RESCON 2025 EES 14

OXALIC ACID-MODIFIED ROCK PHOSPHATE AS A SUSTAINABLE PHOSPHORUS FERTILIZER: ENHANCEMENT OF PHOSPHORUS SOLUBILITY AND CONTROLLED RELEASE BEHAVIOR

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Eppawala Rock Phosphate (ERP), is a locally available but sparingly soluble phosphate source in Sri Lanka. It has limited applications in neutral to alkaline soils due to its low solubility. While organic acid treatments, such as with oxalic acid, have been explored to improve phosphorus release, the combined effect of oxalic acid treatment with mechanochemical grinding on ERP solubility remains underexplored, marking a key research gap. This study investigated the modification of ERP by varying ERP: oxalic acid (OA) ratio (0.2:1.0 to 1.2:1.0), with a focus on enhancing phosphorus availability through mechanochemical grinding, a process that promotes solid-state reactions of ERP and oxalic acid. The objective was to assess the phosphorus, iron, and aluminium releasing ability of the modified ERP (OA-ERP) in both aqueous and soil systems, comparing it with unmodified ERP and triple superphosphate (TSP) as controls. The OA-ERP at a 1.2:1.0 ratio released 99.9% of its phosphorus, exceeding TSP's 82.9% release. Investigation of kinetics revealed a zero-order release pattern for OA-ERP (1.2:1.0), indicating a surface-controlled release mechanism. OA-ERP (0.9:1.0) followed pseudo-first order kinetics, indicating diffusion-limited release. Iron release was highest in OA-ERP (1.2:1.0) (19.99 mg g^{-1}), compared to TSP (0.58 mg g^{-1}), facilitated by oxalate-induced surface activation and complexation. The release of Al was minimal and stabilised over time due to strong oxalate complexation. In soil, TSP released phosphorus quickly, showing a rapid spike early on, but its cumulative release remained relatively low over time, reaching only about 13.6% of the applied phosphorus by the 50th day. In contrast, OA-ERP treatments demonstrated more sustained phosphorus release with OA-ERP (1:1) and OA-ERP (1.2:1.0) treatments releasing 22.3% and 28.8%, respectively. These findings demonstrate that mechanochemical grinding combined with oxalic acid treatment significantly enhances ERP's fertilizer potential, positioning OA-ERP as a controlled-release, eco-friendly alternative for improving phosphorus use efficiency in sustainable agriculture.

Financial assistance from University of Sri Jayewardenepura, Sri Lanka (Grant No. RC/URG/SCI/2024/12) is acknowledged.

Keywords: Eppawala rock phosphate, Oxalic acid, Phosphorus availability, Soil incubation, Sustainable fertilizer