

Supplementary materials

Optimizing the nitrogen application for Chinese ratoon rice based on yield and reactive nitrogen loss

Table S1 Information of zone, province and experiment sites.

Zone	Province	Experiment sites (number)
SC	Guangdong (2)	Boluo County Mabei town (1); Xingning County Xinxu town (1).
	Guangxi (3)	Luocheng County Xiaochangan town (1); Rongshui County Xiang fentown (1); Tianyang County Baiyu town (1).
	Hainan (2)	Chengmai County (1); Yizhou County (1).
	Taiwan	-
SEC	Fujian (20)	Youxi County Sanming City (5); Mingqing County Shenghuang town (2); Fuan County Shangbaishi town (1); Pucheng County Nanping City (1); Sha County Xiamao town (1); Sanming City (1); Yanping County Nanping City (1); Longyan City (1); Shaowu City (1); Changting County (1); Xianyou County (1).
	Jiangxi (4)	Ganzhou City (1); Jinxian County Nanchang City (2); Nanchang City (1).
	Zhejiang	-
CC	Hubei (24)	Shakou town Honghu City (2); Tuanfeng County Huanggang City (2); Qichun County Huanggang City (9); Yunmeng County Wuluo town (1); Jingshan County Songhe town (1); Jingshan County yanmenkou town (1); Huaqiao town Wuxue City (2); Wuxue County Dajing town (1); Linpu town Jingmen City (1); Qianjiang City (1); Meichuan town Wuxue City (1); Jian County Maoshi town (1); Qichun County Chidong town, Baota town Xianning City, Shakou town Honghu City (1).
	Hunan (8)	Chenxi County AnPing town (1); Shuang County Shangrenli town (1); Chang sha City (3); Datonghu County Yiyang City (1); Yongzhou City (1); Nan County, Heshan County, Linxiang County; Yuanjiang City, Xupu County, Cili County, Qidong County (1).
NEC	Anhui (3)	Huaining County Anqing City (3).
	Henan (1)	Shangcheng County Hefengqiao town. (1)
	Jiangsu	-
SC	Sichuan (7)	Liangping County Tianzhu town (1); Lu County Fuji town (1); Yanjiang County Ziyang City (1); Fushun County Daisi town (1); Fushun County Qilong town (1); Sichuan City (1); Longmatan County Luzhou City (1).
	Yunnan	-
	Guizhou	-
	Chongqing (2)	Kai County Yuexi town (1); Tongliang County Chongqing City (1).

Notes: Henan was divided into NEC and Chongqing was divided into SW, SC=South China, SEC=Southern part of East China, CC=Central China, NEC=Northern part of East China, SC=Southwest; “-” show no experiment sites was found.

Table S2 Protein and nitrogen content of grain for ratoon rice in five areas of China.

	Protein (%)		Nitrogen content of grain (%)			Grain N uptake (kg ha ⁻¹)
	Main crop	Ratoon crop	Main crop	Ratoon crop	Average	Average
SC	-	-	1.85	1.39	1.62 ± 0.15	189
SEC (14)	-	8.66	1.85	1.39	1.62 ± 0.15	230
CC (119)	11.57	8.71	1.85	1.39	1.62 ± 1.03	225
NEC (6)	-	6.13	1.21	0.98	1.10 ± 0.05	138
SW (21)	7.59	7.50	1.21	1.20	1.21 ± 0.17	132
China	9.58	7.75	1.60	1.28	1.62	202

Notes: Nitrogen content of grain = Protein/6.25; grain N uptake (kg ha⁻¹) = Nitrogen content of grain * the sum yield of main crop and ratoon crop; “1.62” was used as the average of China due to the lack of NEC and SW data “-” show no data was found, and we use the data closet to the test site.

Table S3 Nutrient source (atmospheric deposition, biological fixation of nitrogen and rice seedling) into cropland.

Items	Zone	Mean (kg ha ⁻¹)	Range	CV	Source
N Deposition	SC	40.95	32.3~49.6	0.21	[13,62]
	SEC	43.17	33.8~51.5	0.17	[13,62]
	CC	46.68	34.9~68.9	0.25	[13,62]
	NEC	47.00	37.1~56.9	0.21	[13,62]
	SW	37.78	24.3~63.0	0.35	[13,62]
Biological fixation of Nitrogen	China	25	-	-	[63]
Rice seedling	China	2.9	-	-	[64]

Table S4 Models for calculating reactive nitrogen (Nr) loss

Zone	NH ₃ (kg ha ⁻¹)	Leaching (kg ha ⁻¹)	Runoff (kg ha ⁻¹)
SC	$Y=4.95+0.17x$ ($R^2=0.59^{**}$)	$Y=2.25e^{0.0033x}$ ($R^2=0.20^{**}$)	$Y=2.62e^{0.0033x}$ ($R^2=0.83^{**}$)
SEC	$Y=-0.54+0.20x$ ($R^2=0.40^{**}$)	$Y=2.25e^{0.0033x}$ ($R^2=0.20^{**}$)	$Y=3.05e^{0.0040x}$ ($R^2=0.17^{**}$)
CC	$Y=-0.54+0.20x$ ($R^2=0.40^{**}$)	$Y=2.25e^{0.0033x}$ ($R^2=0.20^{**}$)	$Y=3.05e^{0.0040x}$ ($R^2=0.17^{**}$)
NEC	$Y=-0.54+0.20x$ ($R^2=0.40^{**}$)	$Y=2.25e^{0.0033x}$ ($R^2=0.20^{**}$)	$Y=3.05e^{0.0040x}$ ($R^2=0.17^{**}$)
SW	$Y=4.95+0.17x$ ($R^2=0.59^{**}$)	$Y=2.25e^{0.0033x}$ ($R^2=0.20^{**}$)	$Y=2.62e^{0.0033x}$ ($R^2=0.83^{**}$)

Notes: Y and x denote N loss (kg N ha⁻¹) and fertilizer N rate (kg N ha⁻¹), respectively. $^{**}p<0.01$ and $^{*}p<0.05$ indicate significance of the regression model, and the calculation is from Cui et al [65].

Table S5 Relationship between N application and yield for RR in five areas of China.

Site	Yield response	N rate for highest point (kg ha ⁻¹)	n	p
SC	$Y=-8E-05x^2+0.0462x+4.5561$	288.75	47	$p<0.05$
SEC	$Y=-5E-05x^2+0.0252x+9.9022$	252.00	109	$p<0.05$
CC	$Y=-4E-05x^2+0.0244x+9.9475$	305.00	371	$p<0.05$
NEC	$Y=-0.0011x^2+0.8698-158.71$	395.36	23	-
SW	$Y=-4E-05x^2+0.0198x+8.3064$	278.75	137	$p<0.05$

Notes: “n” indicates the total data.

Table S6 Relationship between N application and NUE for RR in five areas of China.

Site	NUE response	N rate for highest point (kg ha ⁻¹)	n	p
SC	$Y=-0.0009x^2+0.285x+39.201$	158.33	30	$p<0.01$
SEC	$Y=-0.0003x^2+0.1171x+53.104$	195.17	127	$p<0.01$
CC	$Y=-0.0004x^2+0.1273x+62.917$	159.13	328	$p<0.01$
NEC	$Y=-0.0129x^2+10.058x-1921.8$	389.84	23	-
SW	$Y=-0.0004x^2+0.1332x+36.021$	166.50	148	$p<0.01$

Notes: “n” indicates the total data.

Table S7 Relationship between N application and grain N uptake for RR in five areas of China.

Site	N uptake by grain response	N rate for highest point (kg ha ⁻¹)	n	<i>p</i>
SC	$Y = -0.0007x^2 + 0.3922x + 135.07$	297.79	47	$p < 0.01$
SEC	$Y = -0.0005x^2 + 0.2839x + 183.53$	283.90	146	-
CC	$Y = -0.0007x^2 + 0.3983x + 170.53$	284.50	382	$p < 0.05$
NEC	$Y = -0.0709x^2 + 55.756x - 10733$	393.20	22	-
SW	$Y = -0.0005x^2 + 0.2807x + 94.372$	280.07	143	$p < 0.01$

Notes: “n” indicates the total data.

Table S8 The accumulated temperature and planting density in different province.

	Accumulated temperature (°C)	Heat index (°C)	Planting density (×10 ⁴ Hills ha ⁻¹)	Source
Guangxi	>6500	≥10	20.29c	[42]
Fujian	>4800	Total accumulated temperature of main crop and ratoon crop	27.15a	[66]
Hubei	4900-5400	≥10	25.33b	[66-67]
Anhui	4600-5300	≥10	-	[43]
Sichuan	5100-5700	≥10	21.65c	[21]

Note: Planting density is from the raw data of 782 studies, “-” show no data was found.