Nitrous oxide emissions after slurry injection in maize cropping

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Agriculture in north-west Germany is characterized by intensive livestock farming and biogas production resulting in high amounts of organic manure and an increasing acreage of maize. To ensure proper early growth of maize most farmers use a side dress mineral nitrogen (N) and phosphorous (P) "starter fertilizer" in addition to broadcast slurry application. This regularly leads to nutrient surpluses at field level, which are at risk to be lost into non-agricultural ecosystems. Slurry injection below the maize seeds has been proven as an option to replace mineral NP starter fertilizer without impairing maize yields and quality. However, the highly concentrated slurry band in the soil might lead to favorable conditions for denitrification resulting in increased nitrous oxide (N_2O) emissions.

To compare different slurry application techniques with regard to N_2O emissions a maize field trial was conducted close to Osnabrück, Lower Saxony, Germany (52°20' N, 07°58' E; soil-type Gleyic Podzol; loamy sand) using a randomized complete block design (4 replications; plot size 3 m x 25 m). The slurry was applied with a four-row slurry injector at a spacing of 75 cm. The following treatments were conducted: (1) Control (no fertilization), (2) broadcast (slurry application by trailing hose applicator followed by immediate incorporation plus a side-banded 23N/10P starter fertilizer at planting, (3) injection (slurry injection), and (4) injection + NI (slurry injection with addition of the nitrification inhibitor ENTEC FL [EuroChem Agro GmbH, Mannheim, Germany] at a rate of 10 l ha^{-1}). Maize seeding was done 8 days later (seeding depth 4.5 cm) directly above the slurry bands.

For N_2O flux measurements PVC collars (78 cm x 78 cm, 15 cm in height) were installed in each plot centered above a maize row. Between April 2015 and March 2016 in total 54 gas samplings were conducted using white-colored PVC chambers (51 cm height). Gas analysis was done using a gas chromatograph equipped with an electron capture detector.

For the control treatment rather low N_2O emissions (> 25 µg N_2O-N/m²/h) were measured throughout the one-year measuring period. An increase in N_2O emissions occurred for the broadcast treatment shortly after slurry application resulting in slightly higher N_2O emissions compared to the control for the following 10 weeks. Injection of slurry into the soil resulted in a considerable intensification of N_2O release with a peak of more than 872 µg N_2O-N/m²/h end of May. Mixing the nitrification inhibitor ENTEC FL into the slurry prior to injection led to significantly lower soil nitrate concentrations for about 8 weeks until 6-leaf stage of maize reducing N_2O emissions by more than 50 % (maximum flux 374 µg N_2O-N/m²/h). From mid-July onwards until harvest of maize N_2O emissions were rather low for all treatments. This is most probably due to low soil nitrate concentrations resulting from N uptake by the maize plants. Also during the winter months until March 2016 very low N_2O emissions occurred and no relevant differences between the control and the slurry treatments could be detected. It can be concluded that the addition of a nitrification inhibitor to the slurry is an appropriate measure to reduce N_2O losses from injected slurry.