Appendix A Ammonia volatilization under conventional fertilization practice in upland agriculture soils of North China

Site	Crop	N rate (kg N ha^{-1})	NH_3 loss[1] (kg N ha^{-1})	NH_3 loss (%)	Measuring method[3]	Reference
Quzhou, Hebei	Summer maize	270	82	30	DTM	Li *et al.* (2017)
Quzhou, Hebei	Winter wheat	270	57	21	DTM	Li *et al.* (2015a)
Yangling, Shanxi	Winter wheat	240	27	11	DTM	Li *et al.* (2015a)
Changwu, Shanxi	Spring maize	250	15	6	DTM	Li *et al.* (2015b)
Lishu, Jilin	Spring maize	300	45	15	DTM	Li *et al.* (2015b)
Haidian, Beijing	Summer maize	263	65	25	WTM	Ju *et al.* (2009)
	Winter wheat	325	63	19		
Haidian, Beijing	Summer maize	300	80	27	WTM	Su *et al.* (2007)
	Winter wheat	300	45	15		
North China	Summer maize	278±20[4]	76±9	27±3	–	–
North China	Winter wheat	284±37	48±16	17±4	–	–
North China	Spring maize	275±35	30±21	11±6	–	–
North China	Summer maize-Winter wheat	576±32	131±7	23±3	–	–

[1] Including soil background NH_3 emission

[2] NH_3 loss (%)=NH_3 loss / N rate×100

[3] DTM: Dräger-Tube Method; WTM: Wind tunnel method

[4] Number represents mean ± standard deviation

Appendix B NH_3 loss and mitigation potential under different management strategies in North China

Site	Crop	Treatment[1)]	N rate (kg N ha^{-1})	NH_3 loss (%)	Mitigation potential[3)] (%)	Measure-ment method[4)]	Reference
Deep placement							
Quzhou, Hebei	Summer maize	SB	150	15.3		VM	Liu *et al.* (2016)
		DBP	150	4.7	69		
Fengqiu, Henan	Summer maize	SB	200	48.0		MBT	Cai *et al.* (2002)
		DPP	200	11.0	77		
	Summer maize	SB	150	26.0			
		DPP	150	12.0	54		
Beijing	winter wheat	SB	180	46.1		AEM	Cao *et al.* (2001)
		IP	180	6.2	87		
North China	–	–	–	–	72±14[5)]	–	–
Controlled-release fertilizer or other fertilizer type							
Langfang, Hebei	Summer maize	U	180	8.9		VM	Zhou *et al.* (2016a)
		CN	180	2.4	73		
		CRU	180	7.1	20		
		CLU	180	7.2	19		
		PGU	180	5.6	37		
		UF	180	3.5	61		
Luancheng, Hebei	Winter wheat-summer maize	U	505	26.9		AEM	Wang *et al.* (2016)
		CRU	505	14.5	46		
		U	385	26.5			
		CRU	385	14.3	46		
Changchun, Jilin	Spring maize	U	240	10.9		VM	Yan *et al.* (2016)
		CRU	240	10.0	8		
Taian, Shandong	Summer maize	U	300	6.7		VM	Lu and Song (2011)
		CRU(S)	300	4.0	40		
		CRU(P)	300	3.4	49		
Taian, Shandong	Summer maize	U	210	6.8		VM	Lu and Song (2011)
		CRU(S)	210	3.5	49		
		CRU(P)	210	3.7	46		
Taian, Shandong	Winter wheat	U	300	15.1		VM	Lu and Song (2011)
		CRU(S)	300	10.4	31		
		CRU(P)	300	9.4	38		
Taian, Shandong	Winter wheat	U	210	15.4		VM	Lu and Song (2011)
		CRU(S)	210	10.3	33		
		CRU(P)	210	9.8	36		
Taian, Shandong	Summer maize	U	300	8.4		VM	Lu *et al.* (2010)

		CRU(S)	300	4.9	42		
		CRU(P)	300	4.3	49		
Taian, Shandong	Summer maize	U	210	6.6		VM	Lu *et al.* (2010)
		CRU(S)	210	4.6	30		
		CRU(P)	210	4.0	39		
Haidian, Beijing	–	U	100	25.4		WTM	Su *et al.* (2006)
		AN	100	2.9	89		
Haidian, Beijing	–	U	100	23.0		WTM	Su *et al.* (2006)
		CAN	100	19.8	14		
Haidian, Beijing	–	U	100	25.8		WTM	Su *et al.* (2006)
		ASN	100	17.5	32		
North China	–	–	–	–	40±18	–	–
Urease inhibitor							
Quzhou, Hebei	Summer maize	U	150	42.7		DTM	Li *et al.* (2017)
		U+Limus	150	11.0	74		
Yangling, Shanxi	Winter wheat	U	150	10.7		DTM	Li *et al.* (2015)
		U+Limus	150	0.0	100		
Quzhou, Hebei	Winter wheat	U	150	22.7		DTM	Li *et al.* (2015)
		U+Limus	150	6.0	74		
North China	–	–	–	–	83±15	–	–
Nitrification inhibitor							
Baoding, Hebei	Summer maize	CF	176	1.5		DCM	Zhou *et al.* (2016b)
		CF +DCD	176	2.2	-47		
Quzhou, Hebei	Summer maize	CF	150	15.3		VM	Liu *et al.* (2016)
		CF +DCD	150	19.4	-27		
Haidian, Beijing	–	U	100	25.7		WTM	Su *et al.* (2006)
		U+DMPP	100	27.6	-7		
North China	–	–	–	–	-(27±20)	–	–

[1)] SB:Surface broadcast; DPP: Deep-point placement; IP: Incorporation; DBP: Deep-band placement. U: Urea; CN: Calcium nitrate; CRU: Controlled-release urea; CRU(S): Controlled-release urea coated with sulfur; CRU(P): Controlled-release urea coated with polymer; CLU: Controlled-loss urea; PGU: Polymer gel urea; UF: Urea formaldehyde; AN: Ammonium nitrate; CAN: Calcium ammonium nitrate; ASN: Ammonium sulphate nitrate; CF: compound fertilizer; Limus: a urease inhibitor; DCD: a nitrification inhibitor; DMPP: a nitrification inhibitor.

[2)] NH_3 loss (%)=NH_3 loss / N rate × 100, NH_3 loss including soil background NH_3 emission

[3)] Mitigation potential (%)=(NH_3 loss rate of control treament - NH_3 loss rate of mitigation strategy) / NH_3 loss rate of control treatment × 100, control treatment here refer to conventional practice which may lead to high NH_3 losses, for example: surface broadcasting N fertilizer, using common urea and so on.

[4)] VM: Venting method; MBT: Micrometeorological mass balance technique; AEM: Continuous airflow enclosure chamber method; WTM: Wind tunnel method; DTM: Dräger-Tube Method; DCM: Dynamic chamber method

[5)] Number represents mean ± standard deviation

Appendix C Nitrate leaching losses under conventional fertilization in different cropping systems in upland agriculture soils of North China

Site	Crop	N rate (kg N ha^{-1})	Leaching loss[a)] (kg N ha^{-1})	Leaching loss [b)] (%)	Measuring method	Reference
Haidian, Beijing	Summer maize	260	31	12	Suction cup	Huang *et al.* (2017)
	Winter wheat	300	3	1		
Dezhou, Shandong	Summer maize	225	19	9	Lysimeter	Huang *et al.* (2015a)
	Winter wheat	270	10	4		
Yangling, Shanxi	Winter wheat –Summer maize	470	16	3	Lysimeter	Yang *et al.* (2015)
Changping, Beijing	Summer maize	240	46	19	Lysimeter	Xi *et al*. (2015)
Gongzhuling, Jilin	Spring maize	270	7	3	Lysimeter	Peng *et al*. (2015)
Changping, Beijing	Summer maize	300	11	4	Lysimeter	Islam *et al.* (2011)
Shunyi, Beijing	Summer maize	260	31	12	Lysimeter	Huang *et al.* (2011)
	Winter wheat	260	6	2		
Haidian, Beijing	Summer maize	263	32	12	Resin core	Ju *et al.* (2009)
	Winter wheat	325	9	3		
Taian, Shandong	Summer maize	240	23	9	Lysimeter	Li *et al*. (2008)
Harbin, Heilongjiang	Spring maize	263	32	12	Resin core	Han *et al*. (2007)
Fengqiu, Henan	Summer maize	228	21	9	Suction cup	Zhu *et al.* (2005)
Haidian, Beijing	Winter wheat –Summer maize	600	52	9	Suction cup and Resin core	Mack *et al.* (2005)
North China	Summer maize	252±24 [c)]	27±11	11±4	–	–
North China	Winter wheat	289±30	7±3	3±1	–	–
North China	Spring maize	267±5	20±18	8±6	–	–
North China	Winter wheat – Summer maize	539±52	35±12	6±2	–	–

[a)] Including background nitrate leaching loss

[b)] Leaching loss rate (%)=Leaching loss / N rate×100

[c)] Number represents mean ± standard deviation

Appendix D Denitrification losses under conventional fertilization practice in upland agriculture soils of North China

Site	Crop	N rate (kg N ha^{-1})	Denitrification loss[a)] (kg ha^{-1})	Denitrification loss rate[b)] (%)	Measuring method[c)]	Reference
Fengqiu, Henan	Summer maize	270	11.3	3.7	AIT	Huang *et al.* (2015b)
	Winter wheat	270	1.9	0.6	AIT	
Hengshui, Hebei	Summer maize	240	7.8	2.3	AIT	Wang *et al*. (2009)
	Winter wheat	300	2.7	0.6	AIT	
Luancheng, Hebei	Summer maize	300	5.4	1.4	AIT	Zhang (2005)
	Winter wheat	300	2.5	0.5	AIT	
Haidian, Beijing	Summer maize	300	7.3	1.6	AIT	Zou *et al*. (2004)
	Winter wheat	300	2.4	0.1	AIT	
Haidian, Beijing	Summer maize	360	21.6	3.8	AIT	Ju *et al*. (2002)
Haidian, Beijing	Summer maize	300	7.4	1.2	AIT	Zou *et al*. (2001)
North China	Summer maize	295±40[d)]	10.1±5.9	2.3±1.2	–	–
North China	Winter wheat	293±15	2.4±0.3	0.5±0.2	–	–
North China	Winter wheat –Summer maize	570±35	10.3±2.2	1.3±0.6	–	–

[a)] Including background denitrification loss

[b)] Denitrification loss rate (%)=(Denitrification loss- background denitrification loss) / N rate×100

[c)] AIT: Acetylene inhibition technique

[d)] Number represents mean ± standard deviation

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