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Humic acid and gypsum affect phosphorus speciation and rice yield in an acidic paddy soil

Hartina[1], Tidarat Monkham[2], Worachart Wisawapipat[1], Patma Vityakon[1], Tanabhat-Sakorn Sukitprapanon[1]

[1] *Khon Kaen University, Soil Science and Environment, Thailand*
[2] *Khon Kaen University, Dept. of Agronomy, Thailand*

Abstract

Acidic paddy soils frequently exhibit low fertility because phosphorus (P) availability is restricted by fixation of aluminum and iron (hydr)oxides. Additionally, the essential element calcium (Ca) is low. While applying soil amendments such as humic acid (HA) and flue gas desulfurisation gypsum (FG) could address both P and Ca deficiencies, the effects of HA, FG, and their combination on phosphorus speciation and subsequent rice production in an acidic paddy soil remain poorly understood. This study employed X-ray absorption near edge structure (XANES) spectroscopy to quantify P speciation in an Aeric Kandiaquult under four different soil managements, including chemical fertiliser (CF) (1), HA (2), FG (3), and coapplication of HA and FG (4). The CF was applied pertaining to local farmer practices at rate of 75, 38 and 38 kg ha^{-1} for N, P_2O_5 and K_2O, respectively. The HA was applied at the optimum rate for rice cultivation in acidic paddy soil of Thailand (975 kg ha^{-1}), while FG was applied at rate of 636 kg ha^{-1}, based on the gypsum requirement for high-acidity soil. Findings of this study revealed that HA application maximised rice yield by enhancing P cycling, especially labile P. In addition, HA increased the proportion of archerite (KH2PO4). In contrast, either FG alone or combined with HA suppressed yield, as they induced the formation of stable brushite ($CaHPO4 \cdot 2(H_2O)$) mineral. Furthermore, the HA+FG application promoted the formation of non-labile P forms, including inositol hexakisphosphate and strengite ($FePO4 \cdot 2H_2O$). This result suggested that the sole application of HA is an effective approach for acidic paddy soil to enhance P availability and rice yield.

Keywords: Phosphorus cycling, soil amendment, tropical region, Ultisol, XANES

Contact Address: Tanabhat-Sakorn Sukitprapanon, Khon Kaen University, Soil Science and Environment, 40002 Khon Kaen, Thailand, e-mail: tanasuk@kku.ac.th