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Nitrogen use efficiency of different slurry management in the pre-alpine grassland region – a 15N tracing experiment

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Grasslands of the alpine and pre-alpine region do not only sustain economic soil functions such as fodder production for local dairy and cattle farming but also important ecological soil functions such as water and nutrient retention, erosion and flood protection and habitat provision for extraordinarily high plant and animal biodiversity. The current management in the more intensively used grasslands in this region is based on fertilization with liquid cattle slurry, which is assumed to be prone to high N leaching and gaseous N emissions with their undesired consequences for soil, air and water quality.

In order to assess the nitrogen use efficiency and trade-offs such as greenhouse gas emissions and nitrate leaching of liquid slurry surface application under the auspices of climate change, we set up a ^{15}N cattle slurry labeling experiment, combined with a space for time climate change experiment using plant-soil mesocosms and lysimeters. The ^{15}N signal was traced in the plant-soil-microbe system for an entire year to assess productivity, plant nitrogen use efficiency, soil nitrogen retention and nitrogen losses. We found surprisingly low plant nitrogen use efficiency (recovery of less than ¼ of the applied ^{15}N in harvested plant biomass), soil N retention (ca ¼ ^{15}N recovery) and high environmental N losses (ca ½ of the ^{15}N tracer remained unrecovered). The estimates of N losses based on unrecovered ^{15}N were in good agreement with independent measurements of gaseous and hydrological N losses. Due to very high productivity and associated N exports with grass harvests, total N exports exceeded total N inputs. Such soil nitrogen mining was especially pronounced in the climate change treatments and was supported by increased soil nitrogen mineralization.

We also tested alternative slurry management (slurry injection into the soil, slurry acidification) that is supposed to increase nitrogen use efficiency. Slurry acidification but not slurry injection slightly increased plant nitrogen use efficiency and reduced nitrogen losses, however could overall not prevent significant soil nitrogen mining.

Consequently, both surface application and the more modern techniques of liquid cattle slurry fertilization showed low nitrogen use efficiency and promoted soil nitrogen mining. This is asking

for a re-consideration of traditional fertilization regimes based on solid manure mixed with straw, a management that over historical timescales likely contributed to the build up of the large nitrogen stocks in pre-alpine grassland soils.