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Integrated Nutrient Strategies for Enhancing Soil Health and Sustainable Phosphorus Management in Rice-Based Cropping Systems

Vaishali Singh[1], U.P. Shahi[1], Omkar Singh[1*], Shivangi[2], Chandrakant Chaubey[2]

[1] Department of Soil Science, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, U.P., India

[2] SMS, Agronomy, KVK Bijnor, India

ABSTRACT

Sustaining productivity in intensive agroecosystems such as the rice-wheat system (9.2 mha in India) requires strategies that enhance nutrient use efficiency while preserving soil health. Phosphorus (P), the second most limiting nutrient after nitrogen, is particularly challenging due to its low bioavailability (<1%) despite high total soil P concentrations (200-3,000 mg kg^{-1}), largely due to fixation with Fe, Al, and Ca under variable redox conditions (Richardson, 2005; Santos *et al*., 2018). Integrated nutrient management (INM), combining mineral fertilizers (NPK) with farmyard manure (FYM), has been shown to enhance P dynamics. Long-term studies indicate that INM increases Fe-bound inorganic P and labile P pools compared to sole NPK application (Bhattacharyya *et al*., 2015). Additionally, FYM with rock phosphate promotes the accumulation of inorganic and NaOH-extractable organic P through enhanced microbial and enzymatic activity (Prakash *et al*., 2022). These improvements in P fractionation and transformation under INM contribute to greater P use efficiency, improved soil biological function, and sustained productivity. Thus, INM supports resilient agroecosystems aligned with Sustainable Development Goals-SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 15 (Life on Land) by minimizing environmental degradation and enhancing long-term soil fertility.

Keywords: integrated nutrient management, SDGs, phosphorus fractions, cropping system

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[*]Corresponding Author:

Omkar Singh, Department of Soil Science, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, U.P., India.
Email: singhomkar.agri@gmail.com