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Manure incorporation reduces environmental nitrogen loss while sustaining crop productivity in the subtropical wheat-maize rotation system: A comprehensive study of nitrogen cycling and balance

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Balancing nitrogen (N) budgets of agricultural systems is essential for sustaining yields at lower environmental costs. The knowledge, however, of total N budgets of agricultural systems including all N fluxes is still rare in the literature. Here, we applied a combination of monitoring in situ N fluxes and field ^{15}N tracer and ^{15}N isotope dilution techniques to investigate the effects of different N fertilizers (control, synthetic fertilizer, 60% synthetic fertilizer N plus 40% pig manure N, pig manure only applied at the same N rate 280 kg N ha^{-1} yr^{-1}) on N pools, cycling processes, fluxes and total N balances in a subtropical wheat-maize rotation system of China. Nitrate leaching and NH_3 volatilization were main hydrological and gaseous N loss pathways, respectively. The warm and wet maize season was associated with significantly larger environmental N losses than the cooler and drier wheat season. The field ^{15}N tracing experiment showed that the wheat system had high N retention capacity ($\sim$50% of ^{15}N application) but with short residence time. I.e. 90% of soil residual ^{15}N labelled fertilizer in the wheat system were utilized by plants or lost to the environment in the subsequent maize season. Our annual total N balances of the different treatments revealed that combined synthetic and organic fertilization or manure only maintained the same level of yields and led to significantly lower N losses and higher N retention, even though larger NH_3 volatilization losses were caused by manure incorporation. Thus, our study suggests that a combination of synthetic and organic N fertilizers is suitable for sustaining agricultural productivity while reducing environmental N losses through fostering interactions between the soil C and N cycle.