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

FRANK MUSSGNUG¹, MATHIAS BECKER¹, TRAN THUC SON², ROLAND BURESHE³, PAUL L. G. VLEK⁴

¹University of Bonn, Plant Nutrition in the Tropics and Subtropics, Germany
²National Institute for Soils and Fertilizers, Viet Nam
³International Rice Research Institute (IRRI), Crop, Soils and Water Sciences Division, Philippines
⁴ZEF - Centre for Development Research, University of Bonn, Germany

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

Contact Address: Frank Mussgnug, University of Bonn, Plant Nutrition in the Tropics and Subtropics, Karlrobert-Kreiten-Straße 13, 53115 Bonn, Germany, e-mail: f.mussgnug@uni-bonn.de