



Denitrification ‘hot spots’ in soil following surface residue application

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The availability of organic C is an important driver for the production and reduction of the greenhouse gas nitrous oxide (N_2O) during denitrification. Denitrification as a response to plant residue amendments to soil surfaces has been extensively researched. However, the nature of hotspot sites of N_2O production and reduction within the soil profile, especially in relation to the location of applied residues, is unknown. In a laboratory experiment we investigated the relationship between denitrifier N_2O surface fluxes and N_2O production and reduction sites. Probes which equilibrate with the soil gas phase by diffusion were developed to quantify denitrification products and product ratios at 1-2 cm, 4.5-5.5 cm or 8-9 cm from the surface. ^{13}C labelled barley straw was incorporated at rates of 0, 2 and 4 t ha $^{-1}$ into the top 3 cm of soil and subsequently amended with $^{14}NH_4^{15}NO_3$. In a three week experiment the soil gas phase at the three depths was analysed for $^{15}N-N_2O$, $^{15}N-N_2$, $^{13}C-CO_2$ and O_2 concentrations. Additionally, cores were destructively sampled for mineral ^{15}N as well as microbial C and dissolved C in the respective depths.

$^{15}N-N_2O$ and CO_2 surface fluxes peaked one day after N application, with residue application resulting in significantly higher $^{15}N-N_2O$ emission rates compared to the non-amended control. The timing of the $^{15}N-N_2O$ surface flux on day 1 was related to maximum $^{15}N-N_2O$ concentrations of 36.6 $\mu g^{15}N L^{-1}$ within the pore space at 5 cm depth. Three days after fertilizer application $^{15}N-N_2O$ pore space concentrations had significantly increased to 193 $\mu g^{15}N L^{-1}$ at 9 cm depth indicating denitrifier activity at greater depth. Denitrification below the soil surface could be explained by increased microbial activity, oxygen depletion with increasing depth and progressive downwards diffusion of fertilizer NO_3^- . However, C availability appeared to only affect denitrification in the surface layer in which the residue was incorporated. Our results provide insight into the nature and drivers of ‘hotspots’ of denitrifier activity within the soil profile. Such information can contribute to the development of sustainable management practices that lower net emissions of N_2O from arable soils.