

Supplementary Materials:

Table S1: The studies used in the meta-analysis to evaluate the impacts of cropping systems and soil management practices on area-scaled N₂O emission, crop yields, and yield-scaled N₂O emission during wheat and maize growing seasons

Cropping season	Location	O ^a	Area-scaled N ₂ O (kg N ha ⁻¹)	Crop yield (Mg ha ⁻¹)	Yield-scaled N ₂ O (kg CO ₂ eq Mg ⁻¹)	Cropping system ^b	Soil management practices				Citation
							N application rate (kg N ha ⁻¹)	Enhanced-Efficiency fertilizer ^c	Organic amendments	Tillage ^d	
Wheat	Nanjing	18	2.60-9.29	1.13-7.57	506-1079	W-R,W-U	0, 100, 150, 200, 225, 300	-	-	NT, RT	Chen et al. 2008
Wheat	Tai'an	6	1.33-1.64	6.10-7.73	86-125	W-U	-	-	straw	NT, RT	Zhao 2008
Wheat	Changwu	5	1.65-2.96	1.39-4.08	91-734	W-U	0, 120	-	manure	-	Li 2009
Wheat	Nanjing	4	0.08-3.80	0.92-6.62	8-618	W-R	0, 220	-	-	-	Huang 2011
Wheat	Jurong	3	0.98-1.93	5.78-5.97	78-151	W-R	-	-	-	-	Ma et al. 2011
Wheat	Jurong	4	0.36-2.14	3.50-7.01	48-143	W-R	0, 100, 200, 270	-	-	-	Ji et al. 2012a
Wheat	Liuhe	4	0.54-1.22	7.60-8.02	33-71	W-R	-	-	straw, manure	-	Sun et al. 2012b
Wheat	Liuhe	4	0.39-1.22	6.85-8.02	23-71	W-R	-	-	straw, manure	-	Sun et al. 2012a
Wheat	Jiangning	5	10.8-16.3	5.77-6.99	851-982	W-R	-	-	straw, manure	-	Zou et al. 2006
Wheat	Yongji	6	0.48-1.08	6.3-8.2	34-67	W-U	0, 60, 120, 180, 300, 400	-	-	-	Liu et al. 2012
Wheat	Yongji	2	1.5-1.6	5.59-6.11	115-134	W-U	-	-	straw	-	Liu et al. 2011a
Wheat	Jurong	4	1.86-3.18	5.25-6.15	166-257	W-U	-	-	straw	-	Ma et al. 2010
Wheat	Shanxi	5	1.12-3.38	1.39-4.08	173-904	W-U	0, 120	-	manure	-	Wei et al. 2010
Wheat	Helan	4	0.08-0.96	0.59-5.14	39-87	W-U	0, 150	-	manure	-	Cai et al. 2013
Wheat	Jurong	12	0.35-3.93	2.93-4.79	51-391	W-R	0, 100, 200, 270	CRF	-	-	Ji et al. 2012b

Wheat	Qiyang	4	0.16-0.80	0.28-1.51	259-540	W-U	0, 90	-	manure	-	Zhai et al. 2011
Wheat	Changsu	8	0.57-1.98	1.65-5.81	68-188	W-R	0, 200	NI	-	NT	Ma et al. 2013
Wheat	Huaitai	5	0.51-0.94	3.15-7.39	53-75	W-U	0, 300	CRF	-	NT	Shi et al. 2013
Wheat	Suzhou	2	1.90-3.70	5.20	171-333	W-R	-	-	-	-	Peng et al. 2013
Wheat	Changsu	2	0.75-4.56	1.92-6.07	182-366	W-R	0-180	-	-	-	Ma et al. 2013
Wheat	Yongji	2	0.92-1.32	6.70-7.10	61-92	W-U	-	NI	-	-	Liu et al. 2013a
Wheat	Quzhou	6	0.22-1.02	2.90-4.45	35-108	W-U	-	CRF, NI	straw, manure	-	Hu et al. 2013
Wheat	Luancheng	8	0.76-1.04	5.88-6.87	58-70	W-U	-	-	-	-	Song et al. 2013
Wheat	Xinxiang	7	0.29-0.88	6.67-7.67	20-55	W-U	-	-	straw, manure	NT, RT	Zhang et al. 2013
Wheat	Huaitai	6	0.38-2.41	3.00-6.90	15-217	W-U	0, 180, 270	-	-	-	Yan et al. 2013
Wheat	Wuxi	4	1.53-3.91	5.83-6.60	109-326	W-R	-	-	straw	NT	Yao et al. 2013
Wheat	Sichuan	4	0.03-1.03	0.60-3.70	23-133	W-U	0, 52,78,130	-	straw, manure	-	Zhou et al. 2014
Wheat	Jiangsu	5	0.79-1.15	4.10-4.80	77-131	W-R	-	-	-	-	Jiang et al. 2015
Wheat	Hebei	5	0.36-0.87	5.17-9.51	23-48	W-U	0,225,280	NI	-	-	Liu et al. 2015
Wheat	Hebei	7	0.27-0.73	3.33-7.80	25-55	W-U	0,150,225,300	NI	-	-	Wang et al. 2015
Wheat	Shandong	4	0.69-1.07	7.32-7.99	40-66	W-U	-	CRF	-	-	Xu et al. 2015
Wheat	Henlan	7	0.35-0.84	5.33-8.20	29-48	W-U	0,225	-	-	-	Han et al. 2016
Wheat	Sichuan	6	0.04-0.24	1.27-3.71	14-84	W-U	-	-	straw, manure	-	Liu et al. 2016
Wheat	Shandong	4	0.89-1.86	7.44-8.57	56-104	W-U	0,225	CRF	-	-	Zhang et al. 2016
Maize	Tai'an	6	4.65-5.63	8.02-9.41	239-289	M-U	-	-	straw	NT, RT	Zhao 2008
Maize	Ziting	6	0.96-2.69	0.41-7.45	133-1105	M-U	0, 150	-	straw, manure	-	Zeng 2011
Maize	Xianlin	6	0.29-0.53	1.80-3.48	57-79	M-U	-	-	-	-	Guo et al. 2009
Maize	Yongji	2	1.90-3.00	7.51-7.60	117-187	M-U	-	-	straw	-	Liu et al. 2011a
Maize	Baoding	6	1.18-9.07	7.56-9.51	73-447	M-U	0, 180, 300	CRF	-	-	Shi 2012
Maize	Baoding	2	4.25-5.92	11.81-11.88	169-233	M-U	-	-	straw	-	Pei et al. 2012

Maize	Xizou	2	0.39-1.31	8.71-9.06	20-71	M	-	-	-	-	Guo et al. 2012
Maize	Jinzhong	4	0.18-1.17	8.41-10.76	10-51	M	0, 180	-	manure	-	Zhou et al. 2011
Maize	Wuwei	3	1.63-2.13	2.77-4.36	229-275	M	0, 300, 450	-	-	-	Lv 2011
Maize	Jinzhong	4	0.21-1.19	8.82-11.22	11-55	M	0, 180	-	-	-	Liu et al. 2011b
Maize	Jinzhong	11	0.21-1.60	8.78-13.30	11-61	M	0, 180	CRF , NI	-	-	Liu 2011
Maize	Shenyang	4	1.21-4.00	6.88-7.86	72-259	M	-	CRF	-	-	Huang et al. 1998
Maize	Fengqiu	4	0.41-0.77	8.35-9.60	21-43	M-U	-	NI	-	-	Ding et al. 2011
Maize	Haerbing	2	0.21-0.88	5.51-7.50	18-55	M	0, 225	-	-	-	Ni et al. 2012
Maize	Yongji	6	1.01-4.49	4.90-8.40	97-259	M-U	0, 75, 150, 250, 350, 450	-	-	-	Liu et al. 2012
Maize	Fengqiu	4	0.22-1.81	0.84-8.11	72-122	M-U	0, 150	-	manure	-	Cai et al. 2013
Maize	Qiyang	4	0.14-1.42	0.17-4.45	182-390	M-U	0, 210	-	manure	-	Zhai et al. 2011
Maize	Fengqiu	5	0.08-1.22	1.49-9.82	25-382	M-U	0, 150	-	manure	-	Cai et al. 2012
Maize	Huaitai	5	0.45-1.26	6.13-10.01	35-63	M-U	0, 300	CRF	-	-	Shi et al. 2013
Maize	Yongji	3	1.73-3.18	6.30-7.10	135-236	M-U	-	NI	-	-	Liu et al. 2013a
Maize	Quzhou	6	0.45-2.56	9.05-10.10	25-121	M-U	0, 180	CRF , NI	straw, manure	-	Hu et al. 2013
Maize	Linghai	5	0.82-1.50	9.26-10.97	41-64	M	0, 263	CRF	straw	-	Liu et al. 2013b
Maize	Huaitai	6	0.26-4.27	5.20-8.60	18-307	M-U	0, 297, 330	-	-	-	Yan et al. 2013
Maize	Gongzhulin	10	0.57-4.39	4.50-11.40	36-183	M	0, 230	-	manure	-	Guo et al. 2013
Maize	Hebei	5	0.21-0.83	0.19-6.30	55-539	M-U	0, 93, 210	-	straw, manure	-	Zhang et al. 2014
Maize	Sichuan	4	0.12-1.00	0.40-7.50	44-140	M-U	0, 60,90,130	-	straw, manure	-	Zhou et al. 2014
Maize	Shandong	16	0.45-7.09	7.51-12.01	23-339	M-U	0, 225	CRF	-	-	Li et al. 2015
Maize	Hebei	7	0.33-2.30	5.71-10.64	26-145	W-U	0,150,225,300	NI	-	-	Wang et al. 2015
Maize	Henlan	7	1.07-6.23	8.69-11.39	57-256	W-U	0,225	-	-	-	Han et al. 2016
Maize	Sichuan	6	0.08-1.01	1.89-8.24	16-153	W-U	-	-	straw, manure	-	Liu et al. 2016

Maize	Shandong	4	0.59-1.78	7.85-9.80	35-85	W-U	0,240	CRF	-	-	Zhang et al. 2016
Maize	Hebei	5	0.39-4.43	4.53-11.32	29-234	W-U	0, 257	-	-	-	Tian et al. 2017

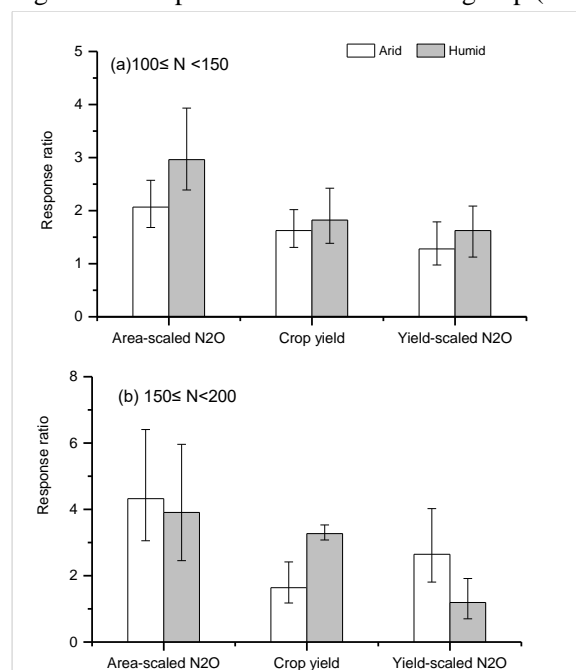
^a: The number of observations in selected studies

^b: W-R: winter wheat-rice rotation; W-U: winter wheat-upland crops rotation; M-U: summer maize-upland crops rotation; M: single spring maize

^c: CRF: control-released fertilizer; NI: nitrification inhibitor

^d: NT: no tillage; RT: reduced tillage

Fig.S1 The response ratios of two N subgroup ($100 \leq N < 150$, $150 \leq N < 200$) in arid and humid regions



References:

- Cai Y, Ding W, Luo J (2012) Spatial variation of nitrous oxide emission between interrow soil and interrow plus row soil in a long-term maize cultivated sandy loam soil. *Geoderma* 181–182:2-10.
- Cai Y, Ding W, Luo J (2013) Nitrous oxide emissions from Chinese maize-wheat rotation systems: A 3-year field measurement. *Atmos Environ* 65:112-122.
- Chen S, Huang Y, Zou J (2008) Relationship between nitrous oxide emission and winter wheat production. *Biol Fert Soils* 44:985-989.
- Ding W, Yu H, Cai Z (2011) Impact of urease and nitrification inhibitors on nitrous oxide emissions from fluvo-aquic soil in the North China Plain. *Biol Fert Soils* 47:91-99.
- Guo Y, Luo L, Chen G et al (2013) Mitigating nitrous oxide emissions from a maize-cropping black soil in northeast China by a combination of reducing chemical N fertilizer application and applying manure in autumn. *Soil Sci Plant Nutr* 59:392-402.
- Guo Y, Wu G, Wu X et al (2012) Influence of different fertilization modes to corn production and greenhouse gas emissions. *J Shanxi Agri Sci* 40:1067-1070. (In Chinese with English abstract)
- Guo Z, Cai C, Li Z et al (2009) Crop residue effect on crop performance, soil N₂O and CO₂ emissions in alley cropping systems in subtropical China. *Agroforestry syst* 76: 67-80.
- Han J, Pan G, Liu Z et al (2016) Constrasting effect of straw return and its biochar on changes in crop yield and intergrated global warming effects under different nitrogen levels. *Journal of Nanjing Agriculture University* 39: 986-995. (In Chinese with English abstract)
- Hu X, Su F, Ju X et al (2013) Greenhouse gas emissions from a wheat-maize double cropping system with different nitrogen fertilization regimes. *Environ Pollut* 176: 198-207.
- Huang G, Chen G, Zhang Z et al (1998) N₂O emission in maize field and its mitigation. *Acta Sci Circumst* 18:344-349. (In Chinese with English abstract)
- Huang T (2011) Greenhouse gas emission from different cropping system in paddy field. Dissertation, Nanjing Agricultural University.
- Ji Y, Liu G, Ma J et al (2012a) Effect of controlled-release fertilizer(CRF) on nitrous oxide emission during the wheat growing period. *Acta Pedol Sin* 49:526-534. (In Chinese with English abstract)
- Ji Y, Liu G, Ma J et al (2012b) Effect of controlled-release fertilizer on nitrous oxide emission from a winter wheat field. *Nutr Cycl Agroecosys* 94:111-122.
- Li F (2009) The effect of long-term fertilization on wheat yield and the ecological environment in the dry-land of Loess Plateau. Dissertation, Northwest A&F University. (In Chinese with English abstract)
- Li N, Ning T, Cui Z et al (2015) N₂O emissions and yield in maize field fertilized with polymer-coated urea under subsoiling or rotary tillage. *Nutrient Cycling in Agroecosystems* 102: 397-410.

- Liu C, Wang K, Meng S et al (2011a) Effects of irrigation, fertilization and crop straw management on nitrous oxide and nitric oxide emissions from a wheat–maize rotation field in northern China. *Agri Ecosyst Environ* 140:226-233.
- Liu C, Wang K, Zheng X (2012) Responses of N₂O and CH₄ fluxes to fertilizer nitrogen addition rates in an irrigated wheat-maize cropping system in northern China. *Biogeosciences* 9:839-850.
- Liu C, Wang K, Zheng X (2013a) Effects of nitrification inhibitors (DCD and DMPP) on nitrous oxide emission, crop yield and nitrogen uptake in a wheat-maize cropping system. *Biogeosciences* 10:2427-2437.
- Liu H, Hua L, Zhang X (2013b) Effect of different methods of N application on yield, N₂O emission in Maize. *J Agri Resour Environ* 30:76-80. (In Chinese with English abstract)
- Liu Y (2011) Mitigation options for N₂O emissions from spring maize soil in North China. Dissertation, Chinese Academy of Agricultural Science. (In Chinese with English abstract)
- Liu, Y, Li, Y, Peng, Z et al (2015) Effects of different nitrogen fertilizer management practices on wheat yields and N₂O emissions from wheat fields in North China. *Journal of Integrative Agriculture* 14: 1184-1191.
- Liu Y, Li Y, Wan Y et al (2011b) Nitrous oxide emission from spring-maize field under the application of different nitrogen and phosphorus fertilizers. *J Agro-Environ Sci* 30: 1468-1475. (In Chinese with English abstract)
- Liu Y, Liu W, Zhu B (2016) Effect of fertilization regime on soil N₂O emission from upland field under wheat-maize rotation system. *Acta Pedologica Sinica* 53: 735-746. (In Chinese with English abstract)
- Lv P (2011) The effects of nitrogen application on CO₂ and N₂O emission flux in the growing season of the maize field. Dissertation, Agricultural University of Gansu. (In Chinese with English abstract)
- Ma E, Ma J, Xu H et al (2011) Nitrous oxide emissions from wheat field at wheat jointing-maturing stage as affected by timing of topdressing. *Acta Pedol Sin* 48:971-978. (In Chinese with English abstract)
- Ma E, Zhang G, Ma J et al (2010) Effects of rice straw returning methods on N₂O emission during wheat-growing season. *Nutr Cycl Agroecosys* 88:463-469.
- Ma Y, Sun L, Zhang X et al (2013) Mitigation of nitrous oxide emissions from paddy soil under conventional and no-till practices using nitrification inhibitors during the winter wheat-growing season. *Biol Fert Soils* 49:1-9.
- Ma Y, Kong X, Yang B et al (2013) Net global warming potential and greenhouse gas intensity of annual rice-wheat rotations with integrated soil-crop system management. *Agri Ecosyst Environ* 164:209-219.
- Ni K, Ding W, Zaman M et al (2012) Nitrous oxide emissions from a rainfed-cultivated black soil in Northeast China: effect of fertilization and maize crop. *Biol Fert Soils*

48:973-979.

- Pei S, Zhang Y, Liu J et al (2012) Greenhouse gas emission under the treatments of fertilization and wheat straw returning during the maize growing seasons. *Environ Chem* 31: 407-414.
- Peng S, Hou H, Xu J et al (2013) Lasting effects of controlled irrigation during rice-growing season on nitrous oxide emissions from winter wheat croplands in Southeast China. *Paddy Water Environ* 11:583-591.
- Shi S (2012) Typical farmland N₂O and CH₄ net exchange characteristics of different nitrogen management. Dissertation, Agricultural University of Hebei. (In Chinese with English abstract)
- Shi Y, Wu W, Meng F et al (2013) Integrated management practices significantly affect N₂O emissions and wheat-maize production at field scale in the North China Plain. *Nutr Cycl Agroecosys* 95:203-218.
- Song L, Zhang Y, Hu C et al (2013) Comprehensive analysis of emissions and global warming effects of greenhouse gases in winter-wheat fields in the high-yield agro-region of North China Plain. *Chin J Eco-agric* 21:297-307. (In Chinese with English abstract)
- Sun G, Zheng J, Chen L et al (2012a) Effects of application of pig manure in combination with chemical fertilizers on CH₄ and N₂O emissions and their greenhouse effects in wheat field. *J Eco Rural Environ* 28:349-354. (In Chinese with English abstract)
- Sun G, Zheng J, Chen L et al (2012b) Effects of chemical fertilizers substitution by biogas slurry on CH₄ and N₂O emissions and their greenhouse effects in wheat field. *J Agro-Environ Sci* 31:1654-1661. (In Chinese with English abstract)
- Tian D, Zhang Y, Mu Y et al (2017) The effect of drip irrigation and drip fertigation on N₂O and NO emissions, water saving and grain yields in a maize field in the North China Plain. *Science of the Total Environment* 575: 1034-1040.
- Wang Y, Li Y, Peng Z et al (2015) Effects of dicyandiamide combined with nitrogen fertilizer on N₂O emission and economic benefit in winter wheat and summer maize rotation system. *Chinese Journal of Applied Ecology* 26: 1999-2006. (In Chinese with English abstract)
- Wei X, Hao M, Xue X et al (2010) Nitrous oxide emission from highland winter wheat field after long-term fertilization. *Biogeosciences* 7:3301-3310.
- Xu Y, Jiang L, Sun Z et al (2015) Effects of corn straw returning and nitrogen fertilizer application methods on N₂O emission from wheat growing season. *Journal of Agricultural Resources and Environment* 32: 552-568. (In Chinese with English abstract)
- Yan G, Zheng X, Cui F et al (2013) Two-year simultaneous records of N₂O and NO fluxes from a farmed cropland in the northern China plain with a reduced nitrogen addition rate by one-third. *Agri Ecosyst Environ* 178:39-50.
- Yao Z, Zheng X, Wang R et al (2013) Nitrous oxide and methane fluxes from a rice-wheat crop rotation under wheat residue incorporation and no-tillage practices. *Atmos Environ* 79:641-649.

- Zeng Z (2011) The effect of fertilization on soil microbial activity and N₂O emissions of purple soil in Hilly of the Central Sichuan. Dissertation, Sichuan Agricultural University.
- Zhai L, Liu H, Zhang J et al (2011) Long-term application of organic manure and mineral fertilizer on N₂O and CO₂ emissions in a red soil from cultivated maize-wheat rotation in China. *Agri Sci Chin* 10:1748-1757.
- Zhang H, Guo L, Xie L et al (2013) The effect of management practices on the emissions of CO₂ and N₂O from winter wheat field in North China Plain. *Chin J Soil Sci* 44: 653-660. (In Chinese with English abstract)
- Zhao J (2008) Effects of conservation tillage on soil environmental factors and the emission of greenhouse gas in the field. Dissertation, Shandong Agricultural University.
- Zhou P, Li Y, Liu L et al (2011) Effects of fertilization and environment factors on N₂O emission in spring corn field in North China Plain. *Chin J Agrometeorol* 32:179-184. (In Chinese with English abstract)
- Zhou M, Zhu B, Brueggemann N et al (2014) N₂O and CH₄ Emissions, and NO₃⁻ Leaching on a crop-yield basis from a subtropical rain-fed wheat-maize rotation in response to different types of nitrogen fertilizer. *Ecosystems* 17:286-301.
- Zou J, Huang Y, Zong L et al (2006) Effect of organic material incorporation in rice season on N₂O emissions from following winter wheat growing season. *Environ Sci* 27: 1264-1270. (In Chinese with English abstract)
- Zhang J, Xia G, Li H et al (2016) Effect of single basal fertilization on N₂O emissions in wheat and maize rotation system. *Journal of Agro-Environment Science* 35: 195-204. (In Chinese with English abstract)
- Zhang, X , Wu, L , Sun, N, et al (2014) Soil CO₂ and N₂O emissions in maize growing season under different fertilizer regimes in an upland red soil region of south China. *Journal of Integrative Agriculture* 13:604-614.
- Jiang J, Chen L, Sun Q et al (2015) Application of herbicides is likely to reduce greenhouse gas (N₂O and CH₄) emissions from rice-wheat cropping systems. *Atmospheric Environment* 107:62-69.