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Plant litter quality controls short-time CO_2 and N_2O emissions of root and shoot residues in agricultural soils

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Availability of easily biodegradable carbon (C) compounds is one of the main drivers of denitrification events in agricultural soils. Potential C sources are root exudates, rhizodeposition and decaying plant and root biomass. Incorporation of plant residues into agricultural soils and its following degradation increases microbial respiration and creates plant litter associated microsites with low O_2 concentrations. These further develop to hotspots for denitrification, when nitrate (NO_3^-) is available from residual fertilizers or mineralization. Studies investigating the effect of plant litter on nitrous oxide (N_2O) emissions mainly considered C/N ratio and total C input as key variables, which control decomposition of plant litter in long-term studies. For short-term responses, however, the quality of C and N compounds is an important predictor. Water-soluble and low-molecular compounds can be directly used in the microbial metabolism, leading to an immediate increase of CO_2 and N_2O fluxes. The composition of structural components further influences the microbial community in soil, with fungi being generally regarded as the main decomposers of plant materials rich in cellulose and lignin. In general, fungi are seen as major contributors to denitrification under aerobic and weakly anaerobic conditions, while bacterial denitrification predominates under strongly anaerobic conditions.

In our study, maize plants (*Zea mays* L.) were grown in a greenhouse for eight weeks, harvested and all roots were removed from soil by sieving and handpicking. Soil, fresh plant shoot and root biomass were used in a 22-day two-factorial laboratory incubation experiment with two N levels (N1 and N2) and three litter addition treatments (Control = no litter input, Root, Root+Shoot). Daily CO_2 and N_2O fluxes, soil nitrate, and water-soluble C_{org} concentrations were analyzed in regular intervals. Microbial communities were analyzed using large-scale metabarcoding.

Maize shoot litter was characterized by a lower relative lignin content, lower lignin/N ratio, and slightly higher C/N ratio compared to maize root litter. Addition of maize litter increased daily CO_2 and N_2O emissions, cumulative emissions and N_2O/CO_2 ratio compared to Control. The effect was much higher with incorporation of Root+Shoot litter, even when higher C inputs were taken into account. Differences in soil NO_3^- concentration between N1 and N2 were very small, but significantly influenced N_2O emissions when water-soluble C_{org} concentrations were high.

We anticipate that higher litter input with higher biodegradability led to stronger anaerobicity in the Root+Shoot treatment compared to Root and Control. Additionally, shrinking of soil incorporated shoot litter created larger soil pores and facilitated rapid escape of generated N_2O. Potentially, a higher share of N_2O was further reduced to N_2 in the Root treatment. Analyses of microbial community structures will give further insights. We expect differences in bacterial and fungal species richness and diversity between the different litter treatments. In conclusion, decomposability, i.e. lignification, total C input and soil bulk density were the main factors influencing N_2O losses from soil in this study.