N_2O emissions from a tea field in subtropical China

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Abstract

Nitrous oxide (N_2O) is one of the potent greenhouse gases, and accurate estimation of N_2O emissions from fertilized arable lands is vital for the national greenhouse gas inventory and the development of emission mitigation strategies. It is well-known that acidic soils are characterised with low pH, high acidification and high N_2O production and emissions due to chemo-denitrification, compared with other cropped soils. In this paper, we report on our experiment to measure N_2O emissions from a tea field soil using the closed chamber method in subtropical China.

Key Words

Nitrous oxide, tea field subtropical China.

Introduction

N_2O is a potent and long-lived greenhouse gas, and contributes a radiative forcing of +0.16±0.02 W m^{-2} of the atmospheric greenhouse effect, with a global warming potential 310 times greater than carbon dioxide (CO_2) for a 100-year time horizon (IPCC 2007). Arable soils to which nitrogen fertilizers applied are considered to be one of the main sources of N_2O emissions (Mosier 1994). N_2O emissions in arable fields exhibit high spatial variability due to many driving factors, such as crop rotations, soil properties, application method for nitrogen fertilizer, topography, and climatic conditions as well. In order to gain high tea yields in subtropical China, more and more nitrogen fertilizers are applied to the tea fields. The large amount of nitrogen fertilizers not only improves the quality of tea leaves, but also causes adverse impacts on the environment at the same time, such as nitrogen leaching and N_2O emissions. It was observed that more nitrogen infiltrates through soil root zones and percolates into the ground water, causing severe ground water contamination (Kihou and Yuita 1991). Heavy application of nitrogen fertilizers also induces soil acidification, and therefore lowers soil pH in the tea fields. Nakasone *et al*. (2000) reported that in 21 Japanese tea fields, soil pH was observed ranging from 2.96-6.26, and even soil micro-organisms was not able to be detected in some fields with the lowest pH value. It is widely established that the low soil pH limits soil biological activities. Hayatsu (1993) indicated that the lowest limit of pH value for soil nitrification in the tea field was around 2.9. It is evidenced that the low pH in the soil is strongly associated with a large leakage of N_2O from the soil nitrification process (Venterea and Rolston 2000). When the amount of nitrogen fertilizer exceeded 1,000 kg N/ha/y, the N_2O production of tea field soil increased with the decreasing of the soil pH value (Tokuda and Hayatsu 2001). It suggested that the nitrogen fertilization and soil acidification may have effects on the nitrogen cycle and N_2O emissions in the tea field soils. Given the booming and intensifying of tea industries in subtropical China, we therefore continuously monitor N_2O emissions from a tea field under three different agricultural managements over a three-year period, and try to analyse the relationship between N_2O emissions and its controlling factors. We also investigate the temporal and spatial variability of N_2O emissions in tea fields.

Material and method

Site

The experiment is carried out in a tea field in the Jinjing experimental base of Institute of Subtropical Agriculture, The Chinese Academy of Sciences (113°20'E, 28°35'N, elevation of 105 m). It is located at 50 km south of Changsha, the capital city of Hunan Province, China. The soil is the Alisols (FAO-UNESCO classification) developed from the granite parent materials. Normally, the tea production seasons are from May to September; and the fertilizers are applied in between tea rows in the fields from March to May and in October. The typical tea yield for this region is 4000-6000 kg/ha/y.

Closed chamber method

N_2O fluxes are measured using the static closed chamber method. Measurements take place between 9 AM and 11 AM when fluxes are expected to close to the mean of the daily fluxes (Benasher *et al*. 1994). There are three different treatments in the tea field, including the conventional treatment (CON, the amount of N fertilizers applied is the same as the standard application rate for the tea cultivar-specified recommendation, 450 kg N/ha/y with three even splits: two in March-May using urea and one in October using oil seed trashes), the rice straw mulching treatment (SM, the nitrogen fertilizer application rate refers to the CON treatment), and the non-fertilizer treatment (CK, 0 kg N/ha/y). Each treatment has three replicates distanced by 10-20 meters. In addition, we also monitor N_2O emissions from the close-by paddy field, vegetable field and masson pine wood land for comparison purpose. The closed chamber is made of two parts, the base and the chamber which covers the former when in the operation. During the installation of closed chambers, the soil and vegetation within the base are not disturbed. Each chamber covers an area of 100 cm^2, and stands a height of 120 cm for the tea field, and 65×65×50 cm^3 for the paddy field, vegetable field and masson pine wood land. The base is made of stainless steel, and the chamber is made of polyvinyl chloride. In sampling, each gas sample is taken from the headspace of the chamber using a 100 ml syringe equipped with three-way cocks and a rubber septum at 0, 10, 20 and 30 min and stored in pre-evacuated 12-ml vials fitted with rubber septum. Gas samples are then brought back to the laboratory for the gas concentration determination by using a gas chromatograph with a 63 Ni electron capture detector. N_2O fluxes (g N ha^{-2}/d) were calculated using the gas concentration gradient with the time as the gas accumulates inside the chamber. The flux measurements will be conducted from January 2010 to December 2012 at either a 1-2 days interval for rainfall and fertilization events or a 1-2 weeks interval for plain seasons.

Environmental factors
Soil temperatures and moistures at depths of 10, 20, 50 and 100 cm are measured by the ECH_2O system (www.decagon.com). Soil pH is measured in a soil/water suspension (1:2.5, dry weight basis) with a glass electrode. Soil solutions at depths of 0-10, 10-20, 20-50 and 50-100 cm are extracted by using the suction cup method, and the inorganic nitrogen contents (nitrate and ammonium) in them are measured by the NP Autoanalyzer. Such measurements are carried out for all replicates of all treatments.

Results
The measurements start from January 2010. So far we have had only two sampling on 21 and 25 January 2010, respectively. With each sampling, we observe that N_2O concentrations in chambers show a significantly positive linear correlation with the time. Furthermore, the increasing rates of the N_2O concentration in chambers vary among treatments and land uses. On 21 January 2010, the N_2O fluxes from three treatments in the tea field are 29.4, 43.1 and 10.8 g N/ha/d, respectively, while on 25 January 2010, they are 27.5, 33.6 and 6.4 g N/ha/d, respectively. We consider the variation of N_2O emissions among treatments is caused by the strong spatial variability of N_2O emissions from soils since the treatment management has not commenced yet. Because the fertilization and mulching will take place in February 2010, we consider the N_2O fluxes from treatments in the tea field as one value and compare with N_2O fluxes from other close-by land uses we are observing. Although the measurements are carried out in the cold winter time (5-10°C), we observe quite large N_2O fluxes from the fields. The average values of our observed N_2O fluxes from the tea field, paddy field, vegetable field and masson pine wood land are 25.1, 24.8, 243.9, and -2.9 g N/ha/d, respectively. The N_2O flux from the vegetable land is the highest, whilst the N_2O flux from the masson pine wood land is the lowest, -2.9 g N/ha/d, not emitting but absorbing N_2O. The discrepancy of N_2O emissions between the tea and paddy fields in these two sampling is very small as both fields are not in the productive stage.

Conclusion
Our preliminary result from few observations of N_2O fluxes even in the winter time indicates that the tea field may be a high spot for N_2O emissions, which is now neglected from the national greenhouse gas emission inventory. In August when the 19th WCSS commences, we will have more data to present in the event.

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