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Discussions

Interactive comment on "Responses of N_2O and CH_4 fluxes to fertilizer nitrogen addition rates in an irrigated wheat-maize cropping system in northern China" *by* C. Liu et al.

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We would like to thank the anonymous reviewer for the professional and meticulous comments. Basically we will follow all the suggestions to improve the current manuscript.

Materials and methods:

The soil of the experimental field is a Mottlic Hapli-Ustic Argosols (Gong et al., 2007), which was analogue to the Luvisols (IUSS Working Group WRB, 2006; Krasilnikov et al., 2009).

A motor-pumped well beside the experimental field was used to pump underground water (depth: 130~140 m) to a manually movable sprinkler irrigation system and irrigate the crops.

The type II chamber allowed the cornstalk to pass through the chamber top and to only cover the maize root. The gap between the type II chamber and the cornstalk was manually patched by sealing a preservative film (thickness: 0.1 mm, material: polyvinylidene chloride, oxygen permeability: 2.9 cm3 m-2 h-1 atm-1) when the chamber was closed. The preservative film was wrapped 3 layers to reduce the leaking of gases through it. (We check the material of preservative film, which is polyvinylidene chloride instead of pure polyethylene.)

Immediately before closing the chamber, ambient air was taken as the sample of deployment time zero. Deployment times were kept to 20~40 min. Five gas samples in total were taken and stored in the plastic syringes. The CH4 and N2O concentrations of gas samples were analyzed within 10 hours after sampling by a gas chromatograph (GC, Agilent 5890D, Agilent Technologies Inc., USA), which was equipped with an electron capture detector (ECD) and a flame ionization detector (FID). The ECD, FID and column of the GC were heated to 350, 150 and 55°C, respectively. The carrier gas of GC was N2 (99.999% purity). To avoid interference of carbon dioxide (CO2) of the gas samples with the ECD-cell during N2O detection, the make-up gas contained a high concentration of CO2 (approximately 10% CO2 in N2, Zheng et al. 2008). The CH4 and N2O concentrations were hourly calibrated by three reference gas injections (2.10 ppm CH4 and 1.02 ppm N2O in N2, Air Products and Chemicals, Inc., Beijing, China).

We do agree to add the information of aboveground biomass and its N content in Table 1.

Herbicide (atrazine) was applied once each wheat and maize growing season. Pesticides (the mixture of emamectin benzoate and chlorpyrifos) were applied only once during the maize growing season.

Nonparametric test of two independent samples (Mann-Whitney U-test) was used to analyze the significance of the differences in the mean crop yield, aboveground biomass, nitrogen contents of grain and aboveground plant between treatments. A t-test and an F-test were performed to determine the significance of regression coefficients and regression equations, respectively. When the probability value of the t-test and F-test for the significance of regression coefficients and equations < 0.05, the regression equations were selected to describe the relationships between crop yield, nitrogen contents of crop straw and grain, soil inorganic nitrogen content, soil DOC content, cumulative N2O emissions, cumulative CH4 uptake and fertilizer rates.

Results:

We do agree to change the section name to “Environment, soil mineral N and DOC”.

Discussion:

The N2O emissions (0.49 ± 0.06% of applied nitrogen in the annual scale) were only a minor loss pathway of the applied fertilizer nitrogen in the wheat-maize rotation field. Ju et al. (2009) also reported very low averaged loss rates of N2O emission to fertilizer nitrogen (0.12 and 0.23% in the wheat and maize seasons) in the wheat-maize rotation fields on the North China Plain. They explained the low N2O loss rates by the low available carbon sources (organic matter: 1.0∼1.5%) and soil WFPS for denitrification in most semi-humid upland soils of the North China Plain. The low availability of SOC (12.4∼13.9 g kg-1) hindered the transformation of nitrate to N2O by denitrification and therefore caused the nitrate accumulation in the soil when high fertilizer nitrogen was applied (Wan et al., 2009; Ju et al., 2009; 2011). Finally the accumulated nitrate was leached out of the root zone due to the irrigation and concentrated rainfall in summer (Zhao et al., 2006; Ju et al., 2009). It’s very likely that the denitrification process was also limited by the low availability of SOC (11.3 ± 0.6 g kg-1) in our wheat-maize rotation field. Many studies have proved that under the native carbon condition of agricultural soils in northern China, the contribution of denitrification to N2O emission

was very limited (Wan et al., 2009; Ju et al., 2009; 2011; Cui et al., 2012). Therefore, the increase of fertilizer rate can not exponentially stimulate the N2O emission due to the limited contribution of denitrification for most upland agricultural soils with low availability of SOC in northern China. However, due to the nitrate accumulation in the soil arose by the lack of decomposable carbon and the extensive application of irrigation following fertilization, the nitrate leaching may be primarily stimulated when high fertilizer nitrogen was applied.

We think that the weak CH4 emission and the presence of anoxic micro-site are possible after the irrigation and continuous rainfall due to the shallow groundwater table in the field. The methanotrophic bacteria can benefit from the increased CH4 concentration. Furthermore, after the irrigation and continuous precipitation the soil WFPS for the treatments with high fertilizer rates decreased faster due to the possibly higher evapotranspiration caused by the higher aboveground biomass as compared with the treatments with low fertilizer rates. It means that the CH4 uptake could rapidly recover for the treatments with high fertilizer rate.

We should change the term “chemical fertilizer” to “synthetic fertilizer”.

The optimized nutrient management should reduce nitrogen fertilizer input where fertilizer nitrogen has been overused, improve nitrogen use efficiency, and finally maintain soil nitrogen balance between inputs (fertilization, deposition and irrigation) and outputs (grain, ammonia volatilization, nitrate leaching, gaseous nitrogen emission by microbial nitrification and denitrification). In our wheat-maize rotation field, the estimated nitrogen inputs by irrigation (about 4 kg N ha-1 yr-1) and deposition (about 89 kg N ha-1 yr-1, Ju et al., 2009; wet deposition: 30∼43 kg N ha-1 yr-1, this study and Liu et al., 2011) were approximately 93 ± 11 kg N ha-1 yr-1. Applying the ratios of nitrogen losses reported by Ju et al. (2009), the processes of ammonia volatilization (approximately 60 kg N ha-1 yr-1 calculated as 19.4 and 24.7% of applied nitrogen in the wheat and maize seasons), nitrate leaching (approximately 21 kg N ha-1 yr-1 calculated as 2.7 and 12.1% of applied nitrogen in the wheat and maize seasons) and denitrification (approximately 5 kg N ha-1 yr-1 calculated as 0.1 and 3.3% of applied nitrogen in the wheat and maize seasons) lost approximately 86 kg N ha-1 yr-1. Among the treatments of six fertilizer nitrogen levels, only the treatment with the fertilizer rate of 270 kg N ha-1 yr-1 could achieve a slightly positive soil nitrogen balance (gain by 33 ± 16 kg N ha-1 yr-1; grain output: 243 ± 13 kg N ha-1 yr-1 see Table 1). The slightly positive soil nitrogen balance meant that the current crop yield (7.0 ± 0.3 and 6.8 ± 0.8 t ha-1 for wheat and maize) might be sustainable and the negative environmental effects could be minimized for N270. The treatments with higher fertilizer rates could obtain a small increase in the crop yield, but sharply stimulated the N2O emission.

Conclusion:

We do agree to condense the conclusion.

Figures and tables:

We do agree to use specific symbols for the given variables in the equations of Figures 2, 3, 5-8.

We do agree to move the equations of Figures 2, 3, 5-8 to a separate table.

References:

The volume number of the literature Ju et al., 2009 is 106 rather than 160.

Interactive comment on Biogeosciences Discuss., 8, 9577, 2011.