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Nitrification and N_2O production processes in soil incubations after ammonium fertilizer application at high concentrations

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High concentrations of ammonium as they occur, e.g., after point-injection of ammonium fertilizer solution according to the CULTAN fertilization technique may retard nitrification. Potential advantages in comparison to conventional fertilization include a higher N efficiency of crops, reduced nitrate leaching, and lower N_2O and N_2 emissions. Dynamics of nitrification due to plant uptake and dilution processes, leading to decreasing ammonium concentrations in fertilizer depots, has only poorly been studied before. Furthermore, there is little information about the relative contribution of different N_2O production processes under these conditions. To elucidate the process dynamics a laboratory incubation study was conducted. After fertilization with ammonium sulfate at 5 levels (from 0 to 5000 mg NH_4^+-N kg^{-1}; 20mg NO_3^--N kg^{-1} each), sandy loam soil was incubated in dynamic soil microcosms for 21 days. N_2O, CH_4 and CO_2 fluxes as well as isotope signatures of N_2O and, at three dates, NO_3^- and NH_4^+ were measured. To identify N_2O production processes, acetylene inhibition (0.01 vol.%), ^{15}N tracer approaches, and isotopomer data (^{15}N site preference and $\delta^{18}O$) were used.
N_2O emissions were highest at 450mg NH_4^+-N kg^{-1} and declined with further increasing concentrations. At 5000 mg NH_4^+-N kg^{-1} nitrification was completely inhibited. However, approximately 90% of N_2O production was inhibited by acetylene application, and there was no change in the relative contribution of nitrification and denitrification to N_2O production with N level.
Applying the non-equilibrium technique to our ^{15}N tracer data revealed heterogeneous distribution of denitrification in soil, with at least two distinct NO_3^- pools, and spatial separation of NO_3^- formation and consumption. In comparison with the acetylene inhibition and ^{15}N tracer approaches the results of the isotopomer approach were reasonable and indicated substantial contribution of nitrifier-denitrification (10-40%) to total N_2O production.