



Effects of fertilization on productivity and nitrogen budget in a long-term rice-rice-fallow cropping system

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Rice productivity and nitrogen (N) budget were investigated in a 16-year field fertilization experiment of rice-rice-fallow cropping system in subtropical China. The treatments included no fertilizer control (CK), mineral fertilizers: N, NP and NPK, and the combination of mineral and organic fertilizers (OF): N+OF, NP+OF and NPK+OF. Straw, green manure, and pig manure were returned as organic fertilizer. After harvest, rice straw was dispersed evenly on the fields. A Chinese milk vetch (*Astragalus sinicus* L.) was cultivated in the fallow season. Half of the plump grains and all the blighted grains from each treatment were ground for pig feeding. Pig manure from each treatment was equally applied to the fields as basal fertilizer for early-rice. The mineral N application rate was $220\text{kg ha}^{-1}\text{year}^{-1}$ for all the treatments, whereas N inputs coming from organic fertilizers were 120, 140, and $150\text{kg ha}^{-1}\text{year}^{-1}$ for N+OF, NP+OF, and NPK+OF, respectively. Rice yield without fertilization was 5.7 Mg ha^{-1} and increased by 13.1%, 64.2%, 40.7%, 65.2%, 60.5%, and 75.9% after N, N+OF, NP, NP+OF, NPK, and NPK+OF fertilization, respectively. The nitrogen use efficiency (NUE) increased during the 16 years for all the fertilization treatments except that with solely N addition. The NUE was 22.1%, 33.1%, and 41.1% for N, NP, and NPK, and increased to 37.1%, 38.5%, and 42.4%, respectively, after organic fertilizer additions. The N residue ratio was 38.9%, 37.2%, 48.0%, 38.4%, 41.0%, and 35.9% for N, N+OF, NP, NP+OF, NPK, and NPK+OF, respectively. The corresponding net N loss ratio was 39.5%, 26.5%, 19.6%, 23.9%, 18.7%, and 22.5%, respectively. Compared with NPK, imbalanced mineral fertilization decreased rice yield and the NUE, and increased nitrogen losses. These negative effects, however, are alleviated by organic fertilizers. We concluded that NPK+OF is the best fertilization in consideration of rice production, N budget and decrease of environmental pollution.