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Characteristics of nitrogen losses from a paddy irrigation-drainage unit system

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ABSTRACT

Application of nitrogen (N) fertilizer plays an indispensable role in rice (*Oryza sativa*) production across the world. However, the dynamic nature of N and its propensity for loss have made N fertilizer management a great challenge for paddy systems. In this field study (2012–2015), we investigated N dynamics in various components of N budgets, i.e., fertilizer, rainfall and irrigation as N inputs and crop harvests, ammonia (NH_3) volatilization and surface runoff as major N exports, in a typical paddy irrigation-drainage unit (IDU) in Hubei province, China. Moreover, N in paddy field ponding water and ditch water was also monitored. The mass balance of N for the rice season showed a net retention of 45.6 ± 7.5 kg N ha^{-1} season^{-1}. Notably, wet deposition (19.5 ± 6.7 kg N ha^{-1} year^{-1}) accounted for 11% of total N input to the paddy field. NH_3 volatilization was the main environmental N loss pathway (mean 34.1 kg N ha^{-1} season^{-1}); equivalent to 25.3% of N fertilizer application. With regard to N loss, the first week after fertilization is the critical period for NH_3 volatilization loss, high total N concentration in the field ponding water and in runoff water. There was about nine days lag between the peaks of N concentrations in paddy field water and in ditch water. In contrast to that of the paddy field, the critical period of N loss from the IDU was 16 days after fertilization. After this period, N concentrations in ditch water declined and stabilized at a low level. Overall, our results suggest that most of the N loss from paddy runoff can be reduced during its delivery from the field to ditches. We suggest best management practices be targeted at the critical loss processes and critical periods in the IDU.

1. Introduction

Application of nitrogen (N) fertilizer plays an indispensable role in grain production across the world (Dong et al., 2015; Vitousek et al., 2009). However, N fertilizer management has been largely challenged by the dynamic nature of N and its propensity for losses (Binder et al., 2000). For example, in many rice producing countries, paddy fields are located in the regions with extensive water networks, and N runoff from the fields is found to contribute to the deterioration of surface water quality (Li et al., 2018; Liu et al., 2018; Xu et al., 2018). Thus, it is very important to examine N transport pathways and dynamics in the paddy systems to assess the impact of rice paddies on surface water deterioration.

Nitrogen losses from paddy fields can lead to a lot of atmospheric and water environmental problems, impacting human life (Gu et al., 2014; Behera et al., 2013). In China, the use of N fertilizer in paddy production is commonly at excessive rates, which has resulted in a large amount of N losses to the atmosphere or surrounding water environment (Chen et al., 2014, 2010; Ti et al., 2011). Among the various forms of N losses, ammonia (NH_3) volatilization and surface runoff are the main pathways of N losses to air and surface water (Li et al., 2017). Some studies indicated that NH_3 volatilization contributed about 69.6% to 83.5% of total N loss in rice planting season (Soares et al., 2012; Yang et al., 2013). In rice production, commonly, N fertilizer is applied to the surface of paddy fields, which leads to a large amount of N remaining in the surface ponding water or soil. When the large N input is coupled with high temperature which is common during rice growing period, large quantity of NH_3 volatilization emits from paddy fields (Yang et al., 2013). The NH_3 volatilized usually stay in the atmosphere for a short time and can stay close to the discharge source (Krupa et al.,

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