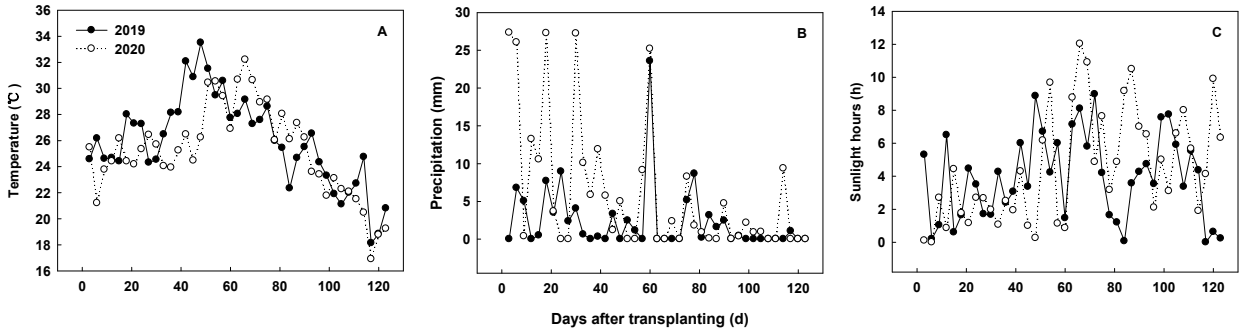

Figure S1. Air temperature (**A**), precipitation (**B**), and sunlight hours (**C**) during the growing seasons of rice at the experiment site of Yangzhou, Southeast China in 2019 and 2020.

Table S1. Analysis-of-variance of F-values of rice growth duration, grain yield, total CH_4 emissions during the whole growth duration (Total CH_4), cumulative CH_4 emissions in panicle differentiation stage (CH_4 in PD), rice root biomass (RB), root oxidation activity (ROA), root radial oxygen loss (ROL) and total organic carbon content in root exudate (ETOC) between/among years and cultivars in experiment 1.

	df	Growth duration	Yield	Total CH_4	CH_4 in PD	RB	ROA	ROL	ETOC
Cultivar	11	4.2**	3.5**	532.7**	311.6**	95.6**	43.8**	16.9**	10.2**
Year	1	ns	ns	224.1**	ns	ns	ns	3.5*	ns
Cultivar ×Year	11	ns	ns	ns	ns	ns	ns	ns	ns

* and ** F-values significant at the 0.05 and 0.01 probability levels, respectively. Ns, non-significant at the 0.05 probability level.

Table S2. Changes in root morphological traits during japonica rice cultivar renewal.

Cultivar type	Cultivar	Root length ($\times 10^3$ m m^{-2})		Root number ($\times 10^3$ m^{-2})		Specific root length (m g^{-1} DW)	
		Booting	Heading	Booting	Heading	Booting	Heading
1950's	Huangkezao	3.35	3.58	3.12	3.24	73.6	72.1
	Guihuaqiu	3.51	3.70	3.2	3.44	68.0	64.9
	Average	**3.43 d**	**3.64 d**	**3.16 d**	**3.34 d**	**70.6 a**	**68.3 a**
1960's	Jinnanfeng	3.48	3.59	3.28	3.45	66.4	62.2
	Guihuahuang	3.66	3.79	3.2	3.33	58.2	54.3
	Average	**3.57 cd**	**3.69 d**	**3.24 d**	**3.39 d**	**61.9 b**	**57.9 b**
1970's	Liming	3.59	3.81	3.34	3.51	54.0	52.6
	Xudao2	3.77	3.95	3.5	3.63	62.2	58.1
	Average	**3.68 c**	**3.88 c**	**3.42 c**	**3.57 c**	**57.9 c**	**55.2 b**
1980's	Yanjing2	3.74	3.82	3.48	3.59	33.8	32.0
	Sidao8	4.01	4.14	3.58	3.77	35.0	34.1
	Average	**3.88 bc**	**3.98 bc**	**3.53 bc**	**3.68 c**	**34.4 d**	**33.1 c**
1990's	Zhendao88	4.08	4.21	3.76	3.95	34.5	33.0
	Huaidao5	3.9	4.03	3.62	3.79	34.1	32.5
	Average	**3.99 b**	**4.12 b**	**3.69 b**	**3.87 b**	**34.3 d**	**32.8 c**
2000's	Huaidao9	4.2	4.31	3.98	4.20	30.7	29.0
	Lianjing7	4.02	4.15	3.84	4.04	27.2	26.2
	Average	**4.11 ab**	**4.23 ab**	**3.91 a**	**4.12 a**	**28.9 e**	**27.5 d**
2010's	Wuyunjing27	4.15	4.36	4.13	4.28	28.1	27.4
	Nanjing9108	4.21	4.32	3.97	4.14	28.1	26.7
	Average	**4.18 a**	**4.34 a**	**4.05 a**	**4.21 a**	**28.1 e**	**27.0 d**

Different letters indicate statistical significance at the $P < 0.05$ probability level.

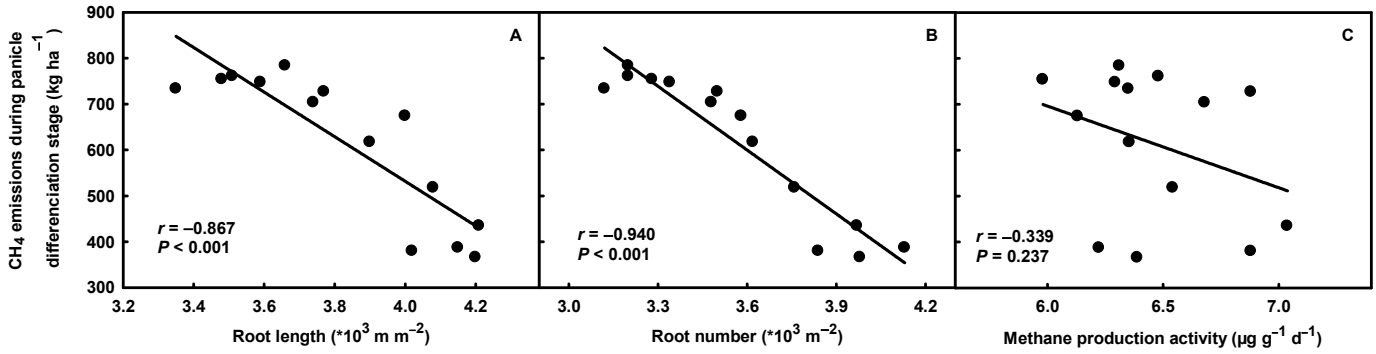

Figure S2. Relationships between cumulative CH_4 emissions in panicle differentiation and root length (A), root number (B), and methane production activity in rhizosphere soil (C).

Table S3. Effect of nitrogen application at panicle differentiation stage on root biomass, root oxidation activity, and root oxygen loss

Cultivar	N treatment	Root biomass ($g\ m^{-2}$)	Root oxidation activity ($\mu g\ \alpha$-NA g^{-1} DW h^{-1})	Root oxygen loss (mmol O_2 $plant^{-1}$ h^{-1})
NJ9108	0N	127.0 b	432.0 b	543.5 b
	NN	150.8 a	513.5 a	617.8 a
WYJ27	0N	136.9 b	426.7 b	521.4 b
	NN	166.4 a	531.8 a	593.4 a

Different letters indicate statistical significance at the $P < 0.05$ probability level within the same rice cultivar.