Knowns and Unknowns of the Use of Nitrogen Transformation Inhibitors

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Background

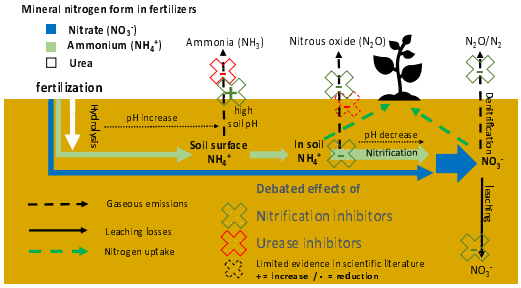


Fig 1: Mineral N transformations in soil influencing N_2O and NH_3 formation and debated effects of nitrification and urease inhibitors

- Agriculture causes ~80% of total nitrous oxide (N_2O) and ~95% of ammonia (NH_3) emissions in Germany, to a considerable extent through the use of synthetic and organic fertilizer (Fig 1.).
- **Nitrification (NI)** and **urease (UI) inhibitors** and their combination (**DI**) intensively discussed **to reduce nitrous oxide (N_2O**, NI) and **ammonia (NH_3**, UI) **emissions** (Fig. 1), already implemented for emission reduction (UI in Germany, Denmark).
- Yields and fertilization efficiency can be increased.

Do we know enough for broad and longterm use of NI and UI for emission mitigation?

Existing Knowledge and Knowledge Gaps

Knowns

Emission mitigation and agronomic efficacy
- Reduction of vegetation period N_2O emission by about 40% by NI (DMPP, DCD, Nitrpyrin)
- Reduction of NH_3 emission from urea and UAN by 60% by use of NBPT
- + yield and + NUE in meta-studies

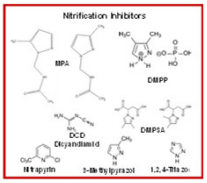
Unknowns

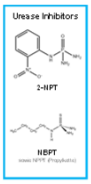
- Efficacy of several inhibitor compounds
- Effect on annual N_2O emission by NI and DI
- Reduction effect after long term application
- Yield effects under various cropping conditions

- Effect on soil fauna
- Effect on soil microbial community (long term)
- Metabolites
- Translocation of compounds in unsaturated and saturated zone

Knowns

Environmental fate/side effects
- Human uptake risk
- Decomposition and metabolites for some compounds (e.g. NBPT)
- translocation with soil water for some compounds
- Human / eco-toxicity labels





Use / mode of action of active ingredients
- 9 NI and 3 UI compounds registered in Germany / EU
- Functional mode of action (MoA) for UI and NI
- biochemical MoAf or UIs NBPT, 2-NPT, NPPT/NBPT

- biochemical mode of action for most NI
- amounts of active ingredient use in agriculture not reported/monitored
- dose/response relationships

- Some compounds would not be eligible for approval under pesticide regulation
- Test data not available
- Existing risk assessments/ REACH not sufficient
- Laboratory test not sufficient to assess compound efficacy

Regulation and available data
- All compounds REACH registered / CLP label
- All compounds with risk assessment
- Laboratory efficacy test for compounds under new EU Fertilizer Regulation

Conclusions

- **Use of (most) compounds for environmental mitigation policy not yet ready**, assessment, use should be compound specific or definition of minimum efficacy
- Need for a clear agreement on assessment protocols for emission mitigation efficacy, also and in particular for long-term use
- International agreement on product assessment/regulation similar to biocides
- further research and data needed, also for biological inhibitors

Further reading
- Grados D; et al. (2022): Synthesizing the evidence of nitrous oxide mitigation practices in agroecosystems. *Environ. Res. Lett.* 17 (11), S. 114024
- Matse, DT et al. (2024): Field efficacy of urease inhibitors for mitigation of ammonia emissions in agricultural field settings: a systematic review. In: Front. Environ. Sci. 12, Artikel 1462098, S. 719. DOI: 10.3389/fenvs.2024.1462098.
- Fan, D., et al. 2022. Global evaluation of inhibitor impacts on ammonia and nitrous oxide emissions from agricultural soils: A meta-analysis. Glob. Change Biol. 28 (17), 5121–5141. 10.1111/gcb.16294.
- Shang, Z. et al. (2020): Measurement of N2O emissions over the whole year is necessary for estimating reliable emission factors. In: Environmental pollution (Barking, Essex : 1987) 259, S. 113864. DOI: 10.1016/j.envpol.2019.113864.

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