Supporting Information

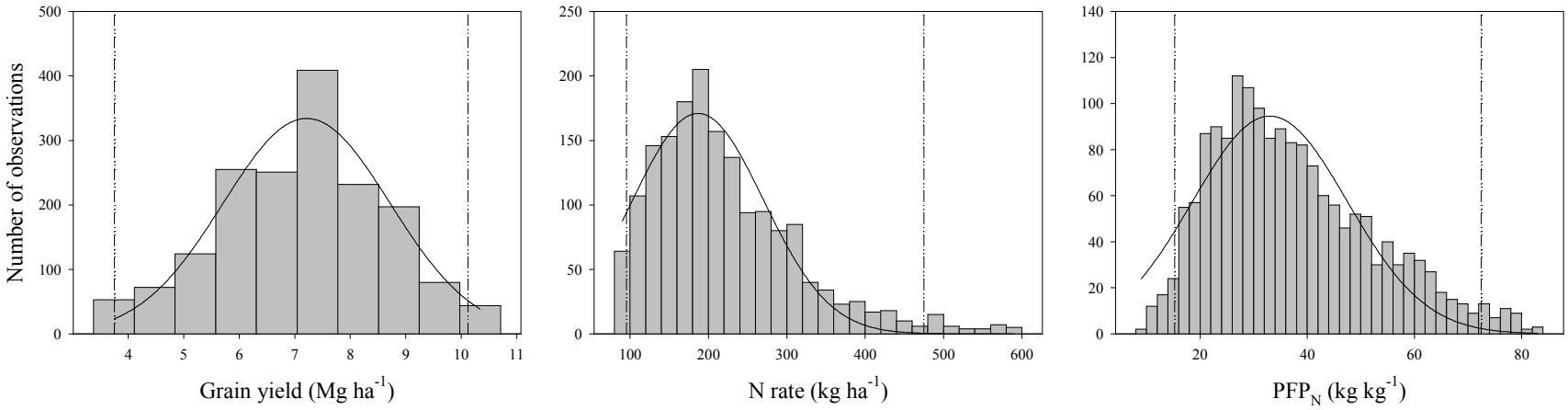

Figure. S1 Distribution of grain yield, N rate and PFPN of farmer's practice for rice system. The solid line is normal distribution, and the dashed line is 2.5th percentile and 97.5th percentile.

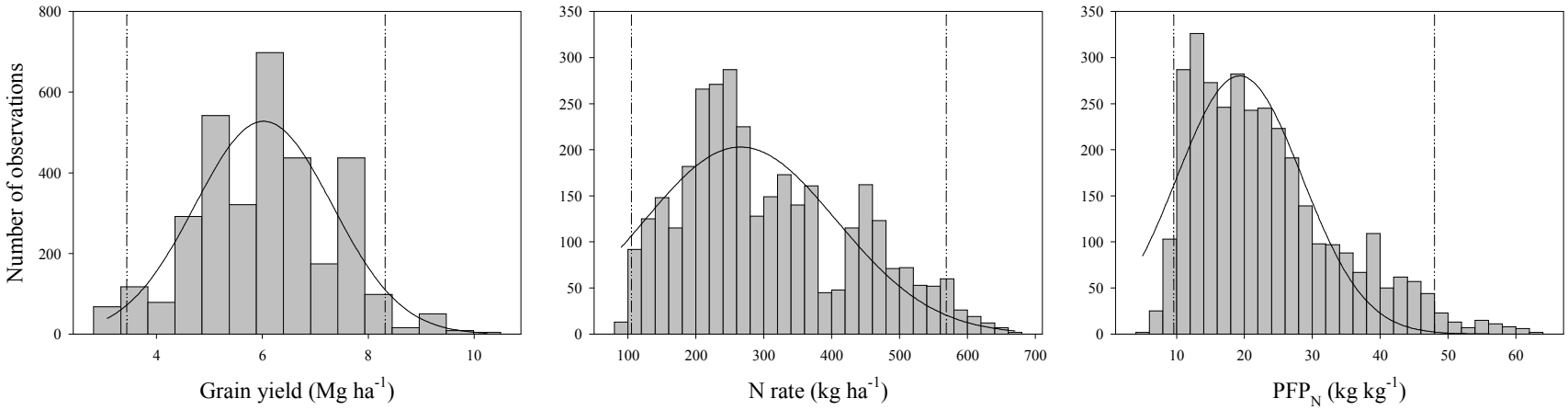

Figure. S2 Distribution of grain yield, N rate and PFPN of farmer's practice for wheat system. The solid line is normal distribution, and the dashed line is 2.5th percentile and 97.5th percentile.

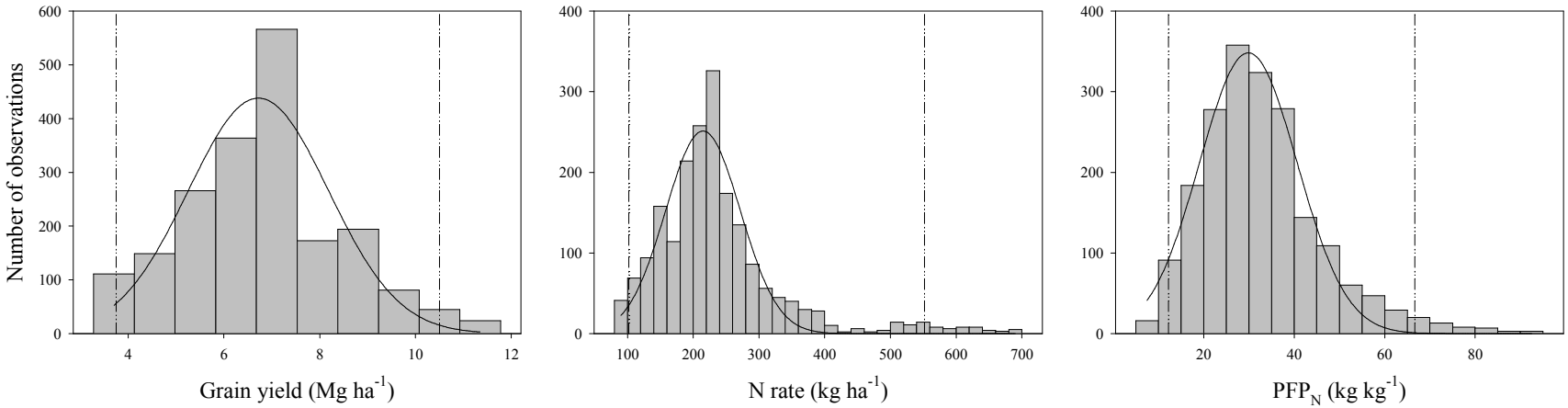

Figure. S3 Distribution of grain yield, N rate and PFPN of farmer's practice for maize system. The solid line is normal distribution, and the dashed line is 2.5th percentile and 97.5th percentile.

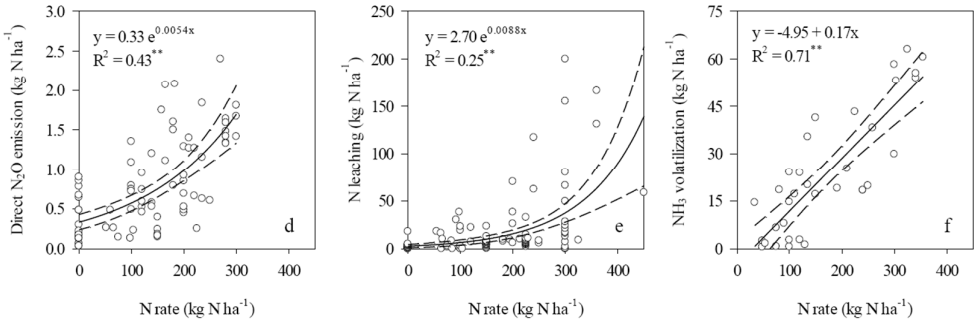

Figure. S4 Relationships between N application rate and direct N2O emissions for rice (a) and wheat (d); N leaching for rice (b) and wheat (e); and NH3 volatilization for rice (c) and wheat (f) in China.

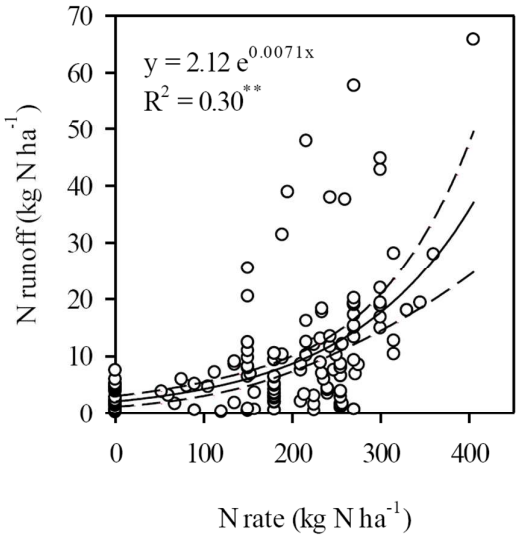

Figure. S5 Relationships between the N application rate and N runoff for rice system in China.

Table S1 The site, year, annual mean precipitation, temperature, organic matter content, total N content, pH, N rate , and direct N_2O emission for different experimental site for rice.

Site	Coordinate	Year	Preci.	Temp.	SOM	Total N	pH	N rate	Fertilizer type	Direct N_2O emission	Experimental treatments	Note	Reference
			mm	^oC	--g kg^{-1}--			Kg N ha^{-1}		kg N ha^{-1}			
Nanjing, Jiangsu	31.9°N, 118.8°E	2000	1000	16.0	30.2	1.9	6.7	277	Urea	0.06	Straw and irrigation treatments	NS, F	Zou et al., 2005a
								277	Urea	1.55		NS, FDF	
								277	Urea	0.03		WS, F	
								277	Urea	1.43		WS, FDF	
		2001						333	Urea	4.11		NS, FDFM	
								333	Urea	4.83		RS, FDFM	
								333	Urea	3.33		WS, FDFM	
		2002						300	Urea	4.44		NS, FDFM	
Changshu, Jiangsu	31.9°N, 118.8°E	2002	1100	20.0	22.6	1.1	6.7	0		1.38	N rates		Zou et al., 2005b
								300	Urea	4.44			
								450	Urea	6.17			
Nanjing, Jiangsu	28.1°N, 112.3°E	2001	1358	16.8	30.2	1.9	6.7	333	Urea	4.14	Straw treatments	NS	Zou et al., 2003
								333	Urea	3.40		WS	
Changshu, Jiangsu	31.5° N, 120.7°E	2003	1038	15.5	27.8	1.8	6.1	0		0.13	N rates		Zhao et al., 2009
								100	Urea	0.24			
								300	Urea	0.50			
Changsu, Jiangsu	31.7°N, 120.8°E	2003	1038	15.5	ND	ND	ND	100	Urea	0.12	N rate		Deng et al., 2012
								150	Urea	0.18			
								200	Urea	0.24			
								250	Urea	0.30			

								300	Urea	0.36			
Wuxi, Jiangsu	29°55′N, 115°30′E	2008	1361	16.8	33.4	2.5	5.4	0		0.44	Tillage treatments	NT	Zhang et al., 2011
								0		0.28		CT	
								210	Urea	4.28		NT	
								210	Urea	3.24		CT	
		2009	1361	16.8	27.0	2.5	5.9	0		0.00		NT	
								0		0.00		CT	
								210	Urea	3.40		NT	
								210	Urea	2.32		CT	
Wuxi, Jiangsu	31.6°N, 120.5°E	2003	963	16.0	25.8	ND	6.8	150	Urea	1.88	Straw and CO_2 treatments	NS	Xu et al., 2005
								150	Urea	1.05		NS, FACE	
								150	Urea	1.39		Half WS	
								150	Urea	0.78		Half WS, FACE	
								150	Urea	1.33		All WS	
								150	Urea	1.01		All WS, FACE	
		2002						150	Urea	1.55		Half WS	
								150	Urea	0.92		Half WS, FACE	
								250	Urea	1.94		All straw	
								250	Urea	1.67		All WS, FACE	
Wuxi, Jiangsu	31.6°N, 120.5°E	2002	963	16.0	24.7	1.4	6.6	300	Urea	1.50	Crop systems	Flooding rice	Xiong et al., 2003
								300	Urea	4.20		Rice-wheat	
								200	Urea	2.20		Early rice	
								300	Urea	1.50		Late rice	
Changshu, Jiangsu	31.5°N, 120.7°E	2008	1042	15.5	34.0	ND	6.4	240	Urea	2.48	Transplanting patterns	Manual	Zhang et al., 2010
								240	Urea	2.21		Mechanical	

Changshu, Jiangsu	31.5°N, 120.7°E	2008	1042	15.5	34	ND	6.4	240	Urea	1.18	Straw and tillage treatments	WS, RT	Zhang et al., 2009
								240	Urea	2.21		NS, RT	
								240	Urea	1.65		WS, TT	
								240	Urea	2.64		NS, TT	
Yancheng, Jiangsu	33.5°N, 120.2°E	2001	1000	14.0	12.5	0.8	8.3	225	Urea	1.37			Li et al., 2003
Jurong, Jiangsu	32.0°N, 119.3°E	1995	1093	15.2	17.0	1.2	6.3	300	Urea	0.93	N rate and straw treatments	WS	Cao et al., 1999
								200	Urea	0.82		WS	
								200	Urea	0.74		NS	
								100	Urea	0.86		WS	
								0		0.62			
Suzhou, Jiangsu	31.3°N, 120.6°E	1994	1097	15.5	34.9	1.9	N D	191	NH_4HCO_3	1.99	N types		Zheng et al., 1997
								191	Urea	1.28			
Suzhou, Jiangsu	31.3°N, 121.0°E	2009	1097	15.5	21.9	1.0	7.4	250	Urea	2.43	N rate and irrigation treatments	CI	Hou et al., 2012
								250	Urea	1.00		OI	
		2010						300	Urea	3.39		CI	
								300	Urea	1.48		OI	
Suzhou, Jiangsu	31.3°N, 120.6°E	2005	1025	16.0	37.1	2.2	6.6	0		1.40	N rates		Yao et al., 2010
								191	Urea	5.90			
Wuxi, Jiangsu	31.6°N, 120.5°E	2005	1079	15.6	25.9	1.6	6.8	0		1.20	N rates		
								250	Urea	2.90		NS	
								250	Urea	2.00		WS	
Jiangdu, Jiangsu	31.6°N, 119.7°E	2005	979	14.9	31.7	1.5	8.0	0		0.50	Straw treatments		
								250	Urea	1.60		NS	
								250	Urea	1.10		WS	

		2006						0		0.80			
								250	Urea	2.90		NS	
								250	Urea	1.70		WS	
Changshu, Jiangsu	31.5°N, 120.7°E	2006	1038	15.5	35	2.1	7.1	0	Urea	0.09	N rates		Wang et al., 2009
								100	Urea	0.12			
								150	Urea	0.12			
								200	Urea	0.18			
								250	Urea	0.20			
								300	Urea	0.21			
Jiangdu, Jiangsu	32.6°N, 119.7°E	2005	748	15.0	18.4	1.5	7.9	250	Urea	0.56	Straw and CO_2 treatments	All WS, FACE	Dong et al., 2009
								250	Urea	0.65		Half WS, FACE	
								250	Urea	2.37		NS , FACE	
								250	Urea	2.09		All WS, FACE	
								250	Urea	2.04		Half WS, FACE	
								250	Urea	1.75		NS , FACE	
Wuxi, Jiangsu	31.6°N, 120.5°E	2003	1080	16.0	15.0	1.6	6.8	0		0.43	N rate		Deng et al., 2012
								250	Urea	1.47			
Yingxing, Jiangsu	31.4°N, 119.7°E	2009	1177	15.7	41.4	1.8	6.5	0		0.76	N rate		Zhang et al., 2010
								300	Urea	1.99			
Jurong, Jiangsu	31.6°N, 119.8°E	2005	1093	15.2	21.7	1.3	6.2	225	Urea	6.30	Midseason aeration treatments	EA	Li et al., 2011
								225	Urea	5.29		NA	
								225	Urea	4.93		DA	
	31.9°N, 119.5°E	2007	1093	15.2	20.5	1.5	6.9	225	Urea	3.90		EA	
								225	Urea	2.31		NA	
								225	Urea	1.71		DA	

								225	Urea	2.51		PA	
Jurong, Jiangsu	32.0°N, 119.3°E	2007	1093	15.2	20.5	1.50	6.9	300	Urea	3.90			Li et al., 2009
Nanjing, Jiangsu	31.9°N, 118.8°E	2007	1250	15.9	26.4	1.5	6.5	0		0.03	N rate and water treatments	F	Liu et al., 2010
								100	Urea	0.05		F	
								200	Urea	0.08		F	
								300	Urea	0.12		F	
								0		0.60		FDF	
								100	Urea	0.90		FDF	
								200	Urea	1.33		FDF	
								300	Urea	1.71		FDF	
								0		0.76		FDFM	
								100	Urea	1.30		FDFM	
								200	Urea	1.80		FDFM	
								300	Urea	2.60		FDFM	
Suzhou, Jiangsu	31.3°N, 120.6°E	1997	1080	15.4	34.9	1.9	6.5	0		1.00			Gou et al., 1999
Wuxi, Jiangsu	31.6°N, 120.5°E	2002	1080	16.0	25.8	1.6	6.8	0		0.07	Straw treatments		Zhou et al., 2010
								250	Urea	0.12		NS	
								250	Urea	0.13		WS	
Wuxi, Jiangsu	31.5°N, 120.5°E	1997	1079	15.6	24.7	1.4	6.7	300	Urea	1.26	Crop systems	Rice fallow	Xing et al., 2002
								300	Urea	4.14		Rice wheat	
								200	Urea	2.18		Early rice	
								300	Urea	1.51		Late rice	
Nanjing,	31.9°N,	1994	1248	15.8	18.5	1.2	8.0	0		0.14	N rates and types		Cai et al.,

Jiangsu	118.8°E							100	$NH_4(SO_4)_2$	0.17			1997
								100	Urea	0.16			
								300	$NH_4(SO_4)_2$	0.98			
								300	Urea	0.62			
Nanjing, Jiangsu	31.9°N, 118.8°E	2007	1093	15.2	26.2	1.7	6.3	0		0.30	Irrigation treatments	RI	Zou et al., 2009
								200	Urea	1.33		RI	
								0		0.81		SI	
								200	Urea	2.24		SI	
Nanjing, Jiangsu	31.9°N, 118.8°E	2006	1093	15.2	25.3	1.3	5.7	0		0.22	Straw and water treatments	FDF	Wang et al., 2011
								220	Urea	0.68		FDF	
								300	Urea	0.73		FDF	
								220	Urea	0.28		WS, FDF	
								220	Urea	0.34		WS, FDF	
								220	Urea	0.37		WS, FDFM	
								0		0.16		F	
								220	Urea	0.55		F	
								0		0.13		F	
								0		0.20		WS, FDF	
Yixing, Jiangsu	31.3°N, 119.9°E	2004	1076	14.9	21.7	1.3	6.2	270	Urea	0.44	Straw treatments	NS	Ma et al., 2009
								270	Urea	0.43		Evenly incorporating	
								270	Urea	0.41		Burying straw	
		2005						270	Urea	0.18		NS	
								270	Urea	0.07		Evenly incorporating	

								270	Urea	0.11		Ditch mulching	
Jurong, Jiangsu	31.9°N, 119.3°E	2006	1093	15.2	14.1	1.1	5.9	300	Urea	1.13		NS	
								300	Urea	0.25		Evenly incorporating	
								300	Urea	0.79		Burying straw	
								300	Urea	0.92		Ditch mulching	
								300	Urea	1.29		Strip mulching	
Shanghai	31.1°N, 121.3°E	2005	1054	15.4	15	1.4	7.0	275	Urea	1.90	N rate		Huang et al., 2007
								0		0.55			
Shanghai	31.1°N, 121.3°E	2002	1054	15.4	13	ND	7.9	0		0.32			Xiao et al., 2005a
Shanghai	30.9°N, 121.8°E	2002	1054	15.4	18.8	1.24	8.0	0		0.30	N rate		Xiao et al., 2005b
								225	Urea	0.42			
Shanghai	30.9°N, 121.8°E	2002	1054	15.4	13	ND	7.9	0		0.15	N rate		Xiao et al., 2005c
								225	Urea	0.21			
Wuhan, Hubei	30.6°N,114.4°E	2006	1361	16.8	16.8	1.09	6.8	225	Urea	2.31	Crop systems	RR	Li et al., 2008
								225	Urea	2.49		RD	
								225	Urea	2.22		RF	
		2007						225	Urea	1.94		RR	
								225	Urea	2.19		RD	
								225	Urea	1.91		RF	
Wuxue, Hubei	29.9°N,115.5°E	2008	1361	16.8	31.5	3.6	6.6	0		0.48	Tillage treatments	NT	Ahmad et al., 2009
								0		0.37		CT	
								210	Urea	4.72		NT	
								210	Urea	3.57		CT	

Wuxue, Hubei	29.9°N, 115.5°E	2008	1361	16.8	31.5	3.6	6.6	0		0.31	Tillage treatments	NT	Li et al., 2009
								0		0.67		TT	
								210	Compound fertilizer and urea	2.95		NT	
								210	Compound fertilizer and urea	2.91		TT	
Wuhan, Hubei	30.5°N, 114.3°E	2006	1269	16.0	11.9	1.0	6.8	122	Compound fertilizer	0.48	Water treatments	F	Yuan et al., 2008
								122	Compound fertilizer	0.81		FDF	
Wuhan, Hubei	30.4°N, 114.2°E	2008	1300	16.8	20.7	0.9	6.3	0		0.57	N rates and times		Liang et al., 2010
								210	Urea	1.56		Twice	
								147	Urea	1.18		Twice	
								147	Urea	1.13		Triple	
Yanting, Sichuan	31.3°N, 105.5°E	2002	826	17.3	21.0	1.2	8.1	133	Urea	1.66	N types		Jiang et al., 2006a
		2003						133	NH_4HCO_3	1.62			
								133	NH_4HCO_3	1.75			
								133	Urea	2.06			
Chengdu, Sichuan	30.7°N, 103.8°E	2005	960	15.7	27.1	1.6	7.8	150	Urea	1.46			Yu et al., 2008
Yanting, Sichuan	31.3°N, 105.5°E	2002	826	17.3	21.0	1.22	8.1	150	Urea	1.65	Crop systems	PF	Jiang et al., 2006b
		2003						150	Urea	1.59		PF	
								150	Urea	1.78		RW	
								150	Urea	2.04		RR	
Ningxiang, Hunan	28.1°N, 112.3°E	2008	1358	16.8	34.9	ND	6.3	144	Urea	0.00	Crop systems and tillage treatments	Early rice, TT	Bai et al., 2010
								144	Urea	0.08		Early rice, RT	
								144	Urea	0.05		Early rice, NT	

								144	Urea	0.01		Late rice, TT	
								144	Urea	0.11		Late rice, RT	
								144	Urea	0.14		Late rice, NT	
Changsha, Hunan	28.1°N, 113.2°E	2009	1500	17.1	28.6	1.78	5.9	150	Urea	1.18	N rates		Lou et al., 2010
								180	Urea	0.00			
Changsha, Hunan	28.1°N, 113.2°E	2008	1500	17.1	33.9	2.0	5.4	150	Urea	0.26	Straw and N rates	NS	Tang et al., 2010
								192	Urea	0.67		NS	
								150	Urea	0.13		WS	
								192	Urea	0.48		WS	
Taoyuan, Hubei	28.9°N, 111.6°E	2007	1448	16.5	28.5	2.7	5.1	0		0.04	Crop systems and fertilizer treatments	Early rice, no fertilizer	Yang et al., 2010
								81	Urea	0.13		Early rice, NP	
								81	Urea	0.13		Early rice, NK	
								81	Urea	0.00		Early rice, NPK	
		2008						0		0.00		Early rice, no fertilizer	
								102	Urea	0.15		Early rice, NP	
								102	Urea	0.16		Early rice, NK	
								102	Urea	0.10		Early rice, NPK	
		2007						0		0.00		Late rice, no fertilizer	
								81	Urea	0.21		Late rice, NP	
								81	Urea	0.26		Late rice, NK	
								81	Urea	0.11		Late rice, NPK	
		2008						0		0.11		Late rice, no	

											fertilizer	
								102	Urea	0.31	Late rice, NP	
								102	Urea	0.14	Late rice, NK	
								102	Urea	0.04	Late rice, NPK	
Wangcheng, Hunan	28.3°N,112.8°E	1998	1350	17.5	20.6	2.1	ND	150	Urea	0.66	WS, NPK	Qin et al., 2006
								0		0.48	NS	
								150	Urea	0.94	NS, NPK	
								180	Urea	0.89	WS, NPK	
								0		0.10	NS	
								180	Urea	0.53	NS, NPK	
Taoyuan, Hubei	28.9°N, 111.5°E	2007	1448	16.5	ND	ND	ND	0		0.04	No fertilizer	Shang et al., 2011
								81	Urea	0.13	N+P	
								81	Urea	0.13	N+K	
								81	Urea	0.00	N+P+K	
		2008						0		0.00	No fertilizer	
								81	Urea	0.21	N+P	
								81	Urea	0.20	N+K	
								81	Urea	0.13	N+P+K	
		2009						0		0.14	No fertilizer	
								81	Urea	0.11	N+P	
								81	Urea	0.21	N+K	
								81	Urea	0.21	N+P+K	
		2007						0		0.00	No fertilizer	
								102	Urea	0.21	N+P	
								102	Urea	0.26	N+K	

								102	Urea	0.11		N+P+K	
		2008						0		0.11		No fertilizer	
								102	Urea	0.31		N+P	
								102	Urea	0.14		N+K	
								102	Urea	0.04		N+P+K	
		2009						0		0.09		No fertilizer	
								102	Urea	0.38		N+P	
								102	Urea	0.11		N+K	
								102	Urea	0.30		N+P+K	
Taoyuan, Hubei	28.9°N, 111.5°E	2006	1448	16.5	28.5	2.7	5.1	102	Urea	0.68	Fertilizer treatments	NP	Wu et al., 2008
								102	Urea	0.85		NK	
								102	Urea	0.08		NPK	
								81	Urea	0.40		JF	
		2007						81	Urea	0.22		NP	
								81	Urea	0.16		NK	
								81	Urea	0.06		NPK	
								42	Urea	0.08		JF	
								102	Urea	0.37		NP	
								102	Urea	0.50		NK	
								102	Urea	0.93		NPK	
								81	Urea	0.61		JF	
Yingtan, Jiangxi	28.1°N, 117.0°E	1999	1795	17.6	12.4	0.7	4.8	0		0.49	N rate		Xiong et al., 2002a
								104	Urea	0.62			
Yingtan, Jiangxi	28.3°N, 116.9°E	2001	1795	17.6	24.1	0.8	5.5	276	Urea	0.35	Crop systems	Early rice	Xiong et al., 2002b
								0		0.18		Early rice	

								276	Urea	0.28		Late rice	
								0		0.23		Late rice	
Xishuangbanna, Yunnan	21.9°N, 101.2°E	2005	1557	21.3	19.3	1.3	5.4	0		1.75	N rate		Wu et al., 2008
								300	Compound fertilizer and urea	3.09			
Guanghan, Sichuan	30.6°N, 104.2°E	2010	826	17.3	ND	ND	ND	240	Urea	1.88	N rate		Liu et al., 2012
								0		0.11			
Changsha, Hunan	28.1°N, 112.6°E	2010	1361	16.8	ND	ND	ND	240	Urea	1.46			
								0		0.23			
Jinxian, Jiangxi	28.4°N, 115.6°E	2010	1795	17.6	ND	ND	ND	240	Urea	1.47			
								0		0.09			
Suzhou, Jiangsu	31.3°N, 120.9°E	2009	1097	15.5	21.9	1.0	7.4	250	Urea	2.54	Irrigation treatments	OI	Peng et al., 2011
								250	Urea	1.00		CI	
Suzhou, Jiangsu	31.1°N, 119.7°E	1994	1097	15.5	ND	ND	ND	191	NH_4HCO_3	1.24	N types		
								191	NH_4HCO_3	1.72			
		1996						191	Urea	1.92			
								191	NH_4HCO_3	1.52			
Wuxi, Jiangsu	31.6°N, 120.5°E	2001	1079	15.6	ND	ND	ND	150	Urea	1.50	N rates		
								250	Urea	2.31			
								250	Urea	1.21			
								0		0.90			
		2002						150	Urea	1.71			
								250	Urea	2.99			
								250	Urea	1.99			
Nanjing, Jiangsu	31.0°N,	1994	1110	15.4	18.5	1.16	7.9	100	Urea	0.17	Water treatments	FDF	Zou et al.,

	118.8°E						9	300	Urea	0.62		FDF	2009
								100	Urea	0.17		FDF	
								300	Urea	0.98		FDF	
Ningxiang, Hunan	28.2°N, 112.5°E	2006	1350	17.5	42.4	2.46	6.2	160	Urea	0.65		FDF	
								160	Urea	0.45		FDF	
								160	Urea	0.37		FDF	
Heshan, Guangdong	22.7°N, 112.9°E	2003	1700	21.7	ND	ND	ND	331	Urea	3.32		FDFM	
Jiaxing, Zhejiang	30.7°N, 120.8°E	2003	1403	17.2	27.1	2.8	6.9	180	Urea	2.78		FDFM	
								360	Urea	3.54		FDFM	
Nanjing, Jiangsu	32.0°N, 118.8°E	2003	1107	15.6	16.7	1.1	6.1	300	Urea	3.80		FDFM	
		2004						300	Urea	3.19		FDFM	
Wangcheng, Hunan	112.6°N, 28.5°E	2004	1350	17.5	35.5	2.1	6.6	0		1.03		FDFM	
								0		0.20		FDFM	
								75	Urea	0.83		FDFM	
								90	Urea	1.60		FDFM	
Suzhou, Jiangsu	31.1°N, 119.7°E	1997	1097	15.5	ND	ND	ND	220	$NH_4(SO_4)2$	3.27			
Yingtan, Jiangxi	28.1°N, 117.0°E	1997	1795	17.6	ND	ND	ND	266	Urea	1.14	N types and crop systems	Early rice	Xing et al., 1998
								266	Urea	0.03		Late rice	
Guangzhou, Guangdong	23.1°N, 113.1°E	1997	1847	21.8	ND	ND	ND	141	Urea	0.27		Early rice	
								141	Urea	1.43		Late rice	
Suzhou, Jiangsu	31.3°N, 120.6°E	1993	1097	15.5	ND	ND	ND	0		0.86	N rates		Zou et al., 2005
								210	Urea	2.57			
								220	Urea	3.27			

								278	Urea	3.01
								310	Urea	2.82
Suzhou, Jiangsu	31.3°N, 120.6°E	1994	1097	15.5	ND	ND	ND	0		0.70
								191	Urea	2.00
		1996						0		0.80
								191	Urea	1.60
								191	Urea	3.20
Nanjing, Jiangsu	32.0°N, 118.8°E	2000	1000	16.0	ND	ND	6.7	275	Urea	2.44

Crop systems: PF, flooded rice followed by a non-rice season; RW, rice-wheat rotation system; RR, rice-rapeseed rotation system. RS, rice combined with fish; RD, rice combined with ducks. Water treatments: EA, early aeration, started on D 24 (24 days after transplanting); NA, normal aeration, started on D 30; DA, delayed aeration, started on D 38; PA, prolonged aeration; F, continuous flooding; FDF, flooding-midseason drainage; FDFM, flooding-midseason drainage-reflooding and moisture but without waterlogging. FACE: Free-Air Carbon Dioxide Enrichment.. JF: following cultivating astragalus smicus. Straw treatments: NS, no straw return; WS, wheat straw return; RS, rape straw return. Tillage treatments: NT, no tillage; CT, conventional tillage; RT, rotary tillage; TT, turn over tillage. Irrigation treatments: CI, conventional irrigation; OI, optimum irrigation; RI, irrigation with river water; SI, irrigation with swage.

Table S2 The site, year, annual mean precipitation, temperature, organic matter content, total N content, pH, N rate, and N leaching for different experimental site for rice system.

Site	Coordinate	Year	Preci.	Temp.	SOM	Total N	pH	N rate	Fertilizer type	N leaching	Experimental treatments	Note	Reference
			mm	^{o}C	--g kg^{-1}--			kg N ha^{-1}		kg N ha^{-1}			
Changshu, Jiangsu	31.6°N, 120.7°E	2005	1038	15.5	35.0	2.1	7.4	0		2.8	N rate		Zhang et al., 2008a
								180	Urea	3.5			
Changshu, Jiangsu	31.6°N, 120.7°E	2006	1038	15.5	35	2.1	7.4	0		4.1	N rates and straw treatments		Zhang et al., 2008b
								180	Urea	5.9		NS	
								270	Urea	5.8		NS	
								270	Urea	6.0		WS	
Wujing, Jiangsu	31.8°N, 120.0°E	1996	1094	15.5	27.4	17.2	ND	0		1.7	N rates		Cui et al., 1998
								150	Urea	3.5			
								250	Urea	5.5			
								350	Urea	8.8			
Shanghai	31.4°N, 121.5°E	2004	1054	15.4	ND	1.38	7	250		6.1			Huang et al., 2007
Shanghai	31.4°N, 121.5°E	2004	1040	15.7	ND	ND	ND	250	Urea	6.4	N rates		Lu et al., 2006
								232	Urea	5.0			
		2005						234	Urea	2.8			
								0		2.4			
Changshu, Jiangsu	31.6°N, 120.7°E	2001	1038	15.5	34.5	1.8	7.4	0		1.6	N rates		Wang et al., 2004
								150	Urea	2.0			
		2002						0		2.9			
								150	Urea	2.7			
Jiaxing,	31.3°N,	2003	1100	15.4	35.0	2.8	ND	0		1.0	N rates		Li, 2007

Zhejiang	121.3°E							90	Urea	4.6			
								180	Urea	5.7			
								270	Urea	7.6			
								360	Urea	14.8			
		2004						0		4.3			
								180	Urea	11.8			
								0		3.7			
								180	Urea	11.3			
Wuxi, Jiangsu	31.6°N, 120.3°E	2009	1080	16	35.7	1.8	ND	270	Urea	6.7	N rates		Xue et al., 2011
								210	Urea	4.5			
								153	Urea	4.1			
								0		3.6			
Wujing, Jiangsu	31.8°N, 120.0°E	1997	1094	15.5	27.4	1.7	ND	265	Urea	9.7	Irrigation treatments	Water-saving irrigation	Li et al., 2001
								265	Urea	18.6		Conventional irrigation	
Jingmen, Hubei	30.8°N, 111.3°E	2003	900	16	18.1	0.9	6.8	180	Urea	8.4	N application methods and irrigation treatments	Continuous flooding and F_1	Liu, 2005
								180	Urea	10.2		Continuous flooding and F_2	
								180	Urea	9.1		Continuous flooding and F_3	
								0		4.1		Water saving irrigation	
								120	Urea	5.5		Water saving irrigation and F_1	

								120	Urea	6.3		Water saving irrigation and F_2	
								120	Urea	5.8		Water saving irrigation and F_3	
								180	Urea	6.7		Water saving irrigation and F_1	
								180	Urea	7.8		Water saving irrigation and F_2	
								180	Urea	7.4		Water saving irrigation and F_3	
Changshu, Jiangsu	31.6°N, 120.7°E	2001	1038	15.5	35.0	2.1	7.4	300	Urea	5.2	N rates		Tian et al., 2006
								225	Urea	4.8			
		2002						0		4.2			
								225	Urea	3.2			
Beibei, Chongqing	30.4°N, 106.4°E	2003	114.8	18.2	12.2	1.0	7.7	225	Urea	16.8	Soil types	Calcareous purple soil	Yi, 2005
								225	Urea	18.0		Neutral purple soil	
								225	Urea	16.4		Acidity purple soil	
								225	Urea	16.3		Neutral purple soil	
Yixing, Jiangsu	31.3°N, 119.9°E	2008	1076	14.9	12.6	0.6	6.2	0		3.7	N rates		Zhao et al., 2012a
								81	Urea	3.1			
								135	Urea	2.9			
								189	Urea	3.6			
								216	Urea	3.6			
								243	Urea	3.7			

Changshu, Jiangsu	31.6°N, 120.7°E	2003	1038	15.5	ND	ND	ND	0		1.0	N rates		Xie et al., 2007
								100	Urea	1.3			
								200	Urea	1.6			
Changshu, Jiangsu	31.5°N, 120.7°E	2001	1038	15.5	34.5	1.8	7.4	0		1.6	N rates		Wang et al., 2007
								150	Urea	2.0			
		2002						0		2.9			
								150	Urea	2.7			
		2003						150	Urea	3.9			
Changshu, Jiangsu	31.5°N, 120.7°E	2003	1038	15.5	27.8	1.8	6.0	0		1.04	N rates		Zhao et al., 2009
								100	Urea	1.3			
Changshu, Jiangsu	31.5°N, 120.7°E	2008	1177	15.7	26.5	1.8	5.6	300	Urea	5.8			Zhao et al., 2012b
Wuhan, Hubei	30.6°N,114.3°E	2007	1361	16.8	16.8	1.1	6.8	225	Urea	6.7			Li et al., 2008
Changsha, Hunan	28.6°N, 112.3°E	2008	1500	17.1	ND	2.6	6.5	150	Urea	1.5	Crop systems	Early rice	Li, 2009
								150	Urea	4.3		Late rice	
Hangzhou, Zhejiang	30.2°N, 120.1°E	1992	1435	16.2	26.5	1.6	6.5	150	Urea	13.0			Wang et al., 1996
Changsha, Hunan	28.6°N, 112.3°E	2005	1400	16.8	23.8	1.9	4.9	0		5.76	N rate and soil types	ASLPS	Ji et al., 2011
								150	Urea	6.83		ASLPS	
					44.2	3.0	7.7	0		1.88		PCCPS	
								150	Urea	1.97		PCCPS	
					27.9	2.0	4.8	0		4.13		RYLPS	
								150	Urea	4.5		RYLPS	
Nanchang,	28.9°N,	2005	1685	ND	13.8	1.5	6.9	0		0.6	Crop systems and	Early rice, WSI	Wang,

Jiangxi	115.1°E	0	0.7	irrigation treatments	Early rice, CI	2007
		140	0.8		Early rice, WSI	
		140	0.8		Early rice, CI	
		140	0.8		Early rice, WSI	
		140	0.7		Early rice, CI	
		0	0.7		Late rice, WSI	
		0	0.8		Late rice, CI	
		140	0.8		Late rice, WSI	
		140	0.8		Late rice, CI	
		140	0.8		Late rice, WSI	
		140	0.8		Late rice, CI	
		210	1.2		Late rice, WSI	
		210	1.3		Late rice, CI	

Irrigation treatments: CI, conventional irrigation; OI, optimum irrigation; RI, irrigation with river water; SI, irrigation with swage; WSI, water-saving irrigation.

Table S3 The site, year, annual mean precipitation, temperature, organic matter content, total N content, pH, N rate, and N runoff for different experimental site for rice system.

Site	Coordinate	Year	Preci.	Temp.	SOM	Total N	pH	N rate	Fertilizer type	N runoff	Experimental treatments	Note	Reference
			mm	°C	--g kg^{-1}--			kg N ha^{-1}		kg N ha^{-1}			
Changshu, Jiangsu	31.5°N, 120.7°E	2001	1038	15.5	34.5	1.8	7.4	0		4.1	N rates		Wang et al., 2007
								150	Urea	20.4			
								300	Urea	44.7			
		2002						0		2.2			
								150	Urea	12.3			
								300	Urea	18.8			
		2003						0		4.4			
								150	Urea	25.4			
								300	Urea	42.7			
Jiaxing, Zhejiang	31.3°N, 121.3°E	2003	1100	15.4	35.0	2.7	7.1	90	Urea	5.05	N rates		Liang et al., 2007
								270	Urea	19.25			
								360	Urea	27.86			
Wujiang, Jiangsu	30.5°N, 120.9°E	2004	1100	15.2	32.7	1.6	5.6	195	Urea	38.80			Jiao et al., 2007
Jiading, Shanghai	31.1°N, 121.3°E	2004	1054	15.4	27.6	1.4	7.0	0		5.89	N rates		Lu et al., 2006
								232	Urea	12.97			
Jiaxing, Zhejiang	31.3°N, 121.3°E	2003	1100	15.4	35.0	2.8	ND	0		0.229	N rates		Li, 2007
								90	Urea	0.397			
								180	Urea	0.481			
								270	Urea	0.542			

Changsha, Hunan	28.6°N, 112.3° E	2008	1400	16.8	37.7	1.9	5.9	0		2.756	N rates and crop systems	Early rice	Shi, 2010
								52.5	Urea	3.74		Early rice	
								105	Urea	4.617		Early rice	
								180	Urea	6.393		Early rice	
								0		1.502		Late rice	
								67.5	Urea	1.63		Late rice	
								135	Urea	1.751		Late rice	
								210	Urea	2.056		Late rice	
Changshu, Jiangsu	31.6°N, 120.7°E	2002	1038	15.5	35.0	2.1	7.4	0		1.34	N and P rates	No fertilizer	Tian et al., 2007
								180	Urea	1.91		With 90 kg P_2O per hectare	
								255	Urea	1.02		With 90 kg P_2O per hectare	
								255	Urea	1.56		With 30 kg P_2O per hectare	
								255	Urea	1.22		With 180 kg P_2O per hectare	
		2003						0		4.81		No fertilizer	
								180	Urea	10.4		With 90 kg P_2O per hectare	
								255	Urea	6.49		With 90 kg P_2O per hectare	
								255	Urea	7.93		With 30 kg P_2O per hectare	
								255	Urea	8.56		With 180 kg P_2O	

												per hectare	
								330		17.9		With 90 kg P_2O per hectare	
		2004						0		1.7		No fertilizer	
								180	Urea	2.81		With 90 kg P_2O per hectare	
								255	Urea	2.75		With 90 kg P_2O per hectare	
								255	Urea	3.83		With 30 kg P_2O per hectare	
								255	Urea	3.68		With 180 kg P_2O per hectare	
Nanjing, Jiangsu	32.0°N, 118.5°E	2002	1000	16.0	37.9	2.0	7.2	0		3.8	N and P rates		Shan et al., 2005
								180	Urea	4.1			
		2003						0		4.6			
								270	Urea	14.9		With 60 kg P_2O per hectare	
								315	Urea	28		With 60 kg P_2O per hectare	
								315	Urea	10.3		With 180 kg P_2O per hectare	
								315	Urea	12.6		With 300 kg P_2O per hectare	
Shanghai	31.4°N, 121.5°E	2004	1040	15.7	ND	ND	ND	250	Urea	10.1	N rates		Mao et al., 2006
								232	Urea	8.8			
								0		4.52			

		2005						275	Urea	8.41			
								234	Urea	6.9			
								0		4.98			
Changshu, Jiangsu	31.6°N, 120.7°E	2001	1038	15.5	34.5	1.8	7.4	257	Urea	12.0			Wang et al., 2007
		2002						257	Urea	1.6			
Wuxi, Jiangsu	31.6°N, 120.5°E	2009	1150	16	25.9	2.8	6.8	270	Urea	18.9	N rates and straw treatments	NS	Liu et al., 2012
								270	Urea	17.1		WS	
								216	Urea	16.1		WS	
								270	Urea	19.0		NS	
								270	Urea	20.0		NS	
Jintan, Jiangsu	31.5°N, 119.3°E	2007	1064	17	19.4	1.1	ND	234	Urea	17.6	Crop systems	Conventional rice field	Yu, 2008
								234	Urea	18.2		Rice combined with ducks	
								260	Urea	37.5		Rice combined with ducks	
Changsha, Hunan	28.6°N, 112.3° E	2008	1500	17.1	ND	2.6	6.5	150	Urea	8	N rates and crop systems	Early rice	Li, 2009
								150	Urea	10		Late rice	
								0		2		Early rice	
								75	Urea	6		Early rice	
								112.5	Urea	7		Early rice	
								150	Urea	11		Early rice	
								225	Urea	12		Early rice	
								300	Urea	15		Early rice	
Changsha,	28.6°N,	2005	1400	16.8	23.8	1.9	4.9	0		1.6	Crop systems and	Early rice, ASLPS	Lu et al., 2008

Hunan	112.3° E							150	Urea	8.1	soil types	Early rice, ASLPS	
								0		1.8		Early rice, PCCPS	
								150	Urea	6.4		Early rice, PCCPS	
								0		1.4		Early rice, RYLPS	
								150	Urea	7.9		Early rice, RYLPS	
								0		0.5		Late rice, ASLPS	
								150	Urea	0.4		Late rice, ASLPS	
								0		0.4		Late rice, PCCPS	
								150	Urea	0.5		Late rice, PCCPS	
								0		0.7		Late rice, RYLPS	
								150	Urea	0.7		Late rice, RYLPS	
Changshu, Jiangsu	31.6°N, 120.7°E	2002	1038	15.5	34.5	1.8	7.4	0		2.1	N rates		Wang et al., 2004
								150	Urea	12.3			
								300	Urea	18.8			
Caohu, Anhui	31.6°N, 117.8°E	2008	996	16	34.07	1.58	6.99	0		0	N rates and straw treatments	NS	Wang et al., 2010
								214	Urea	3.3		NS	
								225	Urea	3.0		NS	
								158	Urea	0.5		NS	
								225	Urea	1.5		WS	
								158	Urea	3.6		WS	
Changshu, Jiangsu	31.5°N, 120.7°E	2007	1177	15.7	26.5	1.79	5.6	300	Urea	21.8			Zhao et al., 2012
		2009						300	Urea	19.2			
Yixing, Jiangsu	30.5°N, 119.8°E	2009	1250	14.9	12.6	0.64	6.23	135	Urea	26.7	N rates		Qiao et al., 1012
								189	Urea	31.3			
								216	Urea	47.8			

								243	Urea	37.8			
								270	Urea	57.7			
								405	Urea	65.7			
		2008						0		7.4			
								135	Urea	9.0			
								189	Urea	10.2			
								216	Urea	12.4			
								243	Urea	13.3			
								270	Urea	15.2			
Danyang, Jiangsu	32.0°N, 119.6°E	2007	1243.4	16.5	5.52	1.52	ND	60	Urea	3.09	N rates		Gu et al., 2009
								236	Urea	5.87			
								272	Urea	6.81			
								247	Urea	7.47			
Jiaxing, Zhejiang	31.3°N, 121.3°E	2002	1100	15.4	ND	ND	ND	0		0	N rates		Liang et al., 2005
								90	Urea	0.396			
								180	Urea	0.468			
								270	Urea	0.567			
Yixing, Jiangsu	31.3°N, 119.9°E	2004	1076	14.9	ND	ND	ND	240	Urea	4.3	Crop systems	Wheat-Rice	Zhu et al., 2007
								240	Urea	4.08		Rape-Rice	
								240	Urea	4.33		Ryegrass-Rice	
								180	Urea	1.96		Astragalus smicus-Rice	
								240	Urea	3.44		Idle field-Rice	
Nanjing, Jiangsu	32.0°N, 118.5°E	2002	1000	16.0	ND	ND	ND	300	Urea	16.68			Bian et al., 2008

								120	Urea	0.03		75 kg P_2O_5 per hectare without straw	
								150	Urea	0.3135		75 kg P_2O_5 per hectare without straw	
Pengshan, Sichuan	30.3°N, 103.9°E	2008	1003.8	16.7	ND	ND	ND	225	Urea	0.327	N, P rates and straw treatments	75 kg P_2O_5 per hectare without straw	Chen et al., 2009
								150	Urea	0.234		112.5 kg P_2O_5 per hectare without straw	
								120	Urea	0.2325		75 kg P_2O_5 per hectare with straw	
								180	Urea	2.91		CT without straw	
								180	Urea	2.59		CT with straw	
		2008						180	Urea	9.21		Balanced fertilization	
Hefei, Anhui	31.5°N, 117.2°E		1000	15.5	16.98	1.24	6	180	Urea	5.09	Tillage and straw treatments	Balanced fertilization Without tillage	Wang et al., 2010
								180	Urea	6.23		CT without straw	
								180	Urea	4.82		CT with straw	
		2009						180	Urea	3.55		Balanced fertilization	
								180	Urea	3.33		Balanced	

												fertilization Without tillage	
Wuxi, Jiangsu	31.6°N, 120.3°E	2009	1080	16.0	35.7	1.8	ND	270	Urea	9.2	N rates		Xue et al., 2011
								210	Urea	7.5			
								210	Urea	8.5			
								180	Urea	9.3			
								153	Urea	6.8			
								0		5.1			
Yixing, Jiangsu	31.3°N, 119.9°E	2008	1076	14.9	12.6	0.6	6.2	81	Urea	4.7	N rates		Zhao et al., 2012
								135	Urea	8.5			
								189	Urea	9.6			
								216	Urea	10.1			
								243	Urea	11.6			
								270	Urea	13.3			

Table S4 The site, year, annual mean precipitation, temperature, organic matter content, total N content, pH, N rate, and NH_3 volatilization for different experimental site for rice system.

Site	Coordinate	Year	Preci.	Temp.	SOM	Total N	pH	N rate	Fertilizer type	NH_3 volatilization	Experimental treatments	Note	Reference
			mm	°C	--g kg^{-1}--			kg N ha^{-1}		kg N ha^{-1}			
Changshu, Jiangsu	31.5°N, 120.7°E	2001	1038	15.5	34.5	1.8	7.4	0		0.0	N rates		Wang et al., 2007
								150	Urea	24.1			
								300	Urea	78.0			
		2002						0		6.9			
								150	Urea	48.9			
								300	Urea	110.7			
		2003						0		3.1			
								150	Urea	45.3			
								300	Urea	112.7			
Changshu, Jiangsu	31.5°N, 120.7°E	2003	1038	15.5	27.8	1.8	6.1	0		0.5	N rates		Zhao et al., 2009
								100	Urea	6.6			
								300	Urea	35.6			
Jiaxing, Zhejiang	31.3°N, 121.3°E	2003	1100	15.4	35.0	2.7	7.1	90	Urea	26.5	N rates		Liang et al., 2007
								270	Urea	72.7			
								360	Urea	103.6			
Changshu, Jiangsu	31.5°N, 120.7°E	2003	1038	15.5	35.0	2.1	7.5	0		2.3	N rates and application methods		Deng et al., 2006
								100	Urea	9.6		Conventional application	
								200	Urea	16.5		Conventional application	
								300	Urea	24.7		Conventional	

												application	
								350	Urea	32.0		Conventional application	
								0		2.3			
								100	Urea	11.1		Optimum application	
								200	Urea	21.4		Optimum application	
								300	Urea	31.9		Optimum application	
								350	Urea	35.0		Optimum application	
Jurong, Jiangsu	32.0°N, 119.3°E	1995	1093	15.2	9.9	ND	6.3	100	Urea	5.4	N rates		Tian et al., 2001
								200	Urea	10.2			
		1997						100	Urea	8.7			
								200	Urea	15.1			
								300	Urea	32.1			
Changshu, Jiangsu	31.5°N, 120.7°E	2000	1038	15.5	34.5	1.8	7.4	150	Urea	44.0	N rates		Li et al., 2008
								300	Urea	104.0			
Qiyang, Hunan	26.8°N, 111.9°E	1998	1325	18.3	24.5	1.6	6.8	0		0.7	Crop systems	Early rice	Li et al., 2005
								150	Urea	57.4		Early rice	
								0		2.2		Late rice	
								150	Urea	59.1		Late rice	
Wuhan, Hubei	30.6°N, 114.4°E	2008	1300	16.8	20.7	0.9	6.3	210	Urea	62.8	N rates and application	Twice	Xia et al., 2010
								147	Urea	45.9		Twice	

								147	Urea	41.3	times	Triple	
Wuxi, Jiangsu	31.6°N, 120.3°E	2009	1080	16.0	35.7	1.8	ND	270	Urea	67.5	N rates		Xue et al., 2011
								210	Urea	52.5			
								153	Urea	33.3			
								0		10.5			
Changshu, Jiangsu	31.5°N, 120.7°E	2005	1038	15.5	35.0	2.1	7.4	0		0.1	N rates and straw managements	No straw	Zhang et al., 2007
								180	Urea	8.2		No straw	
								270	Urea	28.7		No straw	
								270	Urea	27.2		With straw	
		2006						0		0.3		No straw	
								180	Urea	21.8		No straw	
								270	Urea	53.1		No straw	
								270	Urea	62.1		With straw	
Yangzhou, Jiangsu	32.2°N, 119.3°E	2008	1000	15.0	6.7	0.6	7.4	0		0.4	Soil types	Sandy soil	Ye et al., 2011
								100	Urea	11.3		Sandy soil	
								200	Urea	35.4		Sandy soil	
								300	Urea	70.8		Sandy soil	
								400	Urea	102.4		Sandy soil	
					9.8	0.8	7.2	0		0.4		Clay soil	
								100	Urea	10.9		Clay soil	
								200	Urea	28.6		Clay soil	
								300	Urea	55.3		Clay soil	
								400	Urea	87.1		Clay soil	
Changshu, Jiangsu	31.5°N, 120.7°E	2004	1038	15.5	24.6	1.6	5.2	0		2.4	N rates		Huang et al., 2006
								100	Urea	6.1			

								150	Urea	11.7			
								200	Urea	21.2			
								250	Urea	25.5			
								300	Urea	34.4			
								350	Urea	41.5			
Changshu, Jiangsu	31.5°N, 120.7°E	2005	1038	15.5	35.0	2.1	7.3	100	Urea	16.4	N application methods	Conventional application	Xu et al., 2006
								200	Urea	35.0		Conventional application	
								300	Urea	53.0		Conventional application	
								350	Urea	68.9		Conventional application	
								100	Urea	12.7		Optimum application	
								200	Urea	30.2		Optimum application	
								300	Urea	42.9		Optimum application	
								350	Urea	59.3		Optimum application	
Yixing, Jiangsu	31.3°N, 119.9°E	2008	1076	14.9	21.7	0.6	6.2	81	Urea	5.8	N rates		Zhao et al., 2012
								135	Urea	10.8			
								189	Urea	17.2			
								216	Urea	24.9			
								243	Urea	33.7			

								270	Urea	43.0			
Changshu, Jiangsu	31.5°N,120.7°E	2002	1038	15.5	35.0	2.1	7.3	0		0.5	N rates		Su et al., 2004
								180	Urea	4.8			
		2003						0		1.5			
								330	Urea	33.4			
								180	Urea	17.3			
								255	Urea	24.5			
								255	Urea	26.2			
Changshu, Jiangsu	31.5°N, 120.7°E	2004	1038	15.5	ND	ND	ND	200	Urea	14.9	N rates		Yan, 2009
								250	Urea	25.8			
Changshu, Jiangsu	31.5°N, 120.7°E	2002	1038	15.5	35.0	2.1	7.3	0		0.3	N and P rates		Tian et al., 2007
								180	Urea	5.4		With 90 kg P_2O_5 per hectare	
								255	Urea	23.5		With 90 kg P_2O_5 per hectare	
		2003						0		1.3			
								180	Urea	24.3		With 90 kg P_2O_5 per hectare	
								255	Urea	27.9		With 90 kg P_2O_5 per hectare	
								255	Urea	33.4		With 30 kg P_2O_5 per hectare	
								255	Urea	37.2		With 1800 kg P_2O_5 per hectare	
								330	Urea	37.8		With 90 kg P_2O_5 per hectare	

Hangzhou, Zhejiang	30.3°N, 120.2°E	2006	1139	17.5	22.4	ND	ND	120	Urea	7.9	N rates		Zhao et al., 2009
								120	Urea	9.9			
								0		2.7			
								80	Urea	7.2			
								160	Urea	11.1			
								240	Urea	14.9			
Liuyang, Hunan	28.1°N, 113.4°E	2010	1637	17.3	ND	ND	ND	150	Urea	58.8	N rates		Shi, 2012
								120	Urea	38.2			
								180	Urea	53.5			
								150	Urea	43.3			
								165	Urea	97.3			
								135	Urea	56.1			
								195	Urea	74.2			
								165	Urea	61.7			
Hefei, Anhui	31.7°N, 117.8°E	2010	1000	15.5	34.1	1.6	7.0	0		1.0	N rates and straw managements	No straw	Zhu et al., 2012
								214	Urea	15.2		No straw	
								225	Urea	13.8		No straw	
								157.5	Urea	9.9		No straw	
								225	Urea	12.9		No straw	
								157.5	Urea	8.3		With straw	
Yangzhou, Jiangsu	32.2°N, 119.3°E	2005	1000	15.0	ND	0.8	ND	100	Urea	58.3	Straw managements	With 6 t straw per hectare	Xu, 2010
								100	Urea	46.1		With 4.5 t straw per hectare	
								100	Urea	58.6		With 3 t straw	

												per hectare	
								100	Urea	62.2		With 1.5 t straw per hectare	
								100	Urea	38.6		No straw	
								100	Urea	38.6	N application methods	100% surface fertilization	
								100	Urea	13.7		80% surface fertilization	
								100	Urea	20.4		60% surface fertilization	
								100	Urea	20.1		40% surface fertilization	
								100	Urea	21.8		20% surface fertilization	
Kunshan, Jiangsu	31.2°N, 120.6°E	2008	1097	15.5	ND	ND	ND	403	Urea	125.3	Irrigation managements	Water-saving irrigation	Peng et al., 2009
								180	Urea	33.3		Flooding irrigation	
								180	Urea	23.7		Water-saving irrigation	
Kunshan, Jiangsu	31.2°N, 120.6°E	2008	1097	15.5	21.9	1.1	7.4	325	Urea	71.7	N rates and irrigation managements	Flooding irrigation	Yang et al., 2010
								207	Urea	48.0		Flooding irrigation	
								325	Urea	58.4		Water-saving irrigation	

								207	Urea	39.6		Water-saving irrigation	
Jurong, Jiangsu	32.0°N, 119.3°E	1995	1093	15.2	9.9	0.7	6.3	200	Urea	11.6	N rates		Cao et al., 2000
								100	Urea	6.8			
								0		1.3			
		1997						300	Urea	27.9			
								200	Urea	18.8			
								100	Urea	14.9			
								0		6.5			
Nanning, Guangxi	22.5°N, 108.2°E	2007	1304	21.7	25.3	1.1	6.8	127	Urea	9.2			Ning, 2008
Wuhan, Hubei	30.6°N, 114.4°E	2007	1361	16.8	16.8	1.1	6.8	225	Urea	46.3			Li et al., 2008
Taoyuan, Hunan	28.9°N, 111.6°E	2006	1448	16.5	28.5	2.7	5.1	0		1.3	Crop systems and fertilizer managements	Early rice without fertilizer	Wu et al., 2009
								81	Urea	10.1		Early rice with NP	
								81	Urea	13.7		Early rice with NK	
								81	Urea	11.6		Early rice with NPK	
								0		3.8		Early rice without fertilizer	
								102	Urea	19.9		Early rice with NP	
								102	Urea	37.1		Early rice with	

												NK	
								102	Urea	18.7		Early rice with NPK	
Nanchang, Jiangxi	23.4°N,115.9°E	2010	1662	17.8	26.3	1.5	5.2	0		5.0	Crop systems and N rates	Early rice	Wang et al., 2012
								60	Urea	22.6		Early rice	
								120	Urea	45.6		Early rice	
								180	Urea	72.7		Early rice	
								240	Urea	111.4		Early rice	
								0		0.9		Late rice	
								60	Urea	22.4		Late rice	
								120	Urea	44.3		Late rice	
								180	Urea	75.3		Late rice	
								240	Urea	104.4		Late rice	
Haining, Zhejiang	30.4°N,120.4°E	2009	1187	15.9	13.5	1.1	7.4	0		3.5	N rates		Yu et al., 2012
								90	Urea	12.4			
								150	Urea	22.9			
								210	Urea	37.1			
								270	Urea	62.2			
								330	Urea	82.6			
Wuxue, Hubei	29.9°N,115.5°E	2009	1361	16.8	31.7	3.6	ND	210	Urea	40.7	Tillage treatments	No tillage	Cao et al., 2010
								210	Compound fertilizer	27.8		No tillage	
								210	Urea	27.7		Conventional tillage	
								210	Compound	18.7		Conventional	

								fertilizer				tillage	
Changshu, Jiangsu	31.5°N, 120.6°E	2003	1038	15.5	ND	ND	ND	0		1.0	N rates		Deng et al., 2012
								100	Urea	11.3			
								200	Urea	22.3			
								300	Urea	27.9			
								350	Urea	35.4			
		2004						0		0.8			
								100	Urea	9.7			
								150	Urea	19.8			
								200	Urea	20.4			
								250	Urea	26.5			
								300	Urea	33.0			
								350	Urea	35.0			
Suzhou, Jiangsu	31.3°N, 120.9°E	2008	1097	15.5	ND	ND	ND	403	Urea	125.3			Peng et al., 2011
Wuxi, Jiangsu	29.9°N, 115.5°E	2008	1361	16.8	33.4	2.5	5.4	0		7.9	N rate and tillage managements	No tillage	Zhang et al., 2011
								210	Urea	36.7		No tillage	
								0		9.8		Conventional tillage	
								210	Urea	28.5		Conventional tillage	
		2009						0		4.4		No tillage	
								210	Urea	27.6		No tillage	
								0		5.6		Conventional tillage	

								210	Urea	18.2		Conventional tillage	
Changshu, Jiangsu	31.5°N, 120.7°E	2009	1200	16.0	38.8	2.2	7.2	0		8.0	N rates and straw managements	No straw	Wang et al., 2012
								180	Urea	39.9		No straw	
								240	Urea	63.2		No straw	
								180	Urea	51.0		With straw	
								240	Urea	82.6		With straw	
		2010						0		4.8		No straw	
								180	Urea	20.8		No straw	
								240	Urea	37.8		No straw	
								180	Urea	28.9		With straw	
								240	Urea	45.2		With straw	
Suzhou, Jiangsu	31.3°N, 120.9°E	2008	1097	15.5	30.3	1.8	7.4	162	Urea	32.1	N rates and irrigation managements	Conventional irrigation	Xu et al., 2012
								403.3	Urea	125.3		Water-saving irrigation	
								162	Urea	37.6		Water-saving irrigation	
Yuhang, Zhejiang	30.3°N, 120.2°E	2004	1350	16.0	19.7	2.3	7.2	0		5.2	N rates		Li et al., 2008
								90	Urea	8.9			
								180	Urea	18.8			
								270	Urea	25.3			
								360	Urea	58.3			
		2005						0		6.4			
								90	Urea	10.7			

								180	Urea	22.2		
								270	Urea	31.7		
								360	Urea	64.6		
Changshu, Jiangsu	31.2°N, 120.1°E	2004	1200	16.0	23.9	2.6	7.1	0		4.5	N rates	
								90	Urea	7.9		
								180	Urea	15.3		
								270	Urea	22.7		
								360	Urea	48.8		
		2005						0		5.3		
								90	Urea	9.9		
								180	Urea	21.7		
								270	Urea	28.0		
								360	Urea	51.5		
Jiaxing, Shanghai	30.5°N, 120.4°E	2004	1403	17.2	35.0	2.7	6.8	0		3.9	N rates	
								90	Urea	7.3		
								180	Urea	13.2		
								270	Urea	20.0		
								360	Urea	40.6		
		2005						0		4.7		
								90	Urea	9.5		
								180	Urea	15.5		
								270	Urea	25.9		
								360	Urea	46.3		
Changshu, Jiangsu	31.2°N, 120.1°E	2003	1200	16.0	24.6	1.6	5.4	100	Urea	9.4	N rates	Lin et al., 2007
								200	Urea	17.9		

								300	Urea	50.0			
								350	Urea	47.9			
Jurong, Jiangsu	32.1°N,119.2°E	2007	1050	15.0	ND	ND	ND	329	Urea	39.7			Ti, 2011
Changshu, Jiangsu	31.2°N, 120.1°E	2002	1200	16.0	43.9	2.6	7.7	135	Urea	38.7	N rates		Song et al. and Zhu et al., 2004
								40.5	Urea	10.3			
								54	Urea	20.9			
								40.5	Urea	7.5			
								270	Urea	80.8			
								81	Urea	23.1			
								108	Urea	39.8			
								81	Urea	17.9			
Fenqiu, Henan	35.2°N, 113.5°E	1984	573	14.0	ND	ND	8.8	90	Urea	27.0	N types		Xing et al., 2000; Cai et al., 2002
								90	NH_4HCO_3	35.1			
Danyang, Jiangsu	32.0°N, 119.6°E	1984	1243	16.5	ND	ND	5.3	90	Urea	8.1			
								90	NH_4HCO_3	16.2			
Fuyang, Anhui	32.5°N, 115.5°E	1984	910	14.9	ND	ND	6.0	90	Urea	9.9			
Yingtan, Jiangxi	28.1°N, 117.0°E	1984	1795	17.6	ND	ND	5.5	90	Urea	36.0			
Shenzhen, Guangdong	22.6°N, 114.0°E	2011	1967	22.5	35.9	1.0	6.1	162.2	Urea	16.1	Crop systems	Early rice	Gong et al., 2013
								162.2	Urea	21.4		Early rice	
								40.9	Urea	9.1		Early rice	
								81.8	Urea	17.2		Early rice	
								40.9	Urea	5.9		Late rice	

	40.9	Urea	8.0	Late rice
	81.8	Urea	10.0	Late rice
	81.8	Urea	13.4	Late rice

Table S5 The site, year, annual mean precipitation, temperature, organic matter content, total N content, pH, N rate, and direct N_2O emission for different experimental site for wheat system.

Site	Coordinate	Year	Preci.	Temp.	SOM	Total N	pH	N rate	Fertilizer type	Direct N_2O emission	Experimental treatments	Note	Reference
			mm	^{o}C	--g kg^{-1}--			kg N ha^{-1}		kg N ha^{-1}			
Fengqiu, Henan	35.0°N, 114.4°E	1999	615	13.9	9.8	0.6	8.6	220	Urea	0.66			Cai et al., 2002
Fengqiu, Henan	35.0°N, 114.4°E	1999	615	13.9	10.0	0.8	8.6	0		0.64	N rate		Ding et al., 2003
								220	Urea	1.27			
Yongji, Shanxi	34.9°N, 110.7°E	2008	562	14.8	11.3	1.1	8.7	180	Urea	1.50	Straw managements	No straw	Liu et al., 2011
								180	Urea	1.60		With straw	
Huantai, Shandong	36.6°N, 117.6°E	2008	586	13.0	17.7	1.1	8.3	0		0.30	N rate		Cui et al., 2012
								270	Urea	2.40			
Fengqiu, Henan	35.0°N, 114.4°E	1994	615	13.9	ND	ND	ND	183	Urea	2.08			Xing et al., 1998
Fengqiu, Henan	35.0°N, 114.4°E	2002	615	13.9	11.0	0.4	8.6	150	Urea	0.24	Fertilizer managements	N, P and K	Meng et al., 2005
								0		0.06		No fertilizer	
								150	Urea	0.15		N and P	
								150	Urea	0.18		N and K	
								0		0.07		P and K	
Fengqiu, Henan	37.9°N, 114.7°E	1994	615	13.9	1.9	0.1	9.0	235	Urea	1.15	Soil types	Sandy soil	Xu et al., 2000
					7.8	0.6	8.6	235	Urea	1.84		Loam soil	
					7.6	0.5	8.2	235	Urea	0.63		Clay soil	
Fengqiu, Henan	35.0°N, 114.2°E	2004	615	13.9	7.3	0.6	8.7	0		0.16	N rates		Ding et al., 2007
								150	Urea	0.39			

								250	Urea	0.60			
Taian, Shandong	36.2°N, 117.2° E	2006	688	13.0	15.3	0.9	ND	280	Urea	1.34	Tillage and straw managements	Conventional tillage without straw	Zhao et al., 2008
								280	Urea	1.48		Conventional tillage with straw	
								280	Urea	1.42		Deep ploughing	
								280	Urea	1.64		Harrow tillage	
								280	Urea	1.59		Rotary tillage	
								280	Urea	1.33		No tillage	
Changwu, Shanxi	35.2°N, 107.7°E	2008	579	9.1	10.5	0.6	8.3	120	Urea	0.52	Fertilizer managements	N and P	Shi, 2011
								120	Urea	0.46		N, P and K	
								0		0.19		No fertilizer	
Changwu, Shanxi	35.2°N, 107.7°E	2004	579	9.1	10.5	0.6	8.3	0		0.48	Fertilizer managements	No fertilizer	Chen, 2007
								120	Urea	0.95		N	
								120	Urea	0.74		N and P	
Dongbeiwang, Beijing	40.2°N, 116.5°E	2001	436	11.5	21.3	1.2	7.9	0		0.03	N rate		Ju et al., 2011
								98	Urea and NH_4HCO_3	0.13			
		2002						0		0.13			
								66	Urea and NH_4HCO_3	0.26			
		2003						0		0.13			

								104	Urea and NH_4HCO_3	0.23			
Quzhou, Hebei	36.9°N, 115.0°E	2009	556	13.2	12.6	0.7	7.7	100	Urea	0.79	Cropping systems	Opt. W/M	Gao, 2012
								100	Urea	0.74		W/M-M	
								100	Urea	0.72		W/S-M	
		2010						300	Urea	1.42		Con.W/M	
								139	Urea	1.20		Opt. W/M	
								139	Urea	0.58		W/M-M	
								139	Urea	0.53		W/S-M	
Haidian, Beijing	39.5°N, 116.3°E	2002	436	11.5	21.4	1.2	8.0	52	Urea	0.26			Gao, 2004
Quzhou, Hebei	36.9°N, 115.0°E	2009	556	13.1	14.7	0.9	8.2	0		0.22	Straw managements		Hu, 2011
								200	Urea	0.45		No straw	
								200	Urea	0.48		With straw	
		2010						0		0.17			
								200	Urea	0.69		No straw	
								200	Urea	0.85		With straw	
Luancheng, Hebei	37.8°N, 114.7°E	1999	537	12.2	15.1	1.0	8.2	0		0.78	N rates		Zhang et al.,
								100	Urea	1.09			
								200	Urea	1.29			
								300	Urea	1.81			
Hengshui, Hubei	38.0°N, 115.5°E	2007	460	12.6	11.7	ND	8.0	0		0.67	N application times		Wang et al., 2009
								300	Urea	1.67		Twice	
								210	Urea	1.40		Twice	
								210	Urea	1.27		Triple	

Baoding, Hebei	38.1°N, 115.1°E	2005	575	12.3	19.3	1.0	8.6	0		0.13	N rates		Ma et al., 2012
								75	Urea	0.14			
								150	Urea	0.16			
								225	Urea	0.25			
Yongji, Shanxi	34.9°N, 110.7°E	2000	559	14.7	19.5	1.1	8.7	0		0.48	N rates		Liu et al., 2012
								60	Urea	0.48			
								120	Urea	0.59			
								180	Urea	0.79			
Huantai, Shandong	36.9°N, 118.0°E	2001	587	12.5	ND	ND	ND	100	Urea	1.35	N rates and straw managements	No straw	Pan et al., 2004
								0		0.85		No straw	
								200	Urea	0.92		With straw	
								200	Urea	0.52		With straw	
								100	Urea	0.49		With straw	
Baoding, Hebei	38.9°N, 115.3°E	2010	555	12.3	8.9	1.1	8.1	0		0.90	Straw managements	No straw	Pei et al., 2012
								165	Urea	2.07		No straw	
								165	Urea	1.11		With straw	
Shijiazhuang, Hebei	38.0°N, 114.3°E	1992	471	13.5	12.5	0.8	8.5	158	Urea	1.75			Zeng et al., 1994

Table S6 The site, year, annual mean precipitation, temperature, organic matter content, total N content, pH, N rate, and N leaching for different experimental site for wheat system.

Site	Coordinate	Year	Preci.	Temp.	SOM	Total N	pH	N rate	Fertilizer type	N leaching	Experimental treatments	Note	Reference
			mm	^{o}C	--g kg^{-1}--			kg N ha^{-1}		kg N ha^{-1}			
Haidian, Beijing	40.0°N, 119.5°E	1998	644	11.5	26.7	1.4	7.9	0		0.0	N rates		Liu et al., 2003
								120	Urea	22.0			
								240	Urea	117.0			
								360	Urea	166.0			
		1999						0		0.0			
								120	Urea	7.0			
								240	Urea	62.0			
								360	Urea	131.0			
Yucheng, Shandong	36.8°N, 116.6°E	2000	515	12.0	9.6	0.6	8.2	0		0.0	N rates and irrigation treatments	85% field capacity	Fang et al., 2006
								100	Urea	23.0		85% field capacity	
								200	Urea	6.0		85% field capacity	
								300	Urea	7.0		85% field capacity	
								0		0.0		70% field capacity	
								100	Urea	0.0		70% field capacity	
								200	Urea	38.0		70% field	

												capacity	
								300	Urea	28.0		70% field capacity	
		2001						0		0.0		85% field capacity	
								100	Urea	0.0		85% field capacity	
								200	Urea	70.0		85% field capacity	
								300	Urea	80.0		85% field capacity	
								0		0.0		70% field capacity	
								100	Urea	19.0		70% field capacity	
								200	Urea	26.0		70% field capacity	
								300	Urea	16.0		70% field capacity	
Dongbeiwang, Beijing	39.0°N, 116.0°E	1999	628	11.5	21.4	1.2	8.0	300	Urea	21.0	N rates and irrigation treatments	Conventional irrigation	Zhao, 2006
								85	Urea	0.0		Conventional irrigation	
								300	Urea	24.0		Optimum irrigation	
								55	Urea	18.0		Optimum	

				irrigation
2000	300	Urea	0.0	Conventional irrigation
	83	Urea	8.0	Conventional irrigation
	300	Urea	0.0	Optimum irrigation
	64	Urea	0.0	Optimum irrigation
2001	300	Urea	66.0	Conventional irrigation
	92	Urea	30.0	Conventional irrigation
	300	Urea	13.0	Optimum irrigation
	98	Urea	38.0	Optimum irrigation
2002	300	Urea	200.0	Conventional irrigation
	63	Urea	16.0	Conventional irrigation
	300	Urea	155.0	Optimum irrigation
	66	Urea	10.0	Optimum irrigation
2003	300	Urea	0.0	Optimum

												irrigation	
								104	Urea	0.0		Optimum irrigation	
Changshu, Jiangsu	31.5°N, 120.7°E	2003	1038	15.5	27.8	1.8	6.1	0		0.4	N rates		Xu et al., 2009
								100	Urea	2.7			
								250	Urea	5.8			
Shanghai	31.4°N, 121.5°E	2004	1040	15.7	27.6	1.4	ND	214	Urea	10.0	N rates		Mao et al., 2006
								182	Urea	9.6			
								0		1.9			
		2005						229	Urea	10.9			
								195	Urea	9.3			
								0		1.5			
Shanghai	31.4°N, 121.5°E	2007	1040	15.7	ND	ND	ND	182	Urea	7.6			Lu et al., 2006
Changshu, Jiangsu	31.5°N, 120.7°E	2005	1038	15.5	ND	ND	ND	0		17.8	N rates		Wang et al., 2001
								150	Urea	23.3			
								225	Urea	32.5			
								300	Urea	49.4			
								450	Urea	58.5			
Changshu, Jiangsu	31.5°N, 120.7°E	2001	1038	15.5	34.5	1.8	7.4	0		0.5	N rates		Wang et al., 2005
								150	Urea	0.7			
								300	Urea	1.9			
		2002						0		0.2			
								150	Urea	0.2			
								300	Urea	0.3			

Beibei, Chongqing	30.9°N, 106.4°E	2003	115	18.2	12.2	1.0	7.7	0		1.9	N rates		Yi, 2005
								75	Urea	3.1			
								150	Urea	3.6			
								225	Urea	4.1			
Beibei, Chongqing	30.9°N, 106.4°E	2001	115	18.2	12.2	ND	7.7	0		1.6	N rates and soil types	Alkaline soil	Yi et al., 2004
								150	Urea	4.0		Alkaline soil	
								225	Urea	4.8		Alkaline soil	
								150	NH_4CL	3.4		Alkaline soil	
								225	NH_4CL	3.9		Alkaline soil	
					13.2	ND	7.2	0		1.6		Acid soil	
								150	Urea	4.3		Acid soil	
								225	Urea	6.0		Acid soil	
								150	NH_4CL	4.3		Acid soil	
								225	NH_4CL	5.7		Acid soil	
					12.0	ND	5.2	0		1.9		Neutral soil	
								150	Urea	5.0		Neutral soil	
								225	Urea	6.2		Neutral soil	
								150	NH_4CL	4.5		Neutral soil	
								225	NH_4CL	5.6		Neutral soil	
Beibei, Chongqing	30.9°N, 106.4°E	1995	115	18.2	12.2	ND	7.7	0		3.9	N rates and soil types	Neutral soil	Yu et al., 1999
								150	Urea	6.8		Neutral soil	
								225	Urea	7.9		Neutral soil	
								150	NH_4CL	6.7		Neutral soil	
								225	NH_4CL	7.7		Neutral soil	
					13.2	ND	7.2	0		3.2		Alkaline soil	

								150	Urea	6.3		Alkaline soil	
								225	Urea	7.7		Alkaline soil	
								150	NH_4CL	6.3		Alkaline soil	
								225	NH_4CL	7.5		Alkaline soil	
								0		3.7		Acid soil	
								150	Urea	6.8		Acid soil	
					12.0	ND	5.2	225	Urea	9.3		Acid soil	
								150	NH_4CL	6.7		Acid soil	
								225	NH_4CL	8.0		Acid soil	
								0		3.7		Neutral soil	
								150	Urea	7.4		Neutral soil	
					12.2	ND	7.7	225	Urea	9.1		Neutral soil	
								150	NH_4CL	7.4		Neutral soil	
								225	NH_4CL	8.8		Neutral soil	
								0		4.4		Alkaline soil	
								150	Urea	8.0		Alkaline soil	
		1996	115	18.2	13.2	ND	7.2	225	Urea	10.9		Alkaline soil	
								150	NH_4CL	7.9		Alkaline soil	
								225	NH_4CL	9.4		Alkaline soil	
								0		4.8		Acid soil	
								150	Urea	8.0		Acid soil	
					12.0	ND	5.2	225	Urea	9.3		Acid soil	
								150	NH_4CL	7.9		Acid soil	
								225	NH_4CL	9.0		Acid soil	
Changshu,	31.5°N,	2005	1038	15.5	35.0	2.1	7.4	0		3.3	N rates		Zhang et al.,

Jiangsu	120.7°E							150	Urea	12.6		2008
								225	Urea	14.5		
								300	Urea	17.0		
Changshu, Jiangsu	31.5°N, 120.7°E	2003	1038	15.5	ND	ND	ND	250	Urea	8.5		Ju et al., 2009
Dongbeiwang, Beijing	39.0°N, 116.0°E	2000	628	11.5	ND	ND	ND	325	Urea	8.8		

Table S7 The site, year, annual mean precipitation, temperature, organic matter content, total N content, pH, N rate, and NH_3 volatilization for different experimental site for wheat system.

Site	Coordinate	Year	Preci.	Temp.	SOM	Total N	pH	N rate	Fertilizer type	NH_3 volatilization	Experimental treatments	Note	Reference
			mm	°C	--g kg^{-1}--			kg N ha^{-1}		kg N ha^{-1}			
Zhangbei, Hubei	41.2°N, 114.7°E	1993	325	2.6	30.7	1.7	7.7	48	NH_4HCO_3	2.4	N types		Bian et al., 1997
								48	Urea	0.5			
Fengqiu, Henan	35.0°N, 114.4°E	1999	615	13.9	ND	0.6	8.8	75	Urea	0.7	N types		Cai et al., 1998
								75	NH_4HCO_3	6.5			
Fengqiu, Henan	35.0°N, 114.4°E	1998	615	13.9	9.8	0.6	8.6	120	Urea	23.9	N application methods	SB	Cai et al., 2002
								120	Urea	2.8		DP	
		1999						100	Urea	14.6		SB	
								100	Urea	0.6		BI	
Luanccheng, Hebei	37.9°N, 114.7°E	1999	615	13.9	ND	ND	ND	240	Urea	18.3			Zhang et al., 2004
Luanccheng, Hebei	37.9°N, 114.7°E	1999	615	13.9	ND	ND	ND	250	Urea	19.7			Zhang et al., 2009
Quzhou, Hebei	36.9°N, 115.0°E	2000	556	13.2	ND	ND	ND	210	NH_4HCO_3	25.2	N rates		Li et al., 2001
		1999						191	NH_4HCO_3	18.9			
		1999						341	NH_4HCO_3	54.0			
Dongbeiwang, Beijing	39.5°N, 116.3°E	2002	640	11.5	21.4	1.2	8.0	150	NH_4HCO_3	17.0	N rates and types		Su et al., 2007
								150	Urea	41.3			
								300	Urea and NH_4HCO_3	29.9			
								300	Urea and	58.3			

									NH_4HCO_3			
								34	Urea	14.4		
		2004						100	Urea	24.0		
								100	NH_4NO_3	2.7		
Quzhou, Hebei	36.6°N, 114.9°E	1998	556	13.2	ND	ND	ND	259	Urea	38.1	N rates	Xiao, 2004
		1999						341	Urea	55.5		
		2000						355	Urea	60.6		
		2001						304	Urea	53.1		
Luancheng, Hebei	37.9°N, 114.7°E	1999	537	12.2	12.0	0.9	ND	130	Urea	1.2	N rates and types	Zhang et al., 2005
								110	Urea	17.1		
								240	NH_4HCO_3	18.3		
Changshu, Jiangsu	31.5°N, 120.7°E	2002	1038	15.5	44.6	2.7	7.2	81	Urea	18.4	N rates	Fan et al., 2005
								135	Urea	35.3		
								54	Urea	1.6		
								90	Urea	7.9		
								135	Urea	20.0		
								225	Urea	43.2		
Dongbeiwang, Beijing	39.0°N, 116.0°E	2000	628	11.5	ND	ND	ND	325	Urea	63.1		Ju et al., 2009

Table S8 The site, year, annual mean precipitation, temperature, organic matter content, total N content, pH, N rate, grain yield, and direct N_2O emission for different experimental site.

Site	Coordinate	Year	Preci.	Temp.	SOM	Total N	pH	N rate	Fertilizer type	Direct N_2O emission	Experimental treatments	Note	Reference
			mm	^{o}C	--g kg^{-1}--			kg ha^{-1}		kg N ha^{-1}			
Shenyang, Liaoning	41.5°N, 122.4°E	1994	700	7.5	16.2	0.8	6.4	0		0.43			Gu et al., 2007; Huang et al., 1998
Harbin, Heilongjiang	45.7°N, 126.6°E	2008	533	3.5	16.2	1.3	7.1	0		0.21	N rate		Ni et al., 2012
								225	Urea	0.88			
Jizhong, Shanxi	37.6°N, 112.8°E	2009	430	9.3	ND	ND	8.4	120	Urea	0.78			Liu. et al., 2011d
Hailun, Heilongjiang	47.4°N, 126.9°E	2000	500	4	48.2	2.6	6.3	0		0.41	N rate		Ding & Wang, 2004
								140	Urea	1.37			
Shenyang, Liaoning	41.3°N, 123.2°E	1992	806	5.3	16.2	0.8	6.3	350	Urea	4.52	N rate		Huang et al., 1995
Jizhong, Shanxi	37.6°N, 112.8°E	2009	430	9.3	16.9	1.8	7.5	0		0.21	Fertilizer management	No fertilizer	Liu et al., 2011c
								180	Urea	0.93		N	
								180	Urea	1.19		N+P	
Fengqiu, Henan	35.0°N, 114.4°E	1998	615	13.9	ND	ND	ND	0		0.10	N application method*		Cai et al., 2002a, b
								75	Urea	1.10		BI	
								75	Urea	0.80		SB	
								200	Urea	2.30		DP	
		1999	615	13.9	ND	ND	ND	0		0.30			
								150	Urea	2.55		DP	
								150	Urea	2.85		SB	
Yongji, Shanxi	34.9N, 110.7°E	2009	562	14.8	11.3	1.1	8.7	210	Urea	3.00	Straw management	With straw	Liu et al., 2011a
								210	Urea	1.90		No straw	

Fengqiu, Henan	35.0°N, 114.4°E	2009	615	13.9	12.0	1.5	8.6	200	Urea	0.77			Ding et al., 2010
Fengqiu, Henan	35.0°N, 114.4°E	2002	615	13.9	11.7	0.4	8.5	150	Urea	0.50	Fertilizer management	N+P+K	Meng et al., 2005
								0		0.08		No fertilizer	
								150	Urea	0.42		N+P	
								150	Urea	0.37		N+K	
								0		0.06		P+K	
Yanting, Sichuan	31.0°N, 105.4°E	2005	826	17.3	14.6	1.0	8.3	0		0.93	N rate		Zhou et al., 2012
								150	Urea	1.94			
								250	Urea	2.74			
		2006	826	17.3	14.6	1.0	8.3	0		0.17			
								150	Urea	0.45			
								250	Urea	0.47			
		2007	826	17.3	14.6	1.0	8.3	0		0.13			
								150	Urea	1.15			
								250	Urea	1.31			
Haidian, Beijing 11	40.1°N, 116.5°E	2001	404	11.5	21.3	1.2	7.9	0		0.15	N rate	CK	Ju et al., 2011
								75	Urea	0.88		Opt. N	
								300	Urea	2.40		Conv. N	
		2002		11.5	21.3	1.2	7.9	0		0.15	N rate	CK	
								62	Urea	0.44		Opt. N	
								300	Urea	1.71		Conv. N	
		2003		11.5	21.3	1.2	7.9	0		0.15	N rate	CK	
								50	Urea	0.10		Opt. N	
								300	Urea	0.84		Conv. N	
		2004		11.5	21.3	1.2	7.9	0		0.16	N rate	CK	
								122	Urea	0.52		Opt. N	
								300	Urea	0.91		Conv. N	

		2005						0		0.53	N fertilizer type		
								250	$NH_4(SO_4)_2$	3.52			
								250	$Ca(NO_3)_2$	0.87			
		2006						0		0.43	N fertilizer type		
								250	$NH_4(SO_4)_2$	4.52			
								250	$Ca(NO_3)_2$	0.51			
		2007						0		0.27	N fertilizer type		
								250	$NH_4(SO_4)_2$	1.31			
								250	$Ca(NO_3)_2$	0.38			
Fengqiu, Henan	35.0°N, 114.4°E	2007	615	13.9	9.7	0.7	8.3	0	Urea	0.08	Fertilizer management (interrow + row soil)	No fertilizer	Cai et al., 2012
								150	Urea	1.22		N+K	
								150	Urea	0.92		N+P+K	
								0		0.06	Fertilizer management (interrow soil)	No fertilizer	
								150	Urea	0.49		N+K	
								150	Urea	0.47		N+P+K	
Wangdu, Hebei	38.7°N, 115.2°E	2009	413	10.5	ND	ND	ND	0		0.94	N rate/straw	CK without straw	Zhang et al., 2011
								168.2	Urea	2.75		N without straw	
								188.8	Urea	3.21		N with straw	
Luancheng, Hebei	37.8°N, 114.7°E	2000	537	12.2	15.1	1.0	8.2	172.5	Urea	2.46			Zhang et al., 2004; 2005
Fengqiu, Henan	35.00N，114.24E	2009	615	13.9	12.0	0.61	ND	0		0.32	Tillage treatment	No-tillage	Cai et al.2011
								0		0.27		tillage	
Fengqiu, Henan	35.0°N, 114.4°E	1999	615	13.8	10.1	0.6	8.7	0		0.75	N rate		Ding et al. 2001a
								150	Urea	3.12			
Fengqiu, Henan	35.0°N, 114.4°E	1999	615	13.9	9.9	0.6	8.6	0	Urea	0.33	N application method		Ding et al., 2001b; Ding
								150	Urea	3.24		SB	

								150	Urea	1.46		BI	et al., 2003
								150	Urea	2.83		DP	
Fengqiu, Henan	35.0°N, 114.4°E	2000	615	13.9	9.9	0.6	8.6	0		0.18	N fertilizer type		Ding et al., 2004
								150	Urea	0.56			
								150	NH_4HCO_3	0.85			
								150	NH_4NO_3	1.04			
								150	$Ca(NO_3)_2$	0.24			
								0		0.46	N application time		
								150	Urea	0.67		one time	
								150	Urea	2.52		two time	
Haidian, Beijing	39.5°N, 116.3°E	2002	436	11.5	21.4	1.2	8.0	80	Urea	0.62	N rate		Gao, 2004
								300	Urea	1.85			
		2003						80	Urea	0.10			
								300	Urea	0.84			
Quzhou, Hebei	36.5°N, 115.1°E	2008	556	13.1	14.7	0.9	8.2	300	Urea	3.46	N rate		Hu et al., 2011
								250	Urea	2.34			
								185	Urea	1.68			
Quzhou, Hebei	36.5°N, 115.1°E	2009	556	13.1	14.7	0.9	8.2	0		0.55	Straw management		Hu, 2011
								180	Urea	1.70		without straw	
								180	Urea	1.76		with straw	
		2010						0		0.34	Straw management		
								180	Urea	1.09		without straw	
								180	Urea	1.31		with straw	
Baoding, Hebei	38.1°N, 115.1°E	2005	396	13.8	19.3	1.0	7.8	0		0.16	N rate		Li, 2006
								60	Urea	0.19			
								120	Urea	0.47			
								180	Urea	0.44			
								240	Urea	0.65			

Yongji, Shanxi	34.9°N, 110.7°E	2008	624	13.1	9.6	1.1	8.5	60	Urea	0.52	Straw management	with straw	Liang, 2009
								60	Urea	0.39		with 1/2straw	
								60	Urea	0.35		without straw	
Baoding, Hebei	38.0°N, 115.0°E	2006	575	12.3	19.3	1.0	8.6	0		0.16	N rate		Ma et al., 2012
								60	Urea	0.19			
								120	Urea	0.74			
								180	Urea	0.69			
								240	Urea	1.10			
Luancheng, Hebei	37.8°N, 114.6°E	1992	550	13.3	7.4	0.8	8.5	0		0.32	N rate		Song et al., 1997
								138	Urea	0.63			
Luancheng, Hebei	37.8°N, 114.6°E	1993	549	13.3	ND	ND	ND	0		0.36	N rate		Wang et al., 1994
								150	Urea	0.54			
Hengshui, Hebei	38.0°N, 115.3°E	2008	460	12.6	11.7	ND	8.0	0		0.86	N rate/application time		Wang, 2009
								240	Urea	3.16		two times	
								168	Urea	2.61		two times	
								168	Urea	2.01		three times	
Yanting, Sichuan	31.3°N, 105.4°E	2005	826	17.3	12.0	0.9	8.3	0		0.88	N rate		Xiang et al., 2007
								150	Urea	2.19			
								250	Urea	2.52			
					14.3	0.8	7.7	0		0.90	N fertilizer type		
								150	Urea	2.09			
								150	$NH_4(SO_4)_2$	1.80			
								150	KNO_3	1.27			
Luancheng, Hebei	37.8°N, 114.6°E	1998	550	13.3	12.5	0.9	8.5	0		0.75	N rate		Zhang et al., 2001
								100	Urea	1.10			
								200	Urea	0.88			
								300	Urea	1.66			
Luancheng,	37.8°N,	1999	537	12.2	15.1	1.0	8.2	0		0.58	N rate		Zhang, 2005

Hebei	114.6°E							100	Urea	1.00			
								200	Urea	0.75			
								300	Urea	1.59			
		2000	537	12.2	15.1	1.0	8.2	0		0.69	N rate		
								100	Urea	1.97			
								200	Urea	2.46			
								300	Urea	4.51			
Quzhou, Hebei	36.5°N, 115.1°E	2009	556.2	13.2	12.6	0.7	7.7	250	Urea	2.03	Cropping system[#]	Conv.W/M	Gao, 2012
								185	Urea	2.57		Opt.W/M	
								135	Urea	1.35		W/M-M	
								210	Urea	1.56		W/S-M	
								95	Urea	1.12		M	
		2010	556.2	13.2	12.6	0.7	7.7	250	Urea	1.67	Cropping system	Conv.W/M	
								185	Urea	2.01		Opt.W/M	
								185	Urea	1.72		W/M-M	
								150	Urea	1.13		M	
		2011	556.2	13.2	12.6	0.7	7.7	250	Urea	1.76	Cropping system	Conv.W/M	
								185	Urea	1.28		Opt.W/M	
								162	Urea	1.29		W/M-M	
								178	Urea	1.01		W/S-M	
								150	Urea	1.11		M	

*N application method: SB: surface broadcast; BI: broadcast followed by irrigation; DP: deep-point placement

[#] Cropping system: Conv.W/M: convention management of winter wheat/summer maize rotation system in one year; Opt.W/M: optimum management of winter wheat/summer maize rotation system in one year; W/M-M: winter wheat/summer maize in one year and spring maize in next year; W/S-M: winter wheat/soybean in one year and spring maize in next year; M: continuous spring maize in one year.

Table S9 The site, year, annual mean precipitation, temperature, organic matter content, total N content, pH, N rate, grain yield, and nitrate leaching for different experimental site.

Site	Coordinate	Year	Preci.	Temp.	SOM	Total N	pH	N rate	Fertilizer type	Nitrate leaching	Experimental treatments	Note	Reference
			mm	^{o}C	--g kg^{-1}--			kg N ha^{-1}		kg N ha^{-1}			
Changchun, Jilin	43.8°N, 125.3°E	1994	550	ND	ND	ND	ND	0		2.2	N rate		Sun et al., 1995
								248	Urea	4.5			
								330	Urea	6.0			
Hetao, Neimonggu	40.3°N, 107.3°E	1997	82.5	7.6	ND	ND	ND	300	Urea	46.6			Feng et al., 2005
Haidian, Beijing	40.0°N, 116.3°E	2001	436	11.5	ND	ND	ND	263	Urea	31.8			Ju et al., 2009
Haidian, Beijing	39.9°N, 116.3°E	1999	644	11.5	26.7	1.4	7.9	0		0	N rate		Liu et al., 2003
								120	Urea	21			
								240	Urea	38			
								360	Urea	16			
		2000						0		0	N rate		
								120	Urea	70			
								240	Urea	104			
								360	Urea	197			
Yucheng, Shandong	36.8°N, 116.5°E	2001	515	12.5	9.6	0.6	8.2	0		0	N rate and irrigation treatments	85% field capacity	Fang et al., 2006
								200	Urea	96			
								300	Urea	142			
								0		0		70% field capacity	
								200	Urea	140			
								300	Urea	165			
		2002						0		0		85% field	

								100	Urea	0		capacity	
								200	Urea	66			
								300	Urea	132			
								0		0			
								100	Urea	25		70% field capacity	
								200	Urea	59			
								300	Urea	99			
Luangcheng, Hebei	37.8°N, 114.6°E	2001	481	12.3	ND	ND	ND	100	Urea	1	N rate		Li et al., 2006
								200	Urea	57			
								400	Urea	220			
Shiqing, Tianjin	39.1°N, 117.2°E	2008	527	12	18.7	2.1	ND	100	Urea	9.6	N rate		Liu et al., 2011b
								200	Urea	42.7			
								300	Urea	107.0			
								400	Urea	146.2			
Jining, Shandong	34.8°N, 117.0°E	2008	772	13.7	15.3	ND	8.3	0		0.32	Fertilizer management/straw	no fertilizer	Tan et al., 2011
								345	Urea	0.90		N	
								0		0.42		P+K	
								179.4	Urea	0.68		N+P+K	
								179.4	Urea	0.66		N+P+K+straw	
Beibei, Chongqing	30.4°N, 106.4°E	2008	1116	18.3	16.2	0.9	6.6	0		3.33	fertilizer management (site1)	no fertilizer	Wei, 2010
								0		2.35		P+K	
								225	Urea	27.39		N+P+K	
								135	Urea	8.37		N+P+K	
								180	Urea	15.14		N+P+K	
								270	Urea	27.28		N+P+K	
								0		4.32	fertilizer management (site2)	no fertilizer	
								0		2.79		P+K	
								225	Urea	16.4		N+P+K	

								135	Urea	5.62		N+P+K	
								180	Urea	7.88		N+P+K	
								270	Urea	20.57		N+P+K	
								0		2.23	fertilizer management (site3)	no fertilizer	
								0		2.53		P+K	
								225	Urea	21.14		N+P+K	
								135	Urea	4.96		N+P+K	
								180	Urea	9.78		N+P+K	
								270	Urea	15.11		N+P+K	
								0		3.29	fertilizer management (site4)	no fertilizer	
								0		2.56		P+K	
								225	Urea	21.64		N+P+K	
								135	Urea	6.32		N+P+K	
								180	Urea	10.93		N+P+K	
								270	Urea	20.99		N+P+K	
Beibei, Chongqing	30.4°N, 106.4°E	2011	1106	18.4	18.1	1.1	6.4	0		6.8	fertilizer management	no fertilizer	Yao, 2012
								0		7.9		P+K	
								135	Urea	21.1		N+P+K	
								180	Urea	44.7		N+P+K	
								225	Urea	82.4		N+P+K	
								270	Urea	100.3		N+P+K	
Yangling, Shannxi	34.3°N, 108.0°E	2008	575	13.0	17.1	0.9	7.4	0		0	N rate/straw	CK	Yi et al., 2010
								280	Urea	14.1		Conv.N	
								180	Urea	6.4		Opt.N	
								90	Urea	2.6		50%Opt.N	
								270	Urea	12.6		150%Opt.N	
								180	Urea	16.4		Opt.N + straw	
Haidian,	39.9°N,	2000	628	11.5	21.4	1.2	8.0	300	Urea	113	N	Conv. irrigation	Zhao, 2006

Beijing	116.3°E					treatment/Irrigation treatment	+ Conv. N
			30	Urea	0		Conv. irrigation + Opt. N
			300	Urea	148		Opt. irrigation + Conv. N
			42	Urea	3		Opt. irrigation + Opt. N
		2001	300	Urea	11		Conv. irrigation + Conv. N
			65	Urea	0		Conv. irrigation + Opt. N
			300	Urea	51		Opt. irrigation + Conv. N
			75	Urea	13		Opt. irrigation + Opt. N
		2002	300	Urea	166		Conv. irrigation + Conv. N
			77	Urea	0		Conv. irrigation + Opt. N
			300	Urea	233		Opt. irrigation + Conv. N
			62	Urea	0		Opt. irrigation + Opt. N
		2003	300	Urea	37		Conv. irrigation + Conv. N
			59	Urea	0		Conv. irrigation + Opt. N
			300	Urea	48		Opt. irrigation

				+ Conv. N
	50	Urea	16	Opt. irrigation + Opt. N
2004	300	Urea	0	Opt. irrigation + Conv. N
	122	Urea	20	Opt. irrigation + Opt. N

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Table S10 The site, year, annual mean precipitation, temperature, organic matter content, total N content, pH, N rate, grain yield, and NH_3 volatilization for different experimental site.

Site	Coordinate	Year	Preci.	Temp.	SOM	Total N	pH	N rate	Fertilizer type	NH_3 volatilization	Experimental treatments	Note	Reference
			mm	°C	--g kg^{-1}--			kg N ha^{-1}		kg N ha^{-1}			
Fengqiu, Henan	35.0°N, 114.4°E	1998	615	13.9	9.8	0.6	8.6	75	Urea	14	N rate/N application method	BI	Cai et al., 2002
								75	Urea	33		SB	
								200	Urea	22		DP	
								150	Urea	18		DP	
								150		39		SB	
Haidian, Beijing	39.9°N, 116.3°E	2004	630	12	20.1	10.9	7.9	263	Urea	64.9			Ju et al., 2009
Yongji, Shanxi	34.9°N, 110.7°E	2008	530	13.5	16.6	1.1	8.5	60	Urea	4			Yang et al., 2011
Fengqiu, Henan	35.0°N, 114.4°E	1990	615	13.9	5.6	0.5	8.8	80	Urea	9.6	N application method	DP	Zhang et al., 1992
								80	Urea	25.3		SB	
Luancheng, Hebei	37.8°N, 114.6°E	1999	537	12.3	12.5	0.9	8.5	157	Urea	41.8	N rate		Zhang et al., 2004; 2009
								170	Urea	47			
Haidian, Beijing	39.9°N, 116.0°E	2002	630	12	21.4	1.2	8.0	300	NH_4HCO_3	77	N rate		Zhao et al., 2009
								300	Urea	70			
								50	Urea	13			
								117	Urea	31			
Quzhou, Hebei	36.5°N, 115.1°E	1999	556.2	13.2	ND	ND	ND	148	Urea	63.5	N rate		Li et al., 2002
		2000						186	Urea	43			
Haidian,	39.5°N,	2003	640	11.5	21.4	1.2	8.0	100	Urea	19.7	N rate		Su et al., 2007

Beijing	116.3°E	2004						20	Urea	5.7		
								200	Urea	65.4		
								30	Urea	12.5		
								100	Urea	22.4		
								55	Urea	15.5		
								200	Urea	47.4		
								62.3	Urea	15.9		
Quzhou, Hebei	36.5°N, 115.1°E	1999	556.2	13.2	ND	ND	ND	186.3	Urea	45.4	N rate	Xiao, 2004
		2000						148.3	Urea	54.9		
		2001						151.8	Urea	45.5		
		2002						158.7	Urea	38.7		

*N application method: SB: surface broadcast; BI: broadcast followed by irrigation; DP: deep-point placement

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