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DEPT. PLANT AND ENVIRONMENTAL SCIENCES

Model-based estimate of long-term residual effects of slurry application on N-uptake of silage maize

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Problem

- Environmentally sound slurry use in silage maize is hampered by insufficient knowledge about mineralization of organic N as result of long-term slurry application
- Appropriate models may support analysis of long-term effects, where experimental tools fail

Objective

Quantify the residual N effect of cattle slurry in silage maize using the mechanistic SPN model, originally developed for barley (Bleken et al., 2001)

Material and Methods

Modeling data base

- Model calibration based on 5 years of data collected at Karkendamm, Northern Germany
- N fertilization treatments: 3 slurry rates (0, 20, 40 m³ ha^{-1}) and 4 mineral N rates (0, 50, 100, 150 kg N ha^{-1})
- Growth and N uptake recorded every two weeks, soil mineral N registered in spring and autumn, leaching losses estimated by suction cups

Simulation study

- SPN model used for long-term simulation study (1966-2002) of maize yield, N dynamics, and long-term slurry fertilizer value
- Periods of 3-9 years with slurry (30 m³ plus 50 kg mineral N ha^{-1}) interrupted by 3 years without manure and 130 kg mineral N fertilizer, and predicted plant N-uptake compared to that of crops receiving only mineral fertilizer (130 kg N ha^{-1}) every year

Results: model calibration

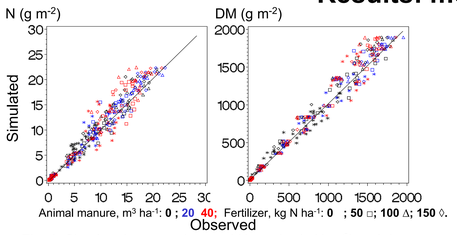

Fig. 1. Simulated versus observed N uptake (g N m^{-2}) and dry matter yield (g DM m^{-2}) sampled during the growing season

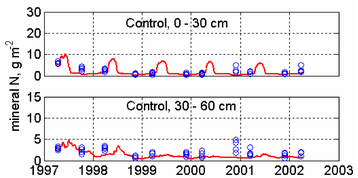

Fig. 2. Simulated (-) and observed (o) soil mineral N in control plots (receiving neither fertilizer nor animal manure)

- Total dry matter (DM) yields, N uptake and mineral N in the soil (Nmin) observed in the field trial well reproduced by the SPN model (Figs. 1-3)
- This was obtained by modifying parameters with respect to crop characteristics (phenology, root distribution, crical N curve), by changing RUE and LAI function of the original barley model, and by introducing a ploughing effect to better predict early N uptake

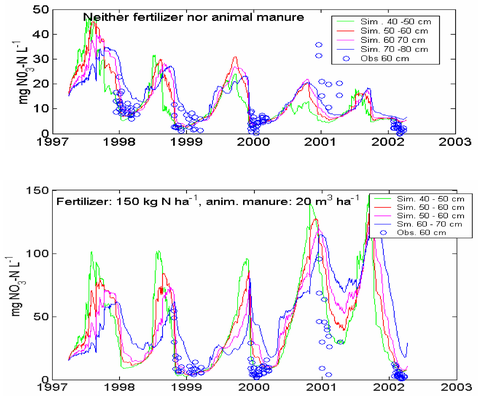

Fig. 3. Simulated and observed nitrate concentration in soil solution (60 cm depth) of the control and a highly fertilized treatment. Note change of scale

- RUE was estimated as function of irradiance and temperature, and LAI as function of biomass; the ploughing effect resulted in a rapid but transient burst of mineralization immediately after spring ploughing
- Soil N mineralization was calibrated using data from the control plots, i.e. without fertilizer or animal manure, and assuming a history of repeated silage maize cropping and manure application

Results: simulation study

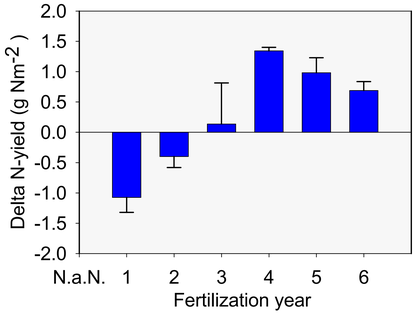

Fig. 4. Difference in in N yield (g N m^{-2}) between manured (3 years slurry followed by 3 years mineral) and mineral fertilizer only treatment, averaged over the simulation period (1966-2002)

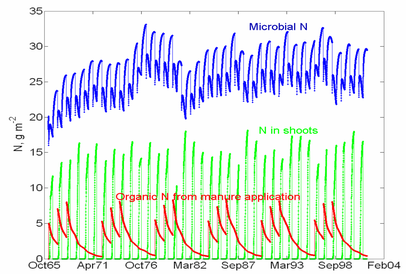

Fig. 5. Nitrogen dynamics of the slurry treatment (3 years slurry followed by 3 years mineral fertilizer) illustrated by microbial N, shoot N, and organic N from the slurry

- Results of model calibration document suitability of SPN model for studying seasonal N flows in soil-plant systems
- Three year application with 30 m³ ha^{-1} a^{-1} (100 kg N ha^{-1} a^{-1}, 50% as ammonium) plus 50 kg mineral N ha^{-1} a^{-1} increased crop N uptake in the following 3 years by 30 kg N ha^{-1}, i.e. 20% of organic N applied (Fig. 4)
- N recovery in the first three year after ceased slurry application was only marginally increased by slurry applications for periods longer than three years
- Nitrogen use efficiency, i.e. N-yield/(manure + fertilizer + deposition N), was somewhat lower in the manured than in the minerally fertilized maize
- N losses by denitrification and leaching, however, were not increased by the slurry treatment
- Unrecovered N in the slurry treatment was mainly found in a lower reduction of the humus N (4 kg N ha^{-1} a^{-1} in the slurry treatment vs. 10 kg N ha^{-1} a^{-1} in the mineral only treatment - the initial active humus N was nearly 5000 kg ha^{-1})

Conclusions

- This study suggests that about 20% or the organic N applied with manure is taken up by successive crops within a relatively short time (3 years)
- The apparent higher N efficiency of the mineral fertilizer only treatment occurred at the expense of the active humus N; manure contributed to sustaining the active humus pool