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STRATEGIES FOR WATER PROTECTION BY OPTIMISED N MANAGEMENT

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Abstract: Nitrogen (N) pollution of groundwater bodies is often a result of high livestock densities combined with use of mineral N fertilisers in Northwest Germany, specifically in combination with sandy soils and high amounts of precipitation. Organic agriculture is discussed as an alternative management practice reducing nitrogen losses due to area-based livestock densities and waiving of mineral N fertilisers. A field trial with integrated ceramic suction cups over three years showed potential for reduced N loads under conventional management specifically with organic fertilisation. Now, the field trial is under transition into organic farming with promising additional benefits for drinking water quality and the great potential to develop optimised N management strategies.

Introduction: Despite of comprehensive measures concerning the nitrate directive, the European Union groundwater quality standard of 50 mg NO3 l-1 is still exceeded in Northwest Germany (EC 2018). Main causes for nitrogen (N) pollution are high livestock densities on mainly sandy soils. Introducing N fertiliser regulations in water protection areas can be an effective strategy for improving ground water quality. Also, organic agriculture is discussed reducing nitrogen losses due to area-based livestock densities and waiving of mineral N fertilisers (Benoit et al. 2015). A comparison of conventional and organic cropping systems regarding nitrogen losses like nitrate leaching is often difficult due to different soil and climate conditions. Therefore, nitrate leaching related with cropping systems has been discussed contradictory in the past (Torstensson et al. 2006, Bergström et al. 2008, Benoit et al. 2014). Especially clover-grass-management practices like time of ploughing in combination with cutting regime seem to have a great optimisation potential regarding nitrogen transfer to the subsequent crop and nitrogen losses (Hansen et al. 2007, Dahlin and Stenberg 2010).

Material and methods: A field trial was established in 2016 on a loamy sand near Osnabrueck, Germany (52.31°N; 8.11°E) with a mean annual air temperature of 9.5°C and a mean annual precipitation of 883 mm (DWD 2019). From 2016 to 2019 the field trial was cultivated conventionally investigating the effects of reduced N-fertilisation (-10/-20 % for cereals/maize) in a winter wheat - winter barley – silage maize rotation with two fertilisation regimes (combined organic and mineral, only mineral). The field trial was performed in a randomized block design with three replications.

For analysing nitrate concentrations in the leaching water, ceramic suction cups were installed in 80 cm depth below the undisturbed root zone in each plot. Soil mineral N samples were taken at the beginning of the vegetation period, after harvest and at the end of the vegetation period in 0 to 90 cm depth. Additionally, crop yield and protein content were determined to calculate N balances and efficiency for each crop. Since 2020 the field trial is under transition to organic cultivation with adapted management practices and crop rotation (Tab. 1).

Tab. 1: Treatments within the organic crop rotation.

crop rotation	treatments			
clover-grass	harvesting		mulching	
	spring ploughed	autumn ploughed	spring ploughed	autumn ploughed
silage maize barley oat	Investigating nitrate leaching and N transfer of the different treatments			

The aim of the study is to identify clover-grass management practices which maximise N input via biological nitrogen fixation (BNF), minimise nitrogen losses via leaching and optimise N transfer to subsequent crops. BNF of clover in the clover-grass stands will be determined using the extended difference method to calculate N input. For examining nitrate leaching from clover-grass management, percolating water will be collected continuously during the winter period and analysed for nitrate content. Nitrogen transfer from clover-grass stands to the subsequent crops will be estimated in consideration of N input (BNF), soil mineral N, nitrate leaching, crop yield and N content of harvest products. Individual results for different important N management options are well known from the literature (Dahlin and Stenberg 2010). This study, however, combines 4 options in a factorial set-up within an entire cropping system to get better insights into the complex interactions and optimisation potentials of organic farming.

Results: Results from the previous three years under conventional cultivation revealed a slight potential for reduced nitrate loads without significant yield decreases by reduced N-application rates (-10/20%). Reduced N-fertilisation led to a mean decrease of nitrate loads (Fig. 1), largest effects were observed in the beginning of leaching water movement in early winter. Since this effect was more pronounced under the combined organic+mineral fertilisation regime it is very likely to achieve good impacts from organic management. After three years of reduced N-application rates protein contents started to decrease slightly in in 2018 for winter wheat. An adopted crop rotation under organic management is likely to compensate this by incorporating spring crops with a more synchronic N demand and delivery from mineralisation. Experiences from the previous trial showed, that different N-application rates did not lead to large differences in soil mineral N content at the beginning of the vegetation period but was depended on the previous crop. A high soil mineral N content after harvest was positively correlated with higher nitrate loads.

Discussion: In this study, N fertiliser regulations improved leaching water quality by reducing nitrate loads. However, a mean concentration of > 100 mg $NO3\ l^{-1}$ in percolating water does not comply with the EU nitrate directive. The results indicate that further strategies besides N fertiliser regulations are needed to prevent N pollution of ground water, especially regarding the increase of extreme weather conditions due to climate change. By converting the conventional field trial to organic cultivation in 2020 additional potential for ground water protection will be investigated. Although, the general potential for organic farming as key strategy for water protection is well-known, specific crop cultivation operations such as clover-grass management practices (e.g. time of ploughing and cutting regime) still show optimisation potential. Furthermore, the specific sensitivity of the given karst aquifer requests a lossless post-harvest N-management.

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Image:

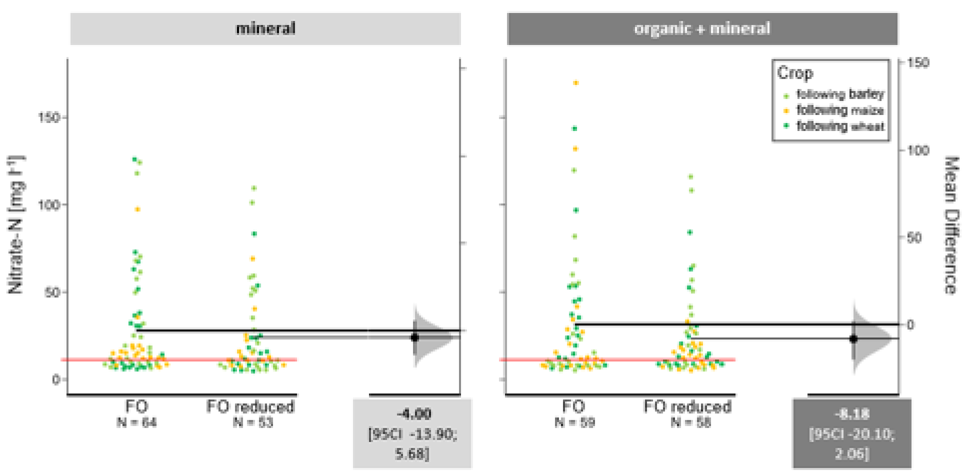

Fig. 1: Nitrate-N concentrations and mean reduction potenial in mg l^{-1} difference [95% confidence interval] between standard fertilser ordinance (FO) need estimation and reduced strategy.

Disclosure of Interest: None Declared

Keywords: nitrate directive, nitrate leaching, nitrogen transfer