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Land-use intensification impact on phosphorus fractions in highly weathered tropical soils

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Deforestation and land-use intensification in tropics have increased over the past decades, driven by the demand for agricultural products. Despite the fact that phosphorus (P) is one of the main limiting nutrients for agricultural productivity in the tropics, the effect of land-use intensification on P availability remains unclear. The objective was to assess the impacts of land-use intensification on soil inorganic and organic P fractions of different availability (Hedley sequential fractionation) and P stocks in highly weathered tropical soils. We compared the P availability under extensive land-use (rubber agroforest) and intensive land-use with moderate fertilization (rubber monoculture plantations) or high fertilization (oil palm monoculture plantations) in Indonesia. The phosphorus stock was dominated by inorganic forms (60 to 85%) in all land-use types. Fertilizer application increased easily-available inorganic P (i.e. H_2O-Pi, $NaHCO_3$-Pi) in intensive rubber and oil palm plantations compared to agroforest. However, the easily-available organic P ($NaHCO_3$-extractable Po) was reduced by half under oil palm and rubber. The decrease of moderately available and non-available P by land-use intensification means that fertilization maintains only short-term soil fertility that is not sustainable in the long run due to the depletion of P reserves. The mechanisms of this P reserve depletion are: soil erosion (here assessed by C/P ratio), mineralization of soil organic matter (SOM) and export of P with yield products. Easily-available P fractions (i.e. H_2O-Pi, $NaHCO_3$-Pi and Po) and total organic P were strongly positively correlated with carbon content suggesting that SOM plays a critical role in maintaining P availability. Therefore, the ecologically based management is necessary in mitigating SOM losses to increase the sustainability of agricultural production in P limited highly weathered tropical soils.