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Soil N_2O emissions from temperate cropland agroforestry and monoculture systems

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Monoculture cropland is a major contributor to agriculture-related sources of N_2O emission, a potent greenhouse gas and an agent of ozone depletion. Cropland agroforestry has the potential to minimize deleterious environmental impacts. Presently, there is no systematic comparison of soil N_2O emission between cropland agroforestry (CAF) and monoculture systems (MC) in Western Europe. Our study aimed to (1) quantify the spatial-temporal dynamics of soil N_2O fluxes, and (2) determine their soil controlling factors in CAF and MC. We selected three sites with different soil types (Phaeozem, Cambisol, and Arenosol) in Germany. Each site has paired CAF and MC (agroforestry sites consisted of 12-m wide tree row and 48-m wide crop row and were established in 2007, 2008 and 2019 in these soil types, respectively). In each management system at each site, we had four replicate plots. In the CAF, we conducted measurements in the tree row and within the crop row at 1 m, 7 m, and 24 m from the tree row. We measured soil N_2O fluxes monthly over 2 years (March 2018–February 2020) using static vented chambers method. Following gas sampling, we also measured soil temperature, water-filled pore space (WFPS), and mineral N (NH_4^+ and NO_3^-) within the same day. Across all sites, soil moisture and N availability were major drivers of soil N_2O fluxes. Both CAF and MC were net sources of soil N_2O at all sites. At the site with Phaeozem soil, annual soil N_2O emissions from CAF in both years (1.84 ± 0.35 and 1.17 ± 0.30 kg N ha^{-1} yr^{-1}) were greater than MC (0.89 ± 0.09 and 0.34 ± 0.05 kg N ha^{-1} yr^{-1}) (P = 0.03). At the site with Cambisol soil, annual soil N_2O emission did not differ between MC (0.49 ± 0.07 kg N ha^{-1} yr^{-1}) and CAF (0.73 ± 0.13 kg N ha^{-1} yr^{-1}) in 2018/2019 (P = 0.20) whereas in 2019/2020 MC was 134% greater than CAF (2.92 ± 0.45 and 1.25 ± 0.08 kg N ha^{-1} yr^{-1}, respectively; P = 0.03). The inter-annual differences were largely related to crop types and to climate conditions. At the site with Arenosol soil, there was no difference between CAF and MC. Our results indicated that CAF may decrease, maintain and/or increase soil N_2O emissions compared to MC depending on tree age, soil characteristics, management and precipitation.