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Soil-N cycling in temperate alley cropping agroforestry and monoculture croplands

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Monoculture croplands are commonly associated with deleterious environmental effects due to high fertilization rates. Agroforestry (alternate alleys of trees and crops or alley cropping) has the potential to mitigate the negative environmental effects from agriculture. Understanding the soil-N cycling aids in assessing how the soil function of nutrient cycling is impacted when monoculture system is converted into agroforestry. Currently, there is no systematic comparison in soil-N cycling rates between monoculture and agroforestry croplands in Western Europe. Our study aimed to investigate gross rates of soil-N cycling between agroforestry and monoculture croplands. We measured gross rates of soil-N cycling, using 15N isotopic pool dilution in May-June 2017, at three sites in Germany (Wendhausen, Dornburg, and Forst with Vertic Cambisol, Calcaric Phaeozem, Gleyic Cambisol soils, respectively); each site has paired monoculture and agroforestry systems (established in 2008, 2007, and 2010 at the respective sites). In each management system at each site, we had four replicate plots; for agroforestry system, we conducted measurements in the tree row and within the crop row at 1 m, 4 m, and 7 m from the tree row. The crop management practices in agroforestry crop row and monoculture were the same at each site.

For gross rates of ammonium cycling, differences were observed between agroforestry tree row, crop row and monoculture at the site with Vertic Cambisol soil. Higher gross N mineralization rates were observed in monoculture than agroforestry tree row whilst agroforestry tree row exhibited higher gross NH_4^+ immobilization rates than agroforestry crop row ($P < 0.02$). This was correlated to higher soil C/N ratio and higher water-filled pore space in the tree row. Tree rows also tend to have higher microbial biomass at all sites. Gross rates of nitrate cycling were higher in the tree row than in the crop row and monoculture at the site with Calcaric Phaeozem soil. This showed a similar pattern with the gene abundance of ammonium oxidizing archeae (AOA), supporting a niche differentiation of AOA by utilizing ammonium mineralized from soil organic matter rather than from fertilizer source. At the site with Vertic Cambisol soil, dissimilatory nitrate reduction to ammonium was very high in the tree row. These changes in soil-N cycling and AOA gene abundance in the tree rows suggest that trees in sites with older agroforestry systems had enhanced the cycling of N in the soil.