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# Effects of biogas digestate and cattle slurry application on greenhouse gas emissions from grasslands on organic soils

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The change in the German energy policy resulted in a strong development of biogas plants in Germany. As a consequence, drained peatlands are increasingly used to satisfy the rising demand for fermentative substrates. In return high amounts of nutrient-rich digestates are used as organic fertilizer to maintain soil fertility and crop yield. It is well known that organic fertilization enhances nitrous oxide ($N_2O$) emissions from managed grasslands, especially in south Germany, a region with frequently frost-thaw cycles. Additionally drained organic soils are considered as hotspots of GHG emissions including $N_2O$.

Our study addressed the question to what extent biogas digestate and cattle slurry application alters $N_2O$ and methane ($CH_4$) fluxes and how different contents of soil organic matter (SOM) promote the production of GHG. The study was conducted at two areas within one grassland parcel, which differed in their soil organic carbon (SOC) contents (10% versus 17%). At each area (named $C_{org}$ medium and $C_{org}$ high) three sites were established: One was fertilized five times with biogas digestate, the second five times with cattle slurry and the third site served as control without fertilization. For each treatment, the fluxes of $N_2O$ and $CH_4$ were measured over two years using the closed chamber method.

Significantly higher short term (16 days) $N_2O$ fluxes after fertilization with digestate compared to slurry could only be found in one out of four fertilisation events. However, on an annual basis the application of biogas digestate significantly enhanced the $N_2O$ fluxes compared to the application of cattle slurry. Furthermore, $N_2O$ fluxes from the $C_{org}$high site significantly exceeded $N_2O$ fluxes from the $C_{org}$ medium sites. Annual cumulative emissions ranged from 0.91 $\pm$ 0.49 kg N $ha^{-1}$ $yr^{-1}$ to 3.14 $\pm$ 0.91 kg N $ha^{-1}$ $yr^{-1}$, reflecting the lower end of literature values from other organic soils and corresponding more to those reported from grasslands on mineral soils in Germany. Significantly different $CH_4$ fluxes between the investigated treatments or the different soil types were not observed. Cumulative annual $CH_4$ exchange rates varied between -0.21 $\pm$ 0.19 kg C $ha^{-1}$ $yr^{-1}$ and -1.06 $\pm$ 0.46 kg C $ha^{-1}$ $yr^{-1}$, confirming the minor importance of $CH_4$ emissions from applied organic fertilizers for the GHG balance of agricultural grasslands. It could be shown that the frequent but low dosage application of fertilizer and quick N uptake by plants avoid conditions favourable for high $N_2O$ emissions. However, the observed linear increase of 16 days cumulative $N_2O$-N exchange or rather annual $N_2O$ emissions, due to a higher mean groundwater level and a higher application rate of $NH_4^+$-N, reveal the importance of site adapted N fertilization and the avoidance of N surpluses during the agricultural use of $C_{org}$ rich grasslands.