UNIVERSITÄT HOHENHEIM

LUFA Speyer

The study site affects the magnitude of N_2O emissions but not the efficacy of mitigation strategies

Reiner Ruser[1], Perik Seiz[1], Andreas Heger[2], Ivan Guzman-Bustamante[1], Rudolf Schulz[1], Martin Armbruster[2], Franz Wiesler[2], Torsten Müller[1]

[1]University of Hohenheim, Institute of Crop Science, Department Fertilization and Soil Matter Dynamics, D-70599 Stuttgart

[2]Landwirtschaftliche Untersuchungs- und Forschungsanstalt, D-673460 Speyer

Introduction

Vegetable production is often associated with high N surpluses, posing the risk of substantial N losses. So far, strategies to reduce N losses into the environment mainly focused on nitrate leaching, whereas only few studies determined the effect on N_2O emissions from vegetable fields. Since N_2O emissions strongly depend on environmental conditions at the study site we aimed to test (i) the application of an optimized N fertilization system, (ii) the use of a nitrification inhibitor, and (iii) the removal of N-rich crop residues as potential N_2O reduction strategies at two vegetable-cropped sites with contrasting physical soil properties.

Material & Methods

Trace gas measurements were conducted (over 608 days) at an experimental farm of the University of Hohenheim (**loamy site**: Haplic Luvisol, 68% silt, 30% clay, 1.8% C_{org}) and the farm of the LUFA Speyer (**sandy site**: Cambisol, 80% sand, 14% silt, 0.72% C_{org}) using closed chambers. Treatments tested: 1) unfertilized (*control*), 2) N-fertilization commonly applied by farmers (*high N*), 3) an optimized-fertilization strategy (*opt N*) adopted to the plant demand, 4) application of a nitrification inhibitor (3,4-DMPP) (*+NI*), and 5) removal of the crop residues (*-CR*). Sum of rainfall and irrigation was 179 and 284 mm during the cauliflower season and 363 and 673 mm during the lettuce & broccoli season in Hohenheim and Speyer, respectively. Mean air temperature over the whole experiment was 1.15°C higher in Speyer.

Results

- ⇨ Almost always highest N_2O flux rates in the *high N* treatment (Figure 1) which also showed the highest nitrate contents in the top soil (significant correlations between N_2O fluxes and soil nitrate at both study sites, not shown).
- ⇨ Higher N_2O fluxes in Hohenheim, which was mainly the result of the higher water content of the loamy soil in Hohenheim. WFPS accounted for 29.6% of the variability of the N_2O fluxes in Hohenheim. Only low degree of explanation in Speyer.
- ⇨ Very high N_2O fluxes during the second winter period in Hohenheim, not always the result of frost/thaw cycling! High soil moisture and the turnover of the crop residues (high amounts and low C/N ratio) favored creation of anaerobic microsites and thus the N_2O release from denitrification.

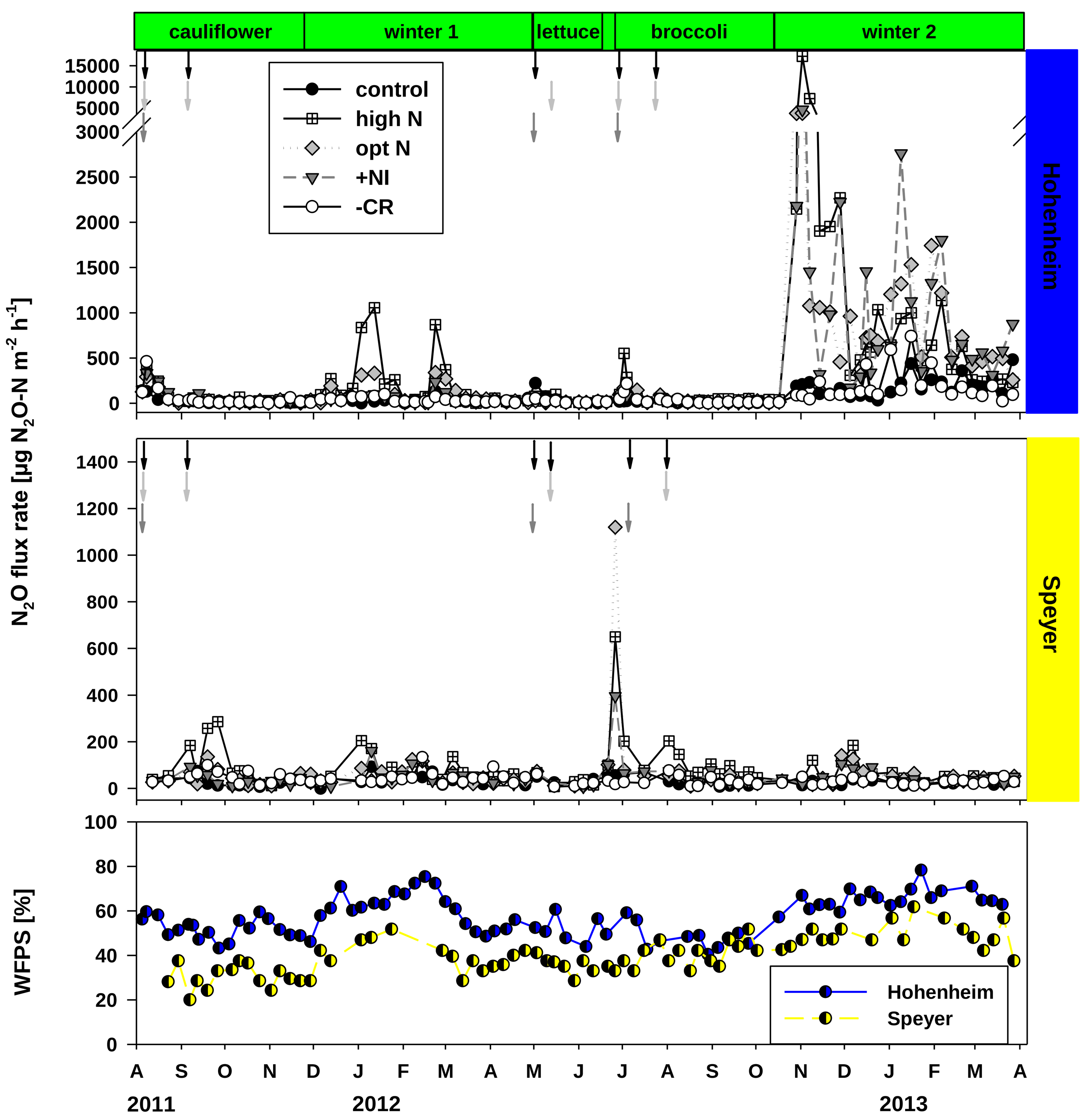

Fig. 1: Mean N_2O flux rates (n=4) as affected by N-fertilization and mitigation strategy and mean (over all treatments) water-filled porosity at the study sites. Arrows indicate N applications.

Tab. 1: Mean cumulative N_2O emissions during the single periods and for the whole experimental period and N_2O reduction of the mitigation strategies as affected by study site.

Site	Treatment	Cauliflower	Winter 1	Lettuce & broccoli	Winter 2	Total	Reduction vs. high N
		------------------------	kg N_2O-N ha^{-1}	------------------------			[%]
Hohenheim	control	$0.86^{c,d}$	1.06^{e}	1.08^{d}	7.49^{c}	10.50^{c}	
	high N	1.95^{a}	6.92^{a}	$2.18^{b,c}$	66.33^{a}	77.39^{a}	
	opt N	$1.72^{a,b}$	$3.90^{a,b}$	$1.45^{c,d}$	$46.29^{a,b}$	$53.35^{a,b}$	$31.1^{c,d}$
	+NI	1.85^{a}	$1.91^{c,d}$	1.06^{d}	41.68^{b}	46.50^{b}	39.9^{c}
	-CR	$1.73^{a,b}$	$1.30^{d,e}$	1.00^{d}	7.28^{c}	11.30^{c}	85.4^{a}
Speyer	control	0.67^{d}	$1.46^{d,e}$	$1.41^{c,d}$	0.99^{f}	4.53^{e}	
	high N	2.17^{a}	$2.59^{b,c}$	4.09^{a}	2.09^{d}	10.93^{c}	
	opt N	$1.01^{c,d}$	$1.85^{c,d}$	$3.21^{a,b}$	1.88^{d}	$7.96^{c,d}$	27.2^{d}
	+NI	$0.83^{c,d}$	$1.77^{c,d}$	$2.25^{b,c}$	$1.74^{d,e}$	$6.59^{d,e}$	39.7^{c}
	-CR	$1.13^{b,c}$	$1.65^{c,d,e}$	1.22^{d}	$1.16^{e,f}$	$5.12^{d,e}$	53.2^{b}

Values with the same letter within a period are not significantly different (LSD test, $\alpha = 0.05$).

- ⇨ Over the entire period, N_2O emission in Hohenheim was between factor 2 and 7 higher than in Speyer (Table 1).
- ⇨ All reduction strategies (*opt N*, *+NI*, and *–CR*) resulted in lower N_2O emissions (over the whole period) when compared to the *high N* treatment.
- ⇨ Highest reduction in the *–CR* treatment down to the emission level of the unfertilized *control.*
- ⇨ Despite strongly varying amounts of N_2O emitted, the reduction efficacy of the mitigation strategies was similarly successful at both study sites.

Conclusions

Denitrification was the main source for N_2O formation and thus, higher soil moisture at the loamy site resulted in higher N_2O emissions.

Despite the different levels of N_2O emissions, the reduction potential for the *opt N* system (~30%) and for the *+NI* treatment (~39%) was similar at both sites. The most effective measure for N_2O reduction at both sites was the removal of crop residues. Further studies should focus on the effect of the removal on the humus contents. For an overall assessment of the environmental impact of residue removal, emissions during the processing of the residues have to be taken into account.

Visit our homepage, download the posters & find more details

Contact:
Reiner Ruser
Reiner.ruser@uni-hohenheim.de