for 51 days. Results revealed that the soils amended with compost and microbial inoculum caused the highest P availability. Further, the magnitude of the response to amendments varied with the type of the soil amendments and the inclusion of microbial inoculant. When the initial P level is low in soil, the organic amendments and microbial inoculum was sufficient to increase the available P satisfactorily. However, it is important to study further on different rates of amendments and microbial inoculum to understand the dynamics of P release in soils.

Keywords: Acidic soils, Microbial inoculum, Organic amendments, Phosphorus, Ultisols

Introduction

The soil available P is influenced by several factors such as, pH, exchangeable and soluble Al, Fe, Ca and soil organic matter (Smithson, 1999). In highly weathered acid soils, the anionic form of phosphate is tightly bonded to soil particles decreasing the plant available phosphorous. According to Brady and Weli (2002), the phosphorus concentration is lower than other macro nutrients in soil solution. According to several studies (Easterwood & Sartain, 1990) incorporation of organic amendments to soil can increase the available P to absorb by plants. Further, Haynes and Mokolobe (2001) showed that the application of organic amendments to the acid soils will improve the P availability in soil. Iyamuremye *et al.* (1996) showed that the incorporation of animal manure has reduced the P adsorption capacity or the increment in P availability in soil. The reason for this is that the P adsorption sites are replaced by the organic residues which are released by the organic amendments. During this process the pH will increase due to the reaction by micro-organisms. Further, the incorporation of microbial inoculum increases the P availability in soil. The microbial inoculum is a type of biodynamic formulation which accelerate the decomposition and introduce higher beneficial bacteria and fungi to the soil. Veeresh *et al.* (2010) has mentioned that the microbial inoculum called "jeevamrutha" has P solubilizing bacteria like *Pseudomonas*.

Therefore, the organic amendments with microbial inoculum could be used as a strategic tool to increase the P availability in acidic P fixing soils. The main objective of the current study was to quantify the P availability in presence of different organic amendments with or without a microbial inoculants in an acidic Ultisols.

Material and Methods

The P availability was determined in an incubation experiment conducted for 51 days in the laboratory of Department of Soil Science, Faculty of Agriculture, University of Ruhuna. The soil samples classified as Ultisols (Mapa *et al.*, 1999) were obtained from a forested area dominated by Mahogany trees (*Swietenia macrophylla*) in the Faculty of Agriculture, University of Ruhuna and pre-incubated for two weeks prior to the introduction of treatments. Eight treatments were arranged in Completely Randomized Design with four replicates: (i) soil + 10 T/ha level of compost (SC), (ii) soil + 10 T/ha level of compost + 500 L/ha level of inoculants (SCI), (iii) soil + 5 T/ha level of green manure (SG) (iv) 5 T/ha level of green manure + 500 L/ha level of inoculants (SGI), (v) soil + 100kg/ha Urea (SU) (vi) 100kg/ha Urea+ 500 L/ha level of inoculants (SUI) (vii) soil + 500 L/ha level of inoculants (SI) (viii) control soil (S). Each amendment was uniformly incorporated with 100g of soil in glass bottle. The moisture content (MC) of all the treated soils were brought to 60% of the field capacity by adding distilled water and adjusted weekly by measuring the weight of the bottles throughout the experiment. The microbial inoculum was prepared using a mixture of fresh cow dung, cow urine, brown sugar, surface soil and water and by keeping it under aerobic conditions for 10 days (Veeresh *et al.*, 2010). The application rate of the inoculum was taken as 500 L/ha after diluting in 1 in 20 parts of water. The treated bottles with four replicates were incubated for 51 days as a batch experiment. Sampling was done on days 2, 5, 7, 14, 21, 28, 36, 44, and 51 to analyze the P availability using the Olsen method (Iatrou *et al.*, 2014). The SPSS version 20 package was used for the statistical analysis.

Results and Discussion

According to the results, the magnitude of the response in different amendments in terms of P release varied with the nature of amendments used. Palm *et al.* (1988) realized that the green manure releases very low amount of P and the present study results was similar to this finding as the *Gliricidia* showed the lowest available P contribution as an organic amendment. At the initial stage, each treatment showed the highest availability of P and then drastically decreased in the day five (Figure 1). This may be due to the increased microbial activity as microorganisms temporarily immobilize P in their biomass. After the day five, P availability has increased again as the organic matter contributes to P availability in soil by several mechanisms. The organic matter coated by Al and Fe oxides will displace sorbed phosphate and thus the P in soil solution will increase accordingly. Organic anions also displace sorbed phosphate. Finally, organic matter itself is a source of P through mineralization reactions. According to the results, the P availability was highest in the soil treated with compost and the microbial inoculum and the soil and compost treated soil showed the next highest P availability. The results revealed that the soil with compost and inoculum has greater contribution to the available P in soil. The highest amount of P was available in compost having 0.6 %. According to the statistical analysis, there is a significant variation ($p < 0.05$) between all the treatments without inoculum and with inoculum.

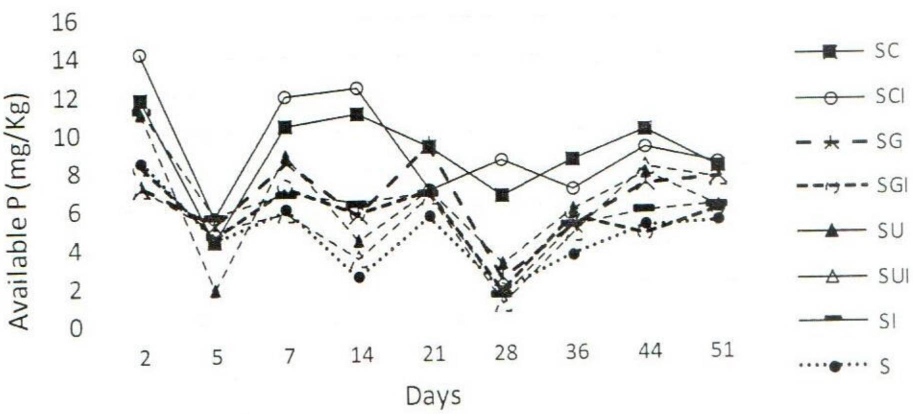

Figure 1: Phosphorous availability in different soil treatments

When considering the pH level of the soil, the acidic soils have grater P sorption capacities. As such, the highly weathered acidic Ultisols have large amount of aluminium and iron oxides and highly weathered kaolin clays. Therefore, in soils with low pH forms very strong bonds with phosphate. In fact, a soil binds twice the amount of phosphorus under acidic conditions, and these bonds are five times stronger. The study shows that the pH has increased slightly near to the neutrality after adding organic amendments (Figure 2). Further, according to statistical analysis P availability and pH pattern showed a significant association ($p<0.05$) in soil with compost and inoculum.

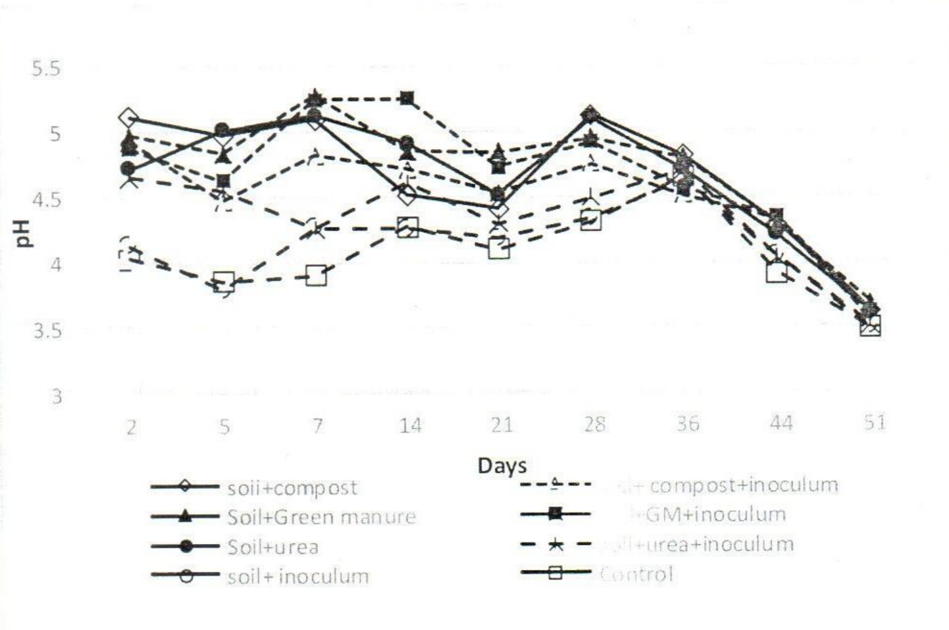

Figure 2: pH of the soils amended with organic amendments and bio fertilizer

Conclusions

The results indicate that in short term, organic amendments with microbial inoculum can increase the soil pH and the available P in acid soils. This result was acceptable as the organic amendments increased soil pH, and, at the same time, they reduced exchangeable acidity, exchangeable Al, and exchangeable Fe. As the soil pH increased, the organic amendments effectively fixed Al and Fe instead of P. The findings suggest that the organic amendments altered soil chemical properties in a way that enhanced the availability of P in this study. Further, the magnitude of the response to amendments varied with the type of the soil amendments and on the inclusion of bio fertilizer. The highest P availability was given by the compost and inoculum amended soil. However, this study indicate that legume leaves are not suitable as a P source. Further, the study reveals that adding microbial inoculum to the soil will increase the P level in soil. As the C:P ratio determines the net mineralization or net immobilization, it is better to study on C:P ratio in future studies based on organic amendments in acid soils. Furthermore, it is important to study further on different rates of amendments and bio fertilizer to understand the dynamics of P release in soils.

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