Response of N$_2$O production and ammonia-oxidizing bacteria and denitrifiers to varying nitrogen, carbon and water management in an agricultural soil

Qiongli Bao$^a$, Xiaotang Ju$^{a,*}$, Zhi Qu$^a$, Peter Christie$^{a,b}$, Yahai Lu$^a$

$^a$Key Laboratory of Plant Nutrition, Ministry of Agriculture; College of Resources and Environmental Sciences, China Agricultural University, Beijing 100193, China $^b$Agri-Environment Branch, Agri-Food and Biosciences Institute, Belfast BT9 5PX, UK

We investigated the linkage between community composition of nitrifiers and denitrifiers and emissions of nitrous oxide (N$_2$O) in a typical agricultural soil on the North China Plain. N$_2$O emissions and community composition and abundance of soil ammonia-oxidizing bacteria (AOB) and denitrifiers were studied under zero-N (Control), NH$_4^+$-based N (NH$_4^+$, favoring nitrification), NO$_3^-$-based N + glucose + soil compaction (NO$_3^-$+Glu+Com, favoring denitrification) and urea + straw (U+S, representing conventional farming practice) fertilizer treatments in a summer maize field. We observed a substantial period of high N$_2$O emissions that commenced after N fertilization and irrigation and lasted for approximately 10 days, especially in the NO$_3^-$+Glu+Com treatment in which the largest N$_2$O emissions occurred. Emissions after fertilization and irrigation averaged 252, 2157 and 295 µg N m$^{-2}$ h$^{-1}$ in the NH$_4^+$, NO$_3^-$+Glu+Com and U+S treatments, respectively. Community structure of AOB in the NH$_4^+$ treatment during the high N$_2$O emission stage based on T-RFLP was similar to that in the control treatment, and there were no changes in the denitrifier community structure in the NO$_3^-$+Glu+Com treatment when greatly elevated N$_2$O emissions occurred compared with the control. However, high abundance of aomA gene copies for AOB and nir-gene copies for denitrifiers were detected during the high N$_2$O emission period in the NH$_4^+$ and NO$_3^-$+Glu+Com treatments. The results indicate that N$_2$O emissions were not related to community composition of AOB and denitrifiers, but to their abundance. The abundance of nirK was greater than that of nirS, suggesting that the nirK-harboring denitrifiers might be more abundant than nirS-harboring denitrifiers, perhaps indicating that nirK-harboring denitrifiers contributed more to denitrification than the nirS-harboring denitrifiers in the treatment favoring denitrification.