**Appendix A**

# Greenhouse gas emissions and reactive nitrogen releases from rice production with simultaneous incorporation of wheat straw and nitrogen fertilizer

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**Various Nr losses empirical models established through meta-analysis of published papers.** We conducted a detailed review of published literature to simulate various Nr losses response to N fertilization for rice production in the TLR. An exhaustive survey of literature published in peer-reviewed journals was launched using the Google Scholar, ISI web of knowledge and China Knowledge Resource Integrated database to identify articles published before April 2015. This survey focused on field observation of various Nr losses from rice production in the TLR, including $NH_3$ volatilization, N leaching and runoff, and $N_2O$ emission. Several criteria were established to ensure studies included in dataset being representative. First, field measurements must be carried out during rice cultivation in the TLR. Second, observation methods of various Nr should be authoritative and widely-agreed. For example, $N_2O$ emission must be measured using static chamber technique (Xia et al., 2014), $NH_3$ volatilization must be observed by dynamic chamber method or micrometeorological method (Zhao et al., 2015) and N leaching and runoff must be measured using lysimeter method or suction cap (Xue et al., 2014, Zhao et al., 2009). Third, observation duration must be covered main Nr discharge period. $NH_3$ volatilization and $N_2O$ emission must be measured for at least 2 weeks after N fertilization.

The Nr releases induced by biological N fixation (BNF) and crop residue incorporation were not calculated in our study, due to the following reasons. First, compared to the synthetic N fertilizer application rate, the Nr input rate through BNF is minor (Ti et al., 2012). Secondly, the effects of BNF and crop residue incorporation on Nr release are not significant. The high C/N ratio of crop residue generally promotes the N contained in the residues to stabilize in soil rather than releasing as various Nr. For example, a meta-analysis that integrated 112 scientific assessments of the crop residue return on the $N_2O$ emissions has found that the practice exerted no statistically significant effect on the $N_2O$ release (Shan and Yan, 2013). And the effects of BNF on Nr release, such as $N_2O$ emission, are not considered in the new IPCC emission inventory guidelines any more (IPCC, 2013).

**Environmental costs incurred by GHG and Nr releases.** The environmental costs that our study considered referred to global warming incurred by GHG emissions, soil acidification incurred by $NH_3$ and $NO_X$ emissions and aquatic eutrophication caused by $NH_3$ emission and N leaching and runoff, mainly referred to Xia and Yan (2011) and Xia and Yan (2012) that based on method adopted by Moomaw and Birch (2005). We did not consider the direct human health damage incurred by GHG and Nr releases due to the fact that the human health damage caused by GHG and Nr releases is quite difficult to quantify directly, which is determined by people's willingness to pay and whether the location where GHG and Nr released also has high density of population (Gu et al. 2012).

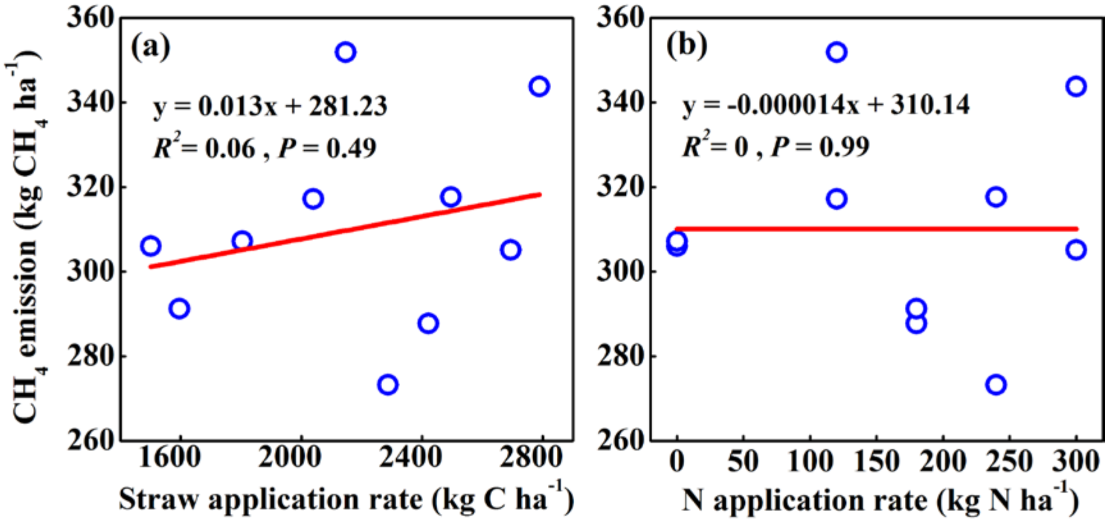


**Fig.S1. Relationship between $CH_4$ emissions and (a) straw incorporation rate and (b) N fertilizer application rate for rice production in rice-wheat cropping system in the TLR**

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