Pervasive control of soil pH on N_2O and N_2 emissions under anaerobic conditions from upland agricultural soils across China

Feifei Zhu[1], Yunting Fang[1]*, Limei Zhang[2], Rong Sheng[3], Wenxue Wei[3], Jizheng He[2,4]

[1]Key Laboratory of Forest Ecology and Management, Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang 110016, China
[2]State Key Laboratory of Urban and Regional Ecology, Research Centre for Eco-environmental Sciences, Chinese Academy of Sciences, Beijing, 100085, China
[3]Key Laboratory of Agro-ecological Processes in Subtropical Region, Institute of Subtropical Agriculture, Chinese Academy of Sciences, Changsha 410125, China
[4]Faculty of Veterinary and Agricultural Sciences, The University of Melbourne, Parkville, VIC, 3010, Australia

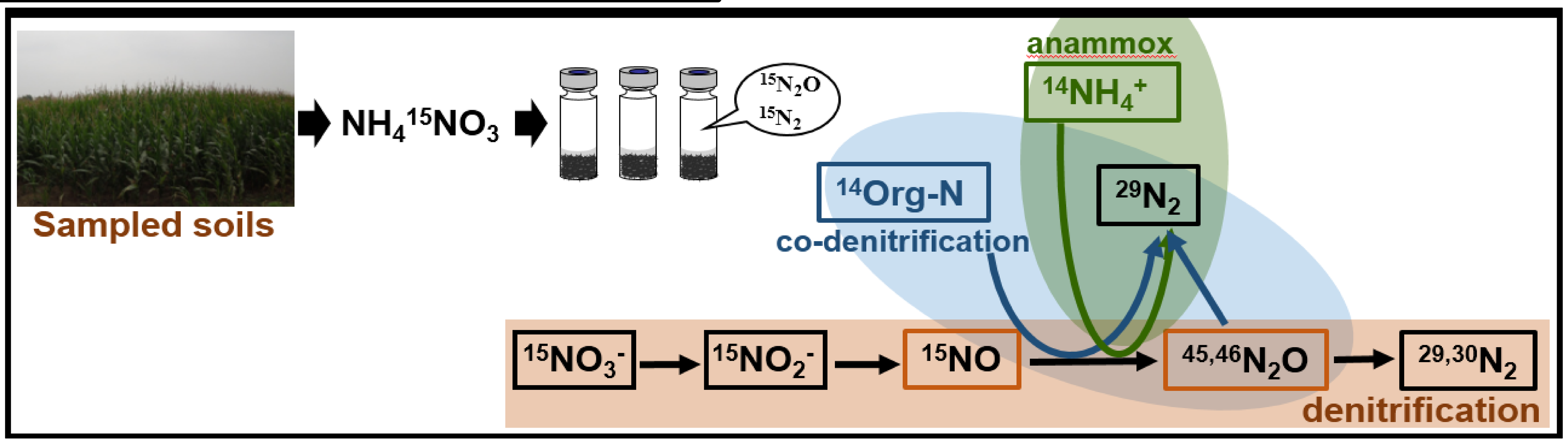
Background

- Soil N_2 emission is an important pathway of N losses, which is difficult to quantify in terms of both the magnitude and the contributions of the processes involved in, yielding uncertainty in closing the N budget for agricultural systems;
- Soil pH might be the most important factor influencing both denitrification and N_2O production, but it remains largely unclear if soil pH regulate the $N_2O/(N_2O + N_2)$ ratio in natural soil pH gradients over relatively large regional scales;
- We know rather little on the contributions of denitrification, co-denitrification to N_2O production, and denitrification, co-denitrification plus anaerobic ammonium oxidation (anammox) to N_2 productions.

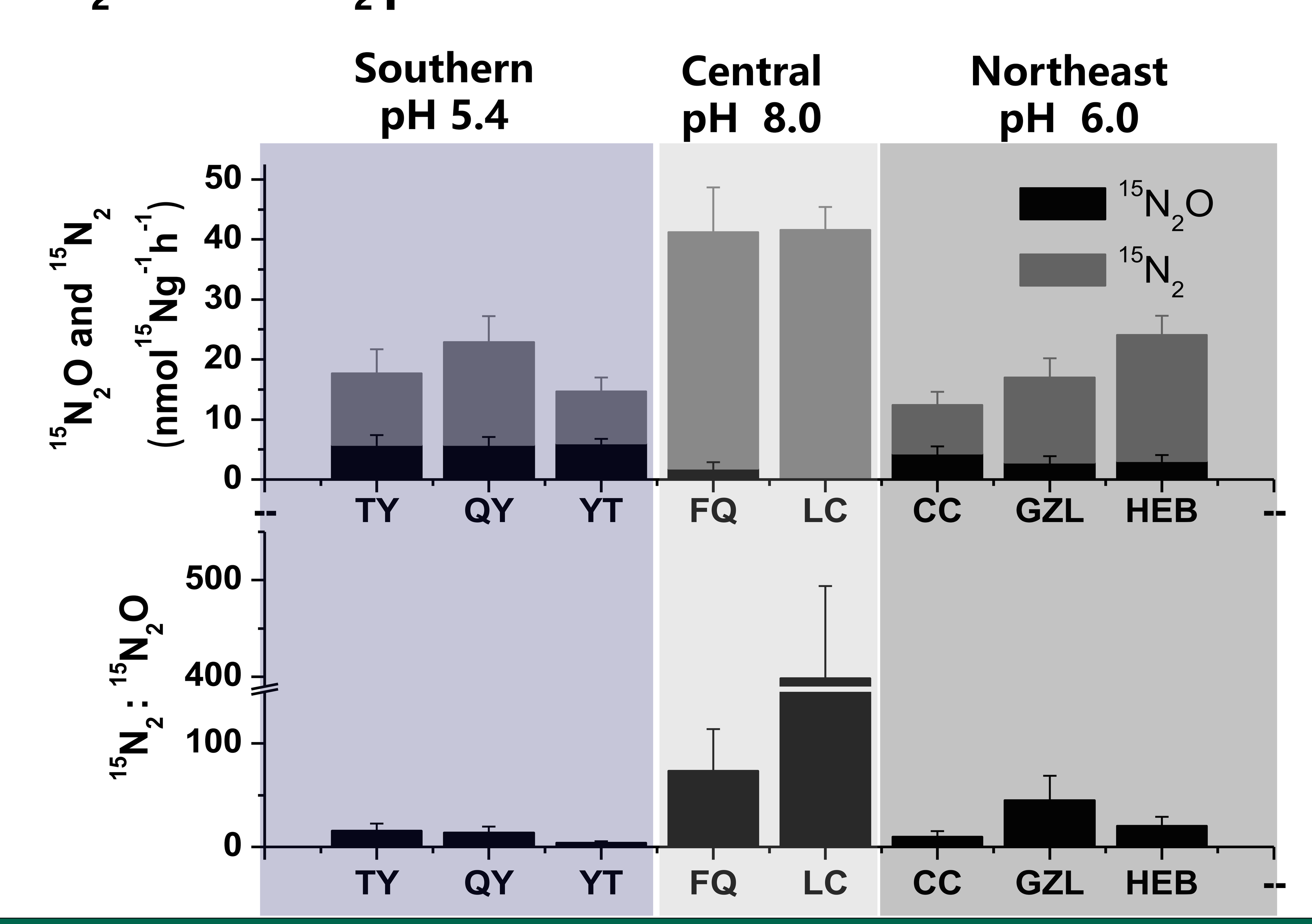
Objectives

- We investigate the influence of environmental factors, especially pH on N_2O and N_2 production, as well as on the $N_2O/(N_2O+N_2)$ ratios in eight areas from three representative agricultural regions across China (northeast, central and southern China);
- We also partitioned the sources of N_2O and N_2 to denitrification or co-denitrification plus anammox based on the different ^{15}N isotope pairing between these processes;
- The overall objective was to improve our understanding of potential N gas losses (N_2O+N_2, except NO and NH_3), $N_2O/(N_2O+N_2)$ ratios, controlling factors, and responsible processes (denitrification vs. co-denitrification plus anammox) from major Chinese upland agricultural soils.

Experimental routes

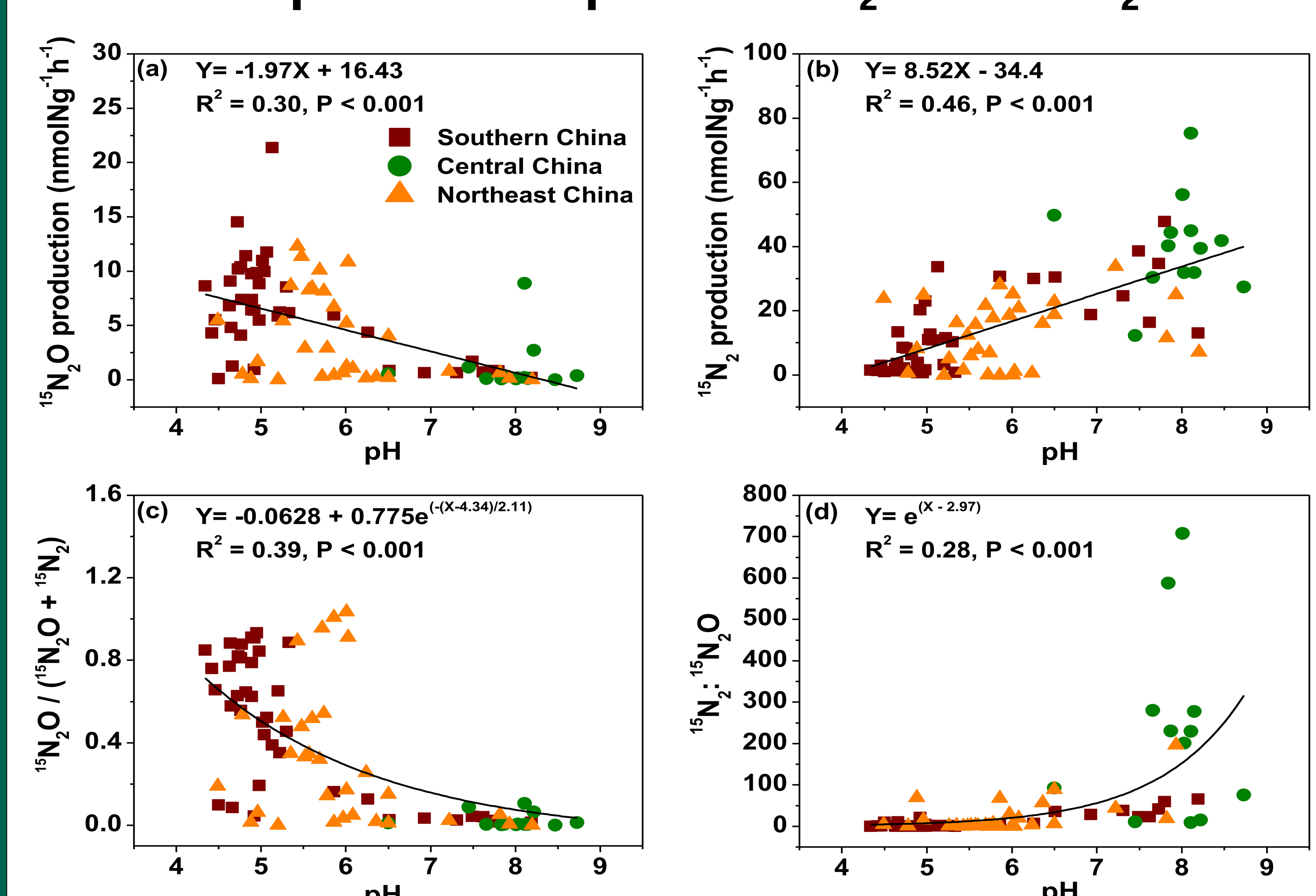


$^{15}N_2O$ and $^{15}N_2$ productions



- N₂ was the dominant end production of denitrification under anaerobic conditions;
- N_2 productions were high at soils with high pH;
- N_2: N_2O ratios ranged from 4 to 372.

Relationships between pH and $^{15}N_2O$ and $^{15}N_2$



- As soil pH increased, N_2O production decreased, N_2 production increased;
- N_2O production was high at low pH soils, suggesting possible N_2O reduction inhibition;

Contributions of denitrification and co-denitrification to N_2O and N_2 productions

Areas	$^{15}NO_3^-$ fraction (Fn, %)	N_2O Rate (nmol N g^{-1} h^{-1})		N_2O Contribution (%)		N_2 Rate (nmol N g^{-1} h^{-1})		N_2 Contribution (%)	
		Denitrification	Co-denitrification	Denitrification	Co-denitrification	Denitrification	C+A	Denitrification	C+A
TY	97.6±0.3	6.5±1.8	0.07±0.04	99.0±0.5 ab	1.0±0.5 b	12.4±4.2 b	0.43±0.15	81.9±6.4 ab	18.1±6.4 ab
QY	97.7±0.1	6.4±1.5	0.17±0.03	95.7±1.1 ab	4.3±1.1 b	18.0±4.6 b	0.07±0.03	97.6±1.2 a	2.4±1.2 b
YT	97.8±0.1	6.7±0.9	0.15±0.02	97.7±0.2 ab	2.3±0.2 b	9.2±2.4 b	0.11±0.04	93.6±3.1 ab	6.4±3.1 ab
FQ	97.7±0.0	2.0±1.3	0.05±0.02	92.1±2.2 ab	7.9±2.2 ab	41.5±7.9 a	0.00±0.00	100.0±0.0 a	0.0±0.0 b
LC	97.9±0.1	0.1±0.0	0.02±0.01	85.2±1.6 b	14.8±1.6 a	43.6±3.9 a	0.00±0.00	100.0±0.0 a	0.0±0.0 b
CC	92.8±2.6	6.3±2.1	0.13±0.08	94.1±3.1 ab	5.9±3.1 ab	8.6±2.4 b	0.55±0.31	65.3±10.8 b	34.7±10.8 a
GZL	92.4±5.5	3.0±1.2	0.41±0.27	89.3±4.0 ab	10.6±4.1 ab	14.9±3.4 b	0.18±0.12	92.7±6.6 ab	7.3±6.6 ab

- Denitrification was the dominant process producing both N_2O and N_2;
- Denitrification contributed to 85~99% of N_2O, and 65~100% of N_2 productions, as compared with co-denitrification (plus anammox for N_2).