Transformation of added phosphorus to acid upland soils with different soil properties in Indonesia

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Abstract

The transformation of added phosphorus (P) to soil and the effect of soil properties on P transformations were investigated for 15 acid upland soils with different physicochemical properties from Indonesia. Based on oxide-related factor scores (aluminum (Al) plus 1/2 iron (Fe) (by ammonium oxalate), crystalline Al and Fe oxides, cation exchange capacity, and clay content) obtained from previous principal component analyses, soils were divided into two groups, namely Group 1 for soils with positive factor scores and Group 2 for those with negative factor scores. The amounts of soil P in different fractions were determined by: (i) resin strip in bicarbonate form in 30 mL distilled water followed by extraction with 0.5 mol L^{-1} HCl (resin-P inorganic (P_i) that is readily available to plant), (ii) 0.5 mol L^{-1} $NaHCO_3$ extracting P_i and P organic (P_o) (P which is strongly related to P uptake by plants and microbes and bound to mineral surface or precipitated Ca-P and Mg forms), (iii) 0.1 mol L^{-1} NaOH extracting P_i and P_o (P which is more strongly held by chemisorption to Fe and Al components of soil surface) and (iv) 1 mol L^{-1} HCl extracting P_i (Ca-P of low solubility). The transformation of added P (300 mg P kg^{-1}) into other fractions was studied by the recovery of P fractions after 1, 7, 30, and 90 d incubation. After 90 d incubation, most of the added P was transformed into NaOH-P_i fraction for soils of Group 1, while for soils of Group 2, it was transformed into resin-P_i, $NaHCO_3$-P_i and NaOH-P_i fractions in comparable amounts. The equilibrium of added P transformation was reached in 30 d incubation for soils of Group 1, while for soils of Group 2 it needed a longer time. Oxide-related factor scores were positively correlated with the rate constant (k) of P transformation and the recovery of NaOH-P_i. Additionally, not only the amount of but also the type (kaolinitic) of clay were positively correlated with the k value and P accumulation into NaOH-P_i. Soils developed from andesite and volcanic ash exhibited significantly higher NaOH-P_i than soils developed from granite, volcanic sediments and sedimentary rocks. Soil properties summarized as oxides-related factor, parent material, and clay mineralogy were concluded very important in assessing P transformation and P accumulation in acid upland soils in Indonesia.

Keywords

acid upland soils • Indonesia • phosphorus • soil properties • transformation

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