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Nitrate reduction in subtropical pasture soils – the role of dissimilatory nitrate reduction to ammonium (DNRA) and denitrification upon rewetting

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Rainfall and irrigation promote to the formation of anaerobic zones in subtropical pasture soils, creating conditions under which denitrification and dissimilatory nitrate reduction to ammonia (DNRA) are thought to compete for available NO_3^-. DNRA is generally assumed to occur under conditions of high C and low NO_3^- availability. Partitioning of available NO_3^- between DNRA and denitrification in C and N rich pasture soils however remains poorly understood. We combined the quantification of N_2 and N_2O with a numerical ^{15}N tracing model to establish the relationship between denitrification and DNRA in three different textured pasture soils in a soil microcosm experiment. After fertilisation with NH_4NO_3 (35 μg N g^{-1}soil), pasture soils were wetted to four different water-filled pore space (WFPS) levels and incubated over two days. The wetting pulse induced a burst of N_2 and N_2O emissions, with peak N_2fluxes $>$13.1 μg N g^{-1}soil day^{-1}. The main product of denitrification at 95% and 80% WFPS was N_2, with the $N_2/(N_2+N_2O)$ ratio ranging from 0.5 to 0.9. At 60% and 40% WFPS, denitrification was dominated by N_2O, with the $N_2/(N_2+N_2O)$ ratio ranging from 0.2 to 0.3. Simultaneous DNRA rates demonstrate the co-occurrence of both processes across soils and WFPS levels. Denitrification and DNRA were positively correlated to WFPS and NO_3^- availability, showing both processes as N-substrate driven. Increasing labile C availability stimulated heterotrophic soil respiration, which did not affect denitrification rates, but increased DNRA. As C availability ($>$4% C_{org}) is unlikely to be limiting for DNRA or denitrification in these soils, heterotrophic soil respiration likely reduced the soil redox potential, which in turn promoted a shift of NO_3^- consumption from denitrification to DNRA. These findings suggest that the high labile C availability under subtropical pastures, together with the increase of labile C upon wetting, drives heterotrophic soil respiration, reduces the soil redox potential and ultimately shifts NO_3^- consumption from denitrification to DNRA. This shift limits denitrification losses and is therefore critical for limiting N loss and increasing N retention in subtropical pasture soils.