Acidification Mechanism of Tropical Forest Soils and its Application to Fertility Management

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Soil acidification is one of land degradation issues that limit crop productivity in humid tropics, whilst acidification is an essential process that promotes weathering (pedogenesis) and nutrient supply to plants. To clarify complex linkage between soil acidity and productivity in tropical ecosystems, (1) proton budgets in soils were quantified to identify the major proton-generating and -consuming processes. Then, (2) the effects of acidification on nutrient cycling were studied in relation to tree root and soil microbial activities. Finally, (3) the effects of land-use change on acidification and neutralization were evaluated in tropical cropland soils to develop low-cost fertility management that can mitigate soil acidification.

(1) Contribution of plants and microorganisms to soil acidification: Proton budgets have been quantified for ion fluxes associated with plant uptake and solute leaching in plant-soil systems. Proton budgets showed that plants and microorganisms promote acidification to acquire bases, even in highly acidic tropical soils in Indonesia. The nitric and organic acids can contribute to mobilization of basic cations and their uptake by plants. The differences in soil sensitivity to acid load between glacial till-derived soils, tropical soils, and volcanic soils can be quantitatively explained based on acid neutralizing capacities and proton budgets in the soils.

(2) Soil acidification and adaption of plants and microorganisms: Acidification can generally limit tree root and microbial activities, but the specific tree roots and rhizosphere microorganisms can release low-molecular-weight organic acids (e.g. citrate and malate) to solubilize non-labile phosphorus. Solubilization of lignin-rich organic matter, which generally retards nutrient cycling, can also be enhanced in acidic organic layers by fungal peroxidases. The large fluxes of dissolved organic matters from the acidic organic layers can function in mobilization of bases without increasing leaching loss. This contrasts with the well-known acidification process via bicarbonate in the moderately acidic tropical soils.

(3) Forest organic matters can neutralize acidity in tropical cropland soils: Conversion of forest to continuous cropping accelerated soil acidification through nitrification and product removal. Most of the acidity can be neutralized by mineralization of organic anions associated with loss of soil organic matter. Acid neutralization capacity depends on stocks of soil organic matter accumulated in fallow periods. Proton budgets in the soils under different land use in Indonesia suggested that the long-term forest fallow (aroma oil production) or short-term *Imperata* grass fallow (healthy herb production) in land-use schemes can increase organic matter stocks and ameliorate soil acidification without decreasing farmers' benefits.

References

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