Project brief

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GülleBest: What low-emissions technology exists for the application of slurry and digestate?

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- **Low-loss manure application techniques can make a decisive contribution to saving nitrogen fertilizer and thus make an important contribution to climate protection.**
- **Maximum ammonia reduction through slurry acidification and open slot injection.**
- **No increase in nitrous oxide emissions through open slot injection and acidification.**
- **Equal nitrogen utilization efficiency of the different application techniques.**

Background and aims

Around 95 % of ammonia emissions in Germany come from agriculture, 40 % of which from the application manure. Manure generally contains high amounts of ammonium nitrogen, which can be rapidly transformed into gaseous ammonia (NH_3), especially upon exposure to the atmosphere. The nitrogen is thus lost to the plants as an important nutrient. The air pollutant NH_3 not only endangers sensitive ecosystems, but also human health.

In addition to their contribution to the emission of the air pollutant NH_3, fertilized soils are also responsible for the emission of the climate-damaging greenhouse gas nitrous oxide (N_2O). The amount of applied nitrogen fertilizer and the type of application technique plays a decisive role.

With the amendment of the Fertilizer Ordinance in 2017, only near-soil application techniques, i.e. in the form of band-shaped application on the soil surface or direct injections into the soil, are permitted for slurry and digestate on cultivated arable land from 2020. From 2025, this will also apply to grassland. In addition to vesting periods, slurry and digestate may only be applied to arable land to a limited extent and after the main crop and after the main crop has been harvested. Therefore, slurry and digestate will increasingly be applied in spring in growing winter crops without the possibility of direct incorporation into the soil.

This is likely to lead to an increase of NH_3 and N_2O emissions from organically fertilized cropland and grassland that are harmful to the climate and the environment, as band-shaped application into the plant stands causes higher emissions than immediate incorporation on uncultivated land. To date, however, this issue has not been fully investigated. It has also been unclear which near-ground application technique yields the greatest reduction potential and how this affects yields.

Approach

The basis of the joint project is a network of coordinated field trials with different soil and weather conditions in Germany.

Emission reduction, fertilization efficiency and practical suitability for cattle slurry and biogas digestate of the following application techniques were investigated and evaluated at four locations:

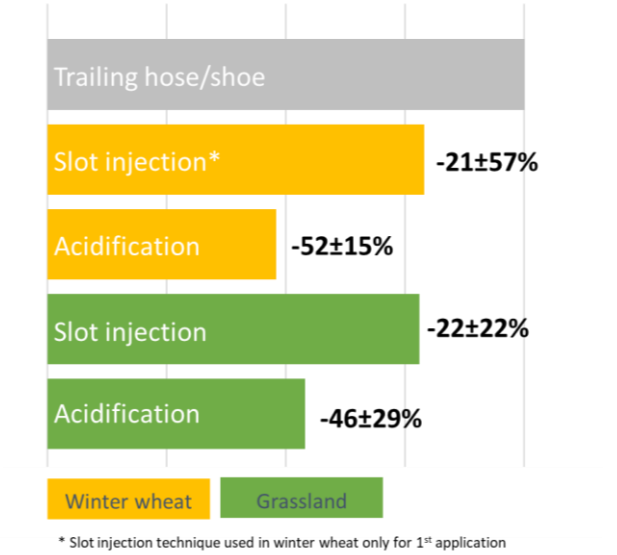
- Application by trailing hose/shoe,
- Application by slot technique (open slot, 5 cm deep),
- Acidification of the slurry/digestate during trailing hose/shoe application,
- Addition of a nitrification inhibitor in the slot technique.

Experimental technique for the application of slurry and digestate to growing crops: trailing hose/shoe or slot technique.

Results

The results of the field trials show a significant reduction of NH_3 emissions by acidification with sulfuric acid to pH 6 at the four locations in Schleswig-Holstein, Lower Saxony and Baden-Wuerttemberg for the measurement years 2019 and 2020. The open slot technique with a slot depth of about 5 cm also successfully reduced NH_3 emissions compared to application by trailing hose in winter wheat and trailing shoe in permanent grassland.

NH_3 mitigation potential in winter wheat and permanent grassland using application of cattle slurry as an example.



* Slot injection technique used in winter wheat only for 1st application

The addition of a nitrification inhibitor (DMPP) did not affect the level of NH_3 emissions. Although a higher overall NH_3 emission level occurred with biogas digestate application, the mitigation effect of the application techniques was comparable to cattle slurry application. Different soil properties and weather conditions at the time of application had a decisive influence on the level of NH_3 emissions.

In addition to NH_3 mitigation potential, N_2O emissions must also be considered to avoid pollution swapping of nitrogen losses. While NH_3 emissions were highest at the northern experimental sites, the highest N_2O emissions occurred at the site in Baden-Württemberg. The influence of weather conditions on N_2O emissions was evident in year-to-year comparisons. Lower precipitation in the second trial year 2020 resulted in significantly lower N_2O emissions compared to the previous year.

No unfavourable effects of NH_3-reducing application techniques on N_2O emissions were evident. The open slot technique with injection of cattle slurry at 5 cm soil depth did not increase N_2O emissions. A reduction in N_2O emissions due to the addition of the nitrification inhibitor could not be confirmed. Also, a possible increase in N_2O emissions due to acidification of cattle slurry and biogas digestate did not occur.

Besides to the site-differentiated analysis of NH_3 and N_2O emissions of the different application techniques, the project results were additionally evaluated in the context of German reporting for air pollutant emissions. Compared to the currently used NH_3 emission factors, the NH_3 emission factors determined in the project are lower and more differentiated by substrate types and application techniques. The project results indicate new lower NH_3 emission factors for the trailing hose/shoe and open slot techniques in grasslands and croplands. In addition, the project was able to derive an NH_3 emission factor for acidification of cattle slurry and biogas digestate for Germany. The N_2O emission factors of 0.18 to 1.2 %.of the applied N amount.are in a comparable range to the currently reported N_2O emission factors for Germany (Vos et al. 2022).

The project results also provide an important basis for agricultural extension, as they show the clear potentials of NH_3 reduction in crop production. At all test sites, the application of cattle slurry and biogas digestate to the growing crops in spring did not lead to a reduction in yield.

Conclusion and recommendations

We derive the following recommendations for further action:

- NH_3 mitigation measures do not lead to increased N_2O emissions.
- NH_3 emissions from the application of cattle slurry and biogas digestate to growing crops can be reduced by both acidification (greatest reduction) and slot injection (moderate reduction).
- When using acidification, the sulfur requirements of the crops must be considered. This limits the applicability for biogas digestate as it has a high acid neutralization capacity.
- Practical demonstration trials on the use and fertilization effect of low-emission application techniques should promote their implementation in practice.

Further Information

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