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Impact of the Application Technique on Nitrogen Gas Emissions and Nitrogen Budgets in Case of Energy Maize Fertilized with Biogas Residues

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Despite an increasing cultivation of energy maize fertilized with ammonia-rich biogas residues (BR), little is known about the impact of the application technique on gaseous nitrogen (N) losses as well as N budgets, indicative of N use efficiency. To contribute to closing this knowledge gap we conducted a field experiment supplemented by a laboratory incubation study.

The field experiment was carried out in Dedelow, located in the Northeastern German Lowlands and characterized by well-drained loamy sand (haplic luvisol). Two treatments with different application technique for BR fertilization – i) trail hoses and ii) injection – were compared to an unfertilized control (0% N). Seventy percent of the applied N-BR was assumed to be plant-available.

In 2013, biweekly nitrous oxide (N_2O) measurements were conducted during the time period between BR application and maize harvest (18.04.-11.09.2013; 147 days) using non-flow-through non-steady-state chamber measurements. To quantify soil N_{min} status, soil samples were taken from 0-30 cm soil depth in the spring (before fertilization) and autumn (after maize harvest). Immediately after BR application, ammonia (NH_3) volatilization was measured intensively using the open dynamic chamber Dräger-Tube method. Export of N due to harvest was determined via plant N content ($N_{harvest}$). Based on the measured N gas fluxes, N soil and plant parameters, soil N budgets were calculated using a simple difference approach. Values of N output ($N_{harvest}$, N_{N2O_cum} and N_{NH3_cum}) are subtracted from N input values ($N_{fertilizer}$ and N_{min_autumn}minus N_{min_spring}). In order to correctly interpret N budgets, other N fluxes must be integrated into the budget calculation. Apart from soil-based mobilization and immobilization turnover processes and nitrate leaching, this applies specifically to N_2 losses due to denitrification. Therefore, we measured the N_2 emissions from laboratory-incubated undisturbed soil cores (250 cm^3) by means of the helium incubation approach.

With cumulative field emissions of 2.9±0.8 kg N_2O-N ha^{-1} and 3.9±0.4 kg N_2O-N ha^{-1} after trail hose application and injection, respectively, our results showed no clear application effect. NH_3-N losses were higher for trail hose application (7.2 kg NH_3-N ha^{-1}) compared to injection (5.2 kg NH_3-N ha^{-1}). The calculated N budgets showed negative values (accumulative deficit) up to -6 kg N ha^{-1} and -32 kg N ha^{-1} for trail hose application and injection, respectively. But differences between treatments were not significant. Overall N budgets were more influenced by plant N uptake (91-96%) than by gaseous N losses (4-9%). However, results from the laboratory incubation indicate that N_2 may also be a potentially important pathway of N loss, contributing to 34% of total gaseous N loss, corresponding to 5 kg N_2-N ha^{-1} yr^{-1}.