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Yield Gaps, P and K Balances and Soil Changes in Irrigated, Rice-Based Cropping Systems on Degraded Soils in the Red River Delta of Viet Nam

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Abstract

Alerted by reports about stagnating or even declining yields in rice-based cropping systems across Asia, we analysed yield gaps, P and K balances and soil nutrient changes in a continuous cropping experiment on a low-fertile Acrisol in the Red River Delta of Viet Nam. The trial included three cropping systems (rice—soybean—rice, soybean—rice—maize, and rice—rice—maize) and 7 treatments comprised of various combinations of N, P and K and farmyard manure (FYM). The application of recommended NPK fertiliser rates resulted in average yield levels of 3.8 Mg ha^{-1} for rice and maize, and 1.2 Mg ha^{-1} for soybean. The complementary application of 10 t FYM ha^{-1} yr^{-1} increased average yields by about 11 % in rice and 22 % in upland crops and maintained the soil carbon content that largely governs cation exchange processes in degraded soils with low clay content. In nutrient omission plots, soil reserves were quickly depleted, irrespective of the cropping system.

The annual P balance was positive (21 to 55 kg P ha^{-1} yr^{-1}) in all cropping systems with recommended fertiliser application rates. The omission of P resulted in negative overall balances of -29 to -35 kg P ha^{-1} yr^{-1} and Olsen P soil contents declined by 32 to 55 % over the 6-yr experimental period. The soil exchangeable K on the other hand declined from initially 0.22 to 0.02 cmol kg^{-1} within the same period. Despite annual K balances ranging from -39 to 37 kg K ha^{-1} yr^{-1}, soil exchangeable K declined by 63 to 81 % in the NPK treatment. This strong K limitation resulted in yield gaps that ranged from 1.2 to 2.2 Mg ha^{-1} in rice depending on season, while it averaged 0.9 Mg ha^{-1} in soybean and 3.4 Mg ha^{-1} in maize. We conclude that K is the nutrient element most limiting continuous crop production in the intensively used systems on degraded soils in the Red River Delta. Apart from K, the application of farmyard manure and secondary nutrient elements (Mg, Zn) is seen to be required for sustained yield levels and a balanced nutrient supply in the long term.

Keywords: Acrisol, *Glycine max*, long-term experiment, *Oryza sativa*, *Zea mays*

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