



# Wheat rhizodeposition stimulates soil nitrous oxide emission and denitrifiers harboring the *nosZ* clade I gene

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## ABSTRACT

Stimulatory effects of growing plants on nitrous oxide (N<sub>2</sub>O) emissions have been widely reported in terrestrial ecosystems, but the potential mechanisms responsible for these effects remain unclear. This study revealed that wheat can induce a 3.5–9.2-fold increase in N<sub>2</sub>O emissions under different soil fertility levels, and that this “plant” source of N<sub>2</sub>O occurs in the rhizosphere. Moreover, plants induced soil niche differentiation between denitrifiers harboring the nitrous oxide reductase genes *nosZI* and *nosZII*. Pulse labeling of wheat demonstrated that 67% of <sup>13</sup>C-labeled *nosZI*-type denitrifiers, but no *nosZII*-type denitrifiers, were more abundant in the rhizosphere than in bulk soil. Furthermore, a higher percentage of bacterial genomes containing nitrite reductase genes was found within plant-associated *nosZI*-type denitrifiers than *nosZII*-type denitrifiers, favoring NO<sub>2</sub><sup>-</sup> to N<sub>2</sub>O conversion. Overall, this study revealed a strong selective stimulating effect of wheat on soil denitrifiers through root-derived carbon and a key role of the *nosZI*-type community in rhizosphere denitrification.

## 1. Introduction

Nitrous oxide (N<sub>2</sub>O) is one of the most important greenhouse gases and ozone-depleting substances on earth (Ravishankara et al., 2009; Tian et al., 2016), and agricultural fields with large nitrogen (N) inputs contribute about 30% of the total terrestrial emissions worldwide (Syakila and Kroeze, 2011). The atmospheric N<sub>2</sub>O concentration has persistently increased at nearly 0.75 ppb per year since 1970 (IPCC, 2014). The only known N<sub>2</sub>O sink is its enzymatic reduction to dinitrogen (N<sub>2</sub>) by denitrifiers harboring the nitrous oxide reductase gene (*nosZ*), which consists of two distinct clades (*nosZI*- and *nosZII*-type denitrifiers). The proportion of these two denitrifier types in soil can have substantial consequences on net N<sub>2</sub>O emissions (Jones et al., 2014).

The stimulatory effect of growing plants on N<sub>2</sub>O emissions has been widely reported (Bowatte et al., 2014; Hakata et al., 2003; Zou et al.,

2005), and there may be several potential mechanisms that contribute to the “plant emissions”. First, N<sub>2</sub>O could be produced directly from plant organs or tissues through NO<sub>2</sub><sup>-</sup> assimilation (Bruhn et al., 2014; Hakata et al., 2003; Smart and Bloom, 2001). For example, it has been reported that wheat leaf N<sub>2</sub>O emissions were correlated with leaf nitrate assimilation activity and occurred during photoassimilation of NO<sub>2</sub><sup>-</sup> in the chloroplast (Smart and Bloom, 2001). Second, plants can play the role of a “conduit” to facilitate the transport of N<sub>2</sub>O from rhizosphere to atmosphere (Baruah et al., 2012; Bowatte et al., 2014; Yan et al., 2000). Scanning electron microscopy revealed that N<sub>2</sub>O emissions were correlated with stomatal frequency of leaf and leaf sheaths (Baruah et al., 2012). Third, some plant-inhabiting microbes in (or on) leaves and roots have the capacity to produce N<sub>2</sub>O just as in soil (Ai et al., 2017; Bowatte et al., 2015). Bacteria such as *Nitrosospora* sp. on pasture grass can convert 0.12% of the oxidized ammonia to N<sub>2</sub>O (Bowatte et al., 2015).

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