Influence of O_2 Availability on Nitrous Oxide Production via Nitrifer Demotrofocatopm

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Introduction

The development of mitigation strategies to reduce anthropogenic nitrous oxide (N_2O) emissions from agricultural soil is dependent on explicating the biophysical factors affecting N_2O production. Nitrification, nitrifier denitrification, denitrification are considered as the main pathways of N_2O production (Fig.1), depending on conditions such as nitrogen form, soil pH and O_2 availability [1].

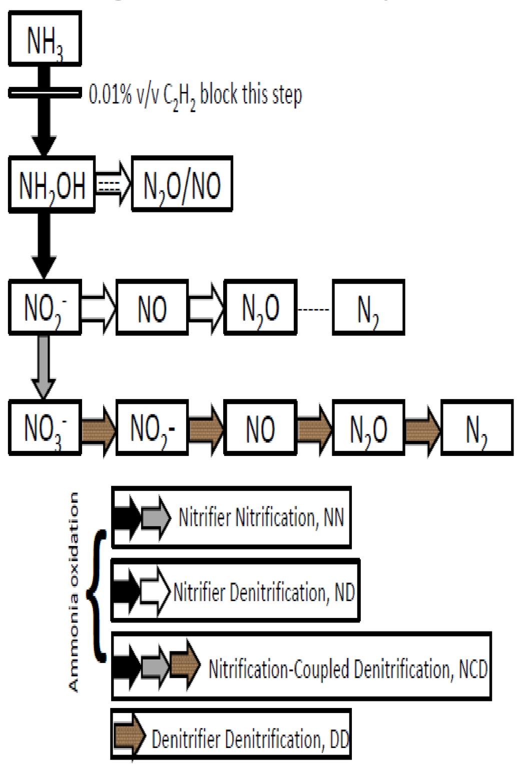

Fig. 1 the main pathways of N_2O production in soil

Previous research has examined soil management, most notably soil moisture, fertilizer N rates, organic amendments[2,3]. Although O_2 availability is the main factor controlling N_2O production, its role in affecting the microbial pathways generating N_2O has rarely been considered other than being indirectly associated with soil moisture status.

Objective

- To examine the interaction of fertilizer N source and O_2 content in influencing the production of N_2O.
- To describe the relative activity of microorganisms producing N_2O as affected by oxygen and fertilizer.

Materials and Methods

- Pre-incubation for 7 days was done before experiment began.

Soil	location	Previous crop	% C	% N	Soil pH (1:1 KCl)
Clay loam	Dixon, CA	wheat	1.60	0.14	5.6

- *C_2H_2 experi*... rtilizer (Control, Urea ... × two C_2H_2 (no C_2H_2 ... 21, 3, 0.5 or 0% O_2 in headspace) treatments. All treatments were set up as a fully randomized design and incubated with 50% of WHC at 22°C. The incubation period was 36 hours.
- ***^{15}N-^{18}O experiment:*** soil received two types of NH_4^+-N fertilizer treatments (Urea or $(NH_4)_2SO_4$, 50 mg N kg^{-1} soil). Each fertilizer treatments receive four different treatments as follows: [1] $H_2^{18}O$ + NO_3^- +NH_4^+; [2] H_2O + $N^{18}O_3^-$ +NH_4^+; [3] H_2O + $^{15}NO_3^-$ + NH_4^+; [4] H_2O + NO_3^- + $^{15}NH_4^+$. ^{18}O enriched H_2O or NO_3 at 1.0 atom% excess; 15N enriched NH4+ or NO3- at 6.0 atom% excess. All treatments were done under the same condition as in C_2H_2 experiment.

Results and discussion

N_2O release and sources − data from C_2H_2 experiment

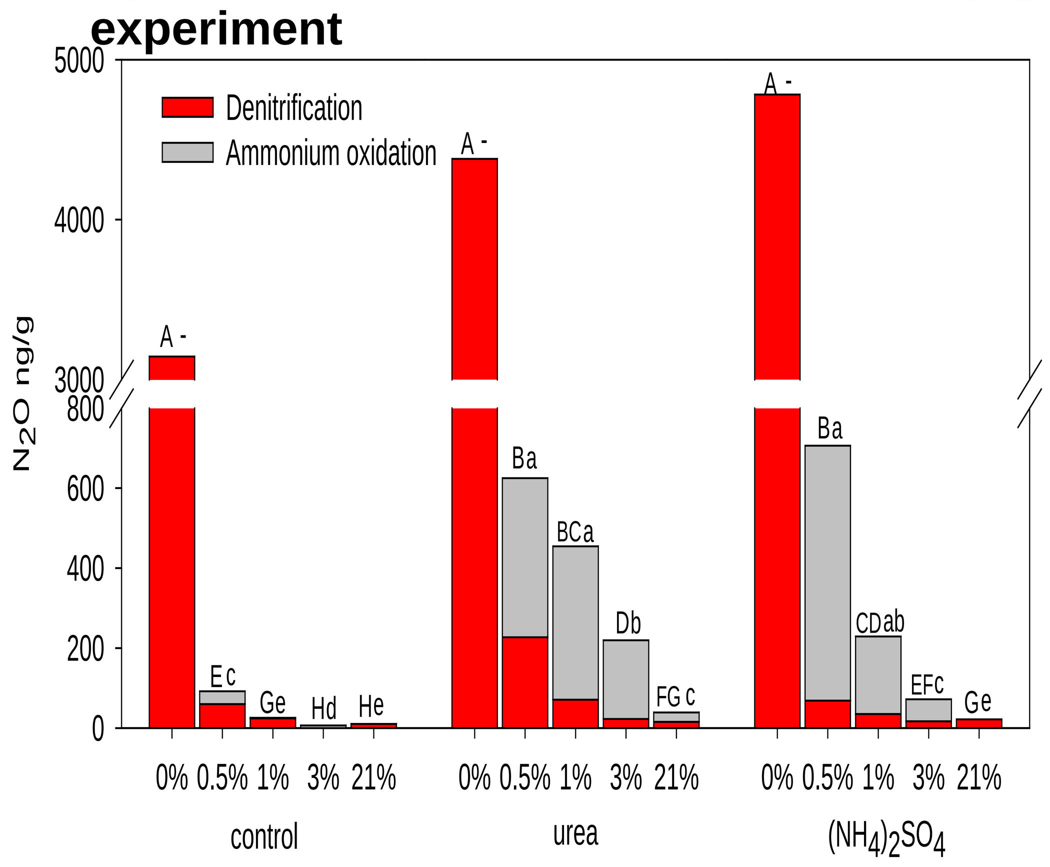

Fig.2 Total N_2O production. N_2O from ammonia oxidation was calculated as the difference between no C_2H_2 and C_2H_2 treatment. O_2 levels are indicated on the x axes. Different uppercase letters indicate a significant difference in total N_2O emission across all treatments, and lowercase letters indicate a significant difference in the proportion of N_2O derived from ammonia oxidation.

At O_2 > 0%, **ammonia oxidation** is the **dominant pathway** of N_2O.

MORE N_2O derived from ammonia oxidation in urea than in $(NH_4)_2SO_4$ soil.

Which pathway in ammonia oxidation is the main pathway responsible for these changes ?

Results and discussion

Distinguish the pathway of N_2O produced from NH_4^+ oxidation − data from ^{15}N-^{18}O experiment

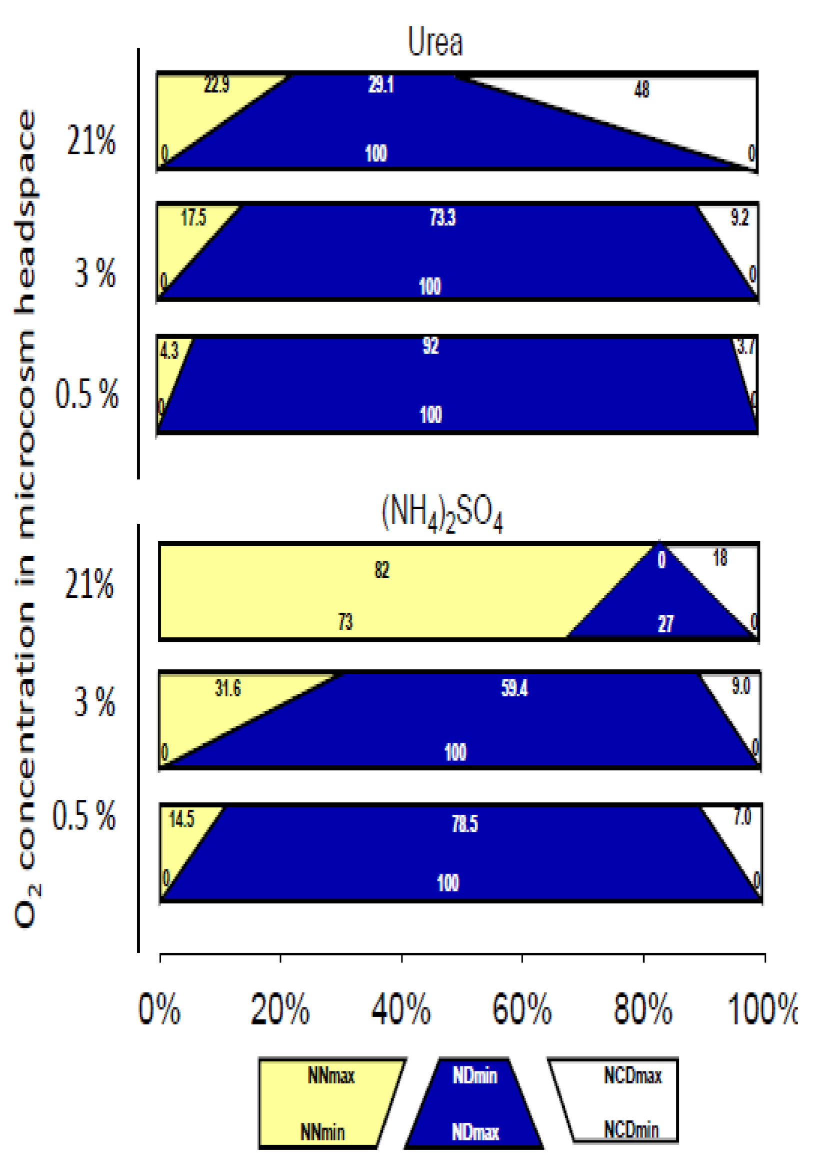

Fig.3 Relative contributions of pathways to N_2O (NH_4^+) . ND is nitrifier denitrification, NN is nitrifier nitrification, NCD is nitrification coupled denitrification.

Nitrifier denitrification was the **main pathway** in ammonia oxidation responsible for the N_2O production, its relative contribution to N_2O production was increased by limited-O_2 availability and urea application

Results and discussion

Soil gross nitrification rate and the amount of N_2O relative to nitrified NO_3^-

Oxygen content	Nitrification rate ng N g^{-1} h^{-1}		N_2O emitted from nitrified N %	
	Urea	$(NH_4)_2SO_4$	Urea	$(NH_4)_2SO_4$
21%	562[Aa]	357[Ba]	0.11[Ac]	0.08[Bc]
3%	258[Ab]	203[Ab]	2.85[Ab]	0.52[Bb]
0.5%	117[Ac]	98.7[Ac]	8.31[Aa]	6.87[Aa]
0%	0.00	0.00	0.00	0.00

Table 2. For each measurement, different uppercase letters indicate a significant difference between urea and $(NH_4)_2SO_4$, and lowercase letters indicate a significant difference among results for each O_2 level

Gross nitrification rates **decreased** as O_2 **decreased** from 21 to 0.5%.

However, the quantity of N_2O-N produced relative to nitrified N **increased**. At 0% O_2, gross nitrification ceased.

Urea addition to soil increased both nitrification rate and the quantity of N_2O-N relative to of nitrified N, resulting in **greater** production of N_2O as compared to $(NH_4)_2SO_4$ at 21% O_2.

Conclusions

N_2O derived from ammonia oxidation increased as O_2 concentration in the headspace decreased, and that this pathway was the main source of N_2O when O_2 concentration was ≥ 0.5%.

Nitrifier denitrification was proved to be the prime pathway of N_2O production in ammonia oxidation responsible for these increases.

As O_2 concentration decreased, **MORE** N_2O-N was produced relative to nitrified N, though gross nitrification rates **decreased** .

Literature Cited

[1]Wrage, N., Velthof, G.L., van Beusichem, M.L., Oenema, O., 2001. Soil Biol Biochem 33, 1723-1732. [2] Bateman, E.J., Baggs, E.M., 2005. Biol Fert Soils 41, 379-388. [3] del Prado, A., Merino, P., Estavillo, J.M., Pinto, M., Gonzalez-Murua, C., 2006. Nutr Cycl Agroecosys 74, 229-243.

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