Impact of N-fertiliser reduction on agronomic parameters and quality aspects for drinking water production in Northwest-Germany

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Abstract

Many groundwater bodies in Northwest-Germany suffer from nitrate leaching in regions with high livestock densities. In Belm-Nettetal (Lower Saxony) farmers have to reduce the nitrogen (N-)fertilisation by 10/20% in cereals/maize within protection zone II since 2017. Effects of this reduction on leaching water quality and crop yield was observed in a field trial. After two years, reduced N-fertilisation did not significantly affect grain or biomass yield but led to lower mean nitrate loads.

Keywords: nitrate leaching, fertiliser ordinance (Düngeverordnung), nitrate directive

1. Introduction

The demand by the European Water Framework Directive of a good ecological and chemical water quality was not reached all over Germany. Specifically, the groundwater bodies in the north western part with high livestock densities suffer from nitrate leaching. Since nitrate concentrations >50 mg l^{-1} cause problems for drinking water supply, some production areas are protected by special regulations for reduced N-fertilisation strategies. Within the drinking water production area Belm-Nettetal (Lower Saxony, Germany) a project was launched to observe the effects of reduced N-fertilisation (-10/-20 % for cereals/maize) on leaching water quality.

2. Materials and Methods

In 2016 suction cups were installed under a field trial with 3 crops (winter wheat, winter barley, silage maize) and 6 N-treatments (Tab. 1) with 3 replications in a randomised block design.

Tab. 1: Fertiliser treatments with mineral and combined organic+mineral application after fertiliser ordinance (FO) N-need estimation

N level	N type	
0	min	
50	min	
FO	min	org+min
FO reduced	min	org+min

During the winter season the percolating water was continuously collected below the root zone and analysed every second week for chemical parameters.

3. Results and Discussion

After 2 years, 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. With reduced N-fertilisation nitrate loads were on average 11 kg ha^{-1} lower following barley, 30 kg ha^{-1} lower following wheat and 21 kg ha^{-1} lower following maize which equals a mean load improvement of 14 % for mineral and 35 % for organic+mineral treatment.

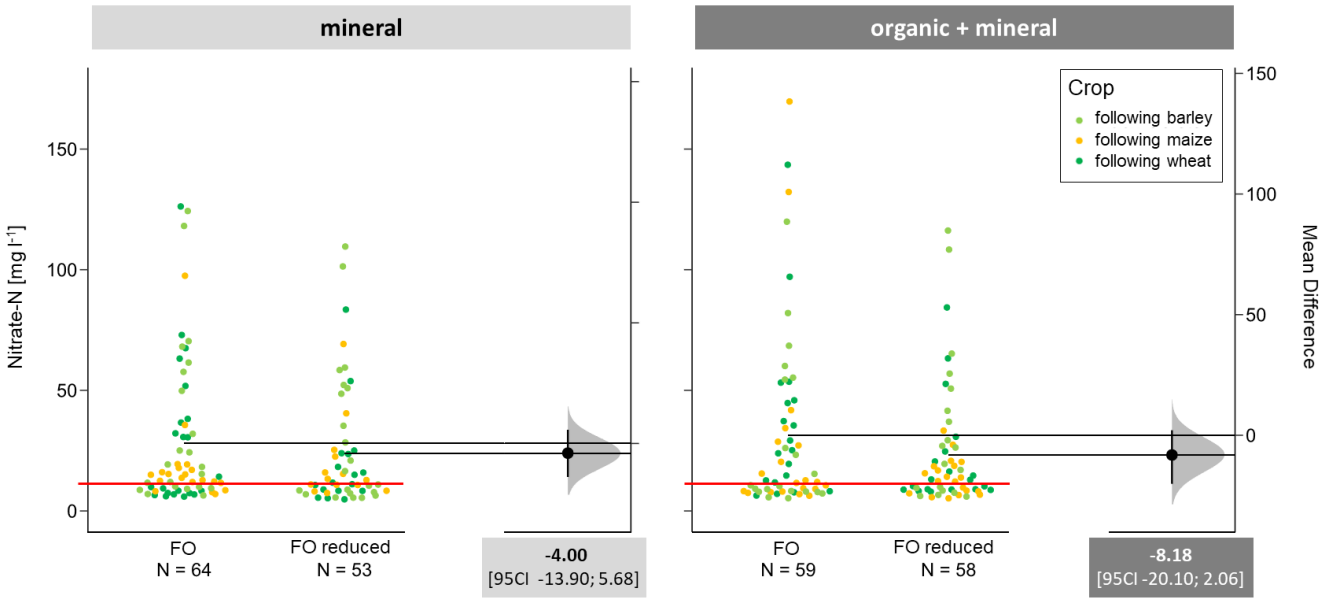

Fig 1.: Nitrate-N concentrations and mean reduction potenial in mg l^{-1} difference [95% confidence interval] between standard fertilser ordninance (FO) need estimation and reduced strategy.

Tab 2.: Mean yield (N=3) ± standard deviation in dt ha^{-1} for each treatment and year. (cereals: grain yield 86% dry matter; maize: whole crop silage dry matter yield; Tukey-Test (α=0.05), small/capital letters: significant differences min/org+min fertilisation

	winter barley		winter wheat		silage maize	
	min	org+min	min	org+min	min	org+min
2017						
0	27.6 ±2.0 b		21.9 ±4.0 c		178.0 ±14.9 b	
50	46.6 ±1.0 ab		39.5 ±1.8 b		216.8 ±1.9 a	
FO	56.3 ±2.0 a	53.8 ±3.4 A	56.9 ±7.2 a	48.7 ±6.5 A	220.9 ±5.4 a	197.6 ±17.1 A
FOred	53.1 ±3.0 ab	49.9 ±4.5 A	52.9 ±2.3 ab	46.1 ±7.4 A	225.5 ±20.6 a	224.8 ±26.2 A
2018						
0	25.5 ±1.5 c		29.6 ±3.5 c		128.2 ±6.9 b	
50	46.8 ±2.5 b		54.5 ±3.1 b		176.8 ±5.9 a	
FO	64.1 ±1.1 a	57.6 ±2.9 A	85.9 ±2.3 a	80.2 ±2.2 A	160.9 ±16.2 a	148.9 ±18.0 A
FOred	65.2 ±1.3 a	57.6 ±1.0 A	86.0 ±2.2 a	74.5 ±4.7 A	177.0 ±9.5 a	154.5 ±17.4 A

Despite low nitrogen balance surpluses and increasing dillution effects over the winter period only 44 % of all measured samples reached the NO_3-limit.

Yields were not significantly affected by reduced N-application for both fertiliser regimes (Tab. 2). Whilst protein contents were not affected in 2017 slightly reduced grain quality was observed under dry conditions in 2018.

4. Conclusion and Perspectives

A moderately reduced N-fertilisation (by 10/20 %) led to increased water quality without significant effects on yields in the first 2 years.

After finishing the 3rd measurement campain the study site will be converted into organic farming with a following project to observe the transition effects.

Acknowledgements

The project in cooperation with LWK NI was funded by NLWKN. Thanks to M. Kohlbrecher for technical support.