

Supplementary Materials

Key factors controlling cadmium and lead contents in rice grains of plants grown in soil with different cadmium levels from an area with typical karst geology

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5

Experimental Soil (Table S1)

Table S1 presents the physicochemical characteristics of the soils utilized in the pot experiment, with the soils named based on their collection site. Prior to thorough mixing of soil sample, all of the samples underwent the removal of stones, animal, and plant residues. Each pot of soil weighed no less than 20 kg. Upon adding the soil to the pots, a base fertilizer (2.8 g per pot, N-P-K balanced compound fertilizer) was applied. There were 12 pots in each group, resulting in a total of 36 pots across three groups. Following soil preparation and potting, water was added to fully saturate the soil. The soil surface was submerged to a depth of 5 cm, and the soil was allowed to stabilize for 20 days to ensure complete dissolution of the base fertilizer, with the water depth maintained at 5 cm throughout. Monitoring of the soil redox potential (E_h) commenced on the 21st day of the stabilization period (prior to transplanting), and seedlings were transplanted on the 22nd day of the stabilization period.

Table S1 Physics and Chemistry Characteristics of Test Soil.*

Site	pH (H ₂ O)	SOM ^a	CEC ^b	Cd ^c	Pb ^c	Zn ^c	Fe ^c	Mn ^c	Ca ^c	Mg ^c
RA	7.12±0.12	26.5±1.9	1.00±0.44	0.26±0.062	16.0±9.5	106±12	23972±781	437±20	1849±166	3815±148
WP	7.00±0.20	49.0±2.6	3.39±0.75	1.18±0.094	85.7±11	230±19	20266±604	164±22	4367±661	4575±428
XQ	7.30±0.056	51.1±1.6	5.08±0.83	13.7±1.1	233±16	1574±76	41881±1031	655±33	6466±396	5500±232

* The basic physicochemical indexes of soil are presented in the accompanying table as $\bar{X} \pm \text{SD}$.

^a The unit for SOM concentration is g/kg.

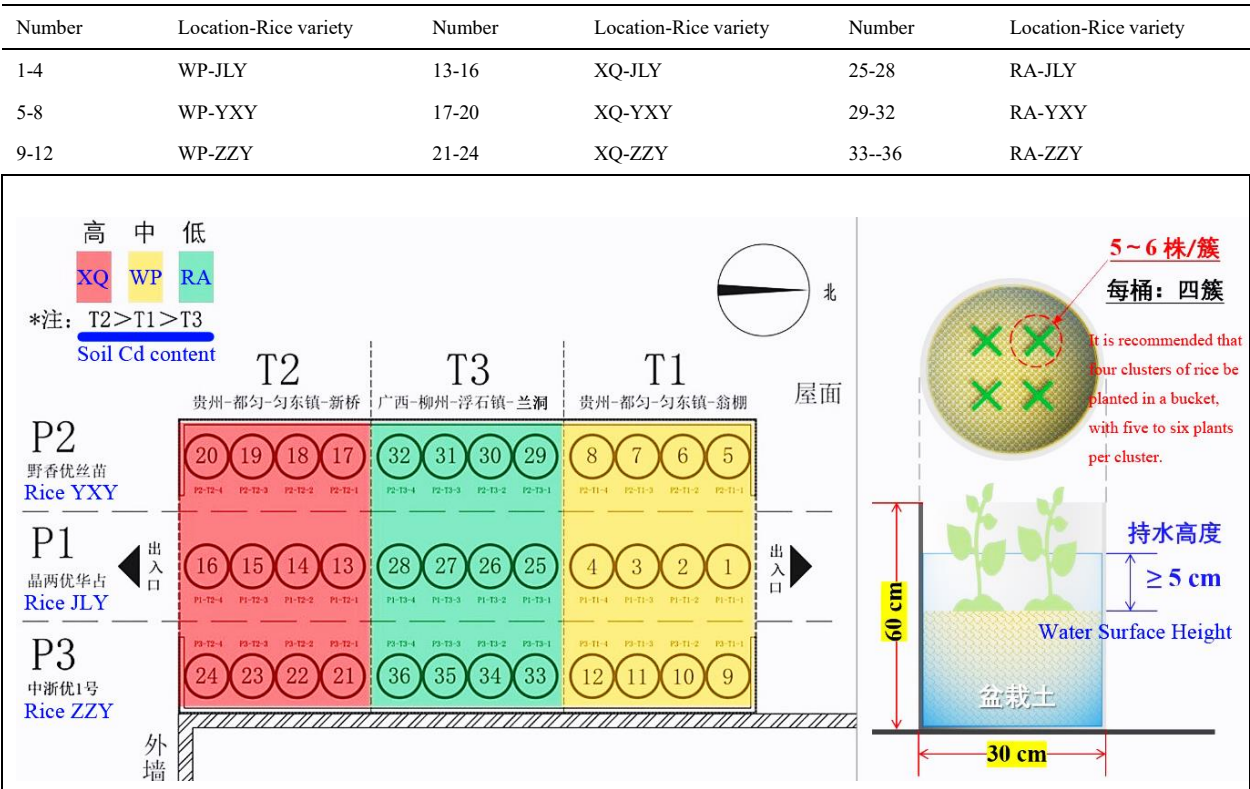
^b The unit for CEC concentration is cmol⁺/kg.

^c The unit for metal elements (Cd, Pb, Zn, Fe, Mn, Ca, and Mg) concentration are mg/kg.

Experimental Design (Table S2)

Table S2 provides an overview of the grouping arrangement for the pot experiments conducted in the greenhouse. At the time of transplanting, four seedlings were planted in each hole. For each rice variety, four parallel experiments were carried out using each group of test soils. Following transplanting, the soil surface remained submerged by water until the completion of the rice blooming period, which occurred on the 60th day after transplanting. From the grain-filling period onwards, water management was implemented using a wet-dry cycle until the rice reached the fully ripe stage on the 80th day after transplanting. Additionally, supplementary basal fertilizer (1.2 g per pot) was applied as the plants approached the booting stage, occurring on the 30th day after transplanting. A foliar fertilizer (KH₂PO₄) application was administered once at the heading stage, occurring on the 60th day after transplanting.

Table S2 Pot Experiment Grouping.



Process Photographs of the Pot Experiment.



(1) The soil samples used in the pot experiment were collected from the field.



(2) The preliminary procedure for the potting experiment soil.



(3) Rice seedlings (Phase 1).



(4) Potting soil already prepared.



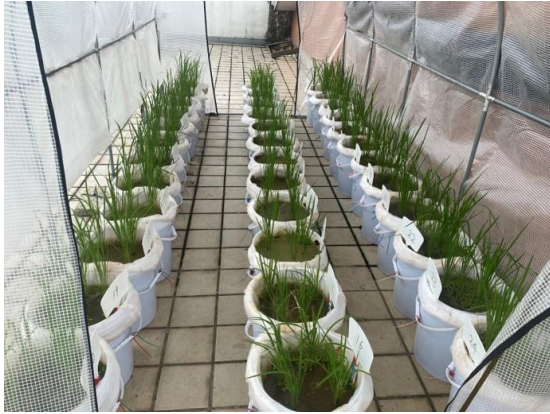
(5) Fill the potting soil with water to begin soaking it (Phase 1).



(6) Soil redox potential monitoring (Phase 2).



(7) Prior to transplanting rice, screen out rice seedlings.



(8) One week after transplanting rice.



(9) Tillering stage of rice (Between Phase 2 and Phase 3).



(10) Full heading stage of rice (Phase 4).



(11) Full ripe stage of rice (Phase 5).



(12) Collection of whole rice plants (Phase 4 and Phase 5).



(13) Collection of soil samples at each phase of rice growth (≥ 1 kg/bag).

Table S3 Basic Form of the Metabolic Mechanism Model (second-order polynomial).

Name ^a	Equations and notes
Ion transport model (n=35)	<p>The meaning of original independent variables: x_1=Cd, x_2=Pb, x_3=Zn, x_4=Fe, x_5=Mn, x_6=Ca, x_7=Mg</p> $Y_{TF} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_{11} x_1^2 + \beta_{22} x_2^2 + \beta_{33} x_3^2 + \beta_{44} x_4^2 + \beta_{55} x_5^2 + \beta_{66} x_6^2 + \beta_{77} x_7^2 + \beta_{12} x_1 x_2 + \beta_{13} x_1 x_3 + \beta_{14} x_1 x_4 + \beta_{15} x_1 x_5 + \beta_{16} x_1 x_6 + \beta_{17} x_1 x_7 + \beta_{23} x_2 x_3 + \beta_{24} x_2 x_4 + \beta_{25} x_2 x_5 + \beta_{26} x_2 x_6 + \beta_{27} x_2 x_7 + \beta_{34} x_3 x_4 + \beta_{35} x_3 x_5 + \beta_{36} x_3 x_6 + \beta_{37} x_3 x_7 + \beta_{45} x_4 x_5 + \beta_{46} x_4 x_6 + \beta_{47} x_4 x_7 + \beta_{56} x_5 x_6 + \beta_{57} x_5 x_7 + \beta_{67} x_6 x_7 + \varepsilon$
Bioconcentration model (n=77)	<p>The meaning of original independent variables: x_1=pH, x_2=SOM, x_3=E_h, x_4=CEC, x_5=Cd, x_6=Pb, x_7=Zn, x_8=Fe, x_9=Mn, x_{10}=Ca, x_{11}=Mg</p> $Y_{BCF} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 + \beta_9 x_9 + \beta_{10} x_{10} + \beta_{11} x_{11} + \beta_{11} x_1^2 + \beta_{22} x_2^2 + \beta_{33} x_3^2 + \beta_{44} x_4^2 + \beta_{55} x_5^2 + \beta_{66} x_6^2 + \beta_{77} x_7^2 + \beta_{88} x_8^2 + \beta_{99} x_9^2 + \beta_{1010} x_{10}^2 + \beta_{1111} x_{11}^2 + \beta_{12} x_1 x_2 + \beta_{13} x_1 x_3 + \beta_{14} x_1 x_4 + \beta_{15} x_1 x_5 + \beta_{16} x_1 x_6 + \beta_{17} x_1 x_7 + \beta_{18} x_1 x_8 + \beta_{19} x_1 x_9 + \beta_{110} x_1 x_{10} + \beta_{111} x_1 x_{11} + \beta_{23} x_2 x_3 + \beta_{24} x_2 x_4 + \beta_{25} x_2 x_5 + \beta_{26} x_2 x_6 + \beta_{27} x_2 x_7 + \beta_{28} x_2 x_8 + \beta_{29} x_2 x_9 + \beta_{210} x_2 x_{10} + \beta_{211} x_2 x_{11} + \beta_{34} x_3 x_4 + \beta_{35} x_3 x_5 + \beta_{36} x_3 x_6 + \beta_{37} x_3 x_7 + \beta_{38} x_3 x_8 + \beta_{39} x_3 x_9 + \beta_{310} x_3 x_{10} + \beta_{311} x_3 x_{11} + \beta_{45} x_4 x_5 + \beta_{46} x_4 x_6 + \beta_{47} x_4 x_7 + \beta_{48} x_4 x_8 + \beta_{49} x_4 x_9 + \beta_{410} x_4 x_{10} + \beta_{411} x_4 x_{11} + \beta_{56} x_5 x_6 + \beta_{57} x_5 x_7 + \beta_{58} x_5 x_8 + \beta_{59} x_5 x_9 + \beta_{510} x_5 x_{10} + \beta_{511} x_5 x_{11} + \beta_{67} x_6 x_7 + \beta_{68} x_6 x_8 + \beta_{69} x_6 x_9 + \beta_{610} x_6 x_{10} + \beta_{611} x_6 x_{11} + \beta_{78} x_7 x_8 + \beta_{79} x_7 x_9 + \beta_{710} x_7 x_{10} + \beta_{711} x_7 x_{11} + \beta_{89} x_8 x_9 + \beta_{810} x_8 x_{10} + \beta_{811} x_8 x_{11} + \beta_{910} x_9 x_{10} + \beta_{911} x_9 x_{11} + \beta_{1011} x_{10} x_{11} + \varepsilon$

^a The n represents the number of independent variables that have been transformed into polynomials within the model.

28

Table S4 Results of Correlation and Fitting in the Test Indicator . ^a

Dependent variable (y) ^b	Independent variable (x)	The correlation coefficient of		The coefficient of determination in the data fit (R^2)					
		Spearman (r) ^c		WP		$RD/\%$ ^e	XQ		$RD/\%$ ^e
		WP	XQ	Linear	Polynomial ^d		Linear	Polynomial ^d	
TF-Pb(n=24)	Root-Cd	-0.645**	-0.043	0.433	0.622	43.7	0.049	0.054	10.2
	Root-Pb	-0.681**	0.247	0.458	0.654	42.8	0.080	0.156	95.0
	Root-Zn	-0.486**	0.399**	0.204	0.292	43.1	0.075	0.148	97.3
	Root-Fe	-0.551**	0.181	0.554	0.629	13.5	0.077	0.163	111.7
	Root-Mn	-0.565**	0.225	0.335	0.413	23.3	0.102	0.298	192.2
	Root-Ca	-0.594**	0.221	0.514	0.637	23.9	0.060	0.165	175.0
	Root-Mg	0.316*	0.036	0.092	0.330	258.7	0.006	0.014	133.3
BCF-Pb(n=24)	Soil-pH	0.457**	0.419**	0.708	0.879	24.2	0.801	0.825	3.00
	SOM	0.512**	0.471**	0.480	0.485	1.04	0.405	0.679	67.7
	Soil-CEC	0.029	0.105	0.006	0.020	233	0.003	0.007	133
	Soil- E_h	0.558**	0.214	0.644	0.646	0.311	0.245	0.281	14.7
	Soil-Cd	0.181	0.406**	0.115	0.117	1.74	0.419	0.459	9.55
	Soil-Pb	-0.500**	-0.435**	0.378	0.437	15.6	0.595	0.649	9.08
	Soil-Zn	-0.442**	-0.623**	0.415	0.509	22.7	0.866	0.896	3.46
	Soil-Fe	-0.609**	-0.493**	0.462	0.532	15.2	0.781	0.835	6.91
	Soil-Mn	-0.587**	-0.486**	0.507	0.599	18.2	0.569	0.680	19.5
	Soil-Ca	-0.370*	-0.449**	0.133	0.137	3.01	0.424	0.475	12.0
	Soil-Mg	-0.377**	-0.471**	0.256	0.276	7.81	0.283	0.321	13.4
TF-Cd(n=24)	Root-Cd	-0.842**	-0.232	0.806	0.903	12.03	0.778	0.908	16.7
	Root-Pb	-0.797**	-0.655**	0.742	0.802	8.086	0.821	0.917	11.7

Table S4 Results of Correlation and Fitting in the Test Indicator . ^a

Dependent variable (y) ^b	Independent variable (x)	The correlation coefficient of Spearman (r) ^c		The coefficient of determination in the data fit (R^2)					
				WP		$RD/\%$ ^e	XQ		$RD/\%$ ^e
		WP	XQ	Linear	Polynomial ^d		Linear	Polynomial ^d	
BCF-Cd(n=24)	Root-Zn	-0.710**	0.051	0.396	0.455	14.90	0.637	0.737	15.7
	Root-Fe	-0.788**	0.428**	0.805	0.814	1.118	0.869	0.882	1.50
	Root-Mn	-0.690**	0.630**	0.364	0.378	3.846	0.642	0.694	8.10
	Root-Ca	-0.823**	0.642**	0.843	0.893	5.931	0.771	0.882	14.4
	Root-Mg	0.447*	-0.297*	0.349	0.589	68.77	0.139	0.337	142
	Soil-pH	0.689**	0.588**	0.821	0.902	9.866	0.805	0.863	7.21
	SOM	0.698**	0.493**	0.413	0.423	2.421	0.607	0.610	0.494
	Soil-CEC	0.011	-0.200	0.0038	0.0043	13.16	0.008	0.108	1250
	Soil- E_h	0.668**	0.192	0.519	0.524	0.963	0.085	0.341	301
	Soil-Cd	0.186	0.239	0.053	0.081	52.83	0.319	0.469	47.0
	Soil-Pb	-0.623**	-0.399**	0.405	0.444	9.630	0.559	0.610	9.12
	Soil-Zn	-0.697**	-0.514**	0.495	0.539	8.889	0.810	0.880	8.64
	Soil-Fe	-0.685**	-0.413**	0.493	0.539	9.331	0.727	0.806	10.9
	Soil-Mn	-0.690**	-0.435**	0.543	0.607	11.79	0.566	0.631	11.5
	Soil-Ca	-0.497*	-0.529**	0.377	0.411	9.019	0.394	0.492	24.9
	Soil-Mg	-0.620**	-0.580**	0.585	0.632	8.034	0.271	0.334	23.3

^a In the table, WP and XQ are abbreviations of the soil site's name.

^b The n is the number of samples.

^c * Significant correlation at the 0.05 level (two-tailed), ** Significant correlation at the 0.01 level (two-tailed).

^d The polynomial fit use second-order.

^e The RD represents relative deviation, $RD = (\text{polynomial fit of } R^2 - \text{linear fit of } R^2) / \text{linear fit of } R^2 \times 100\%$.

29

Table S5 Screening Results of Stepwise Regression. ^c

Model description ^a	Dependent variable (y)	Model number	P_F ^b	Independent variable (x)	P_T ^c	VIF ^d
WP-BCF-Cd	y_1	1	0.000	x_1	0.000	1.000
		2	0.000	x_1	0.000	1.320
				x_2	0.009	1.320
		3	0.000	x_1	0.000	2.555
				x_2	0.001	1.438
				x_5x_{11}	0.029	1.977
		4	0.000	x_1	0.044	227.5
				x_2	0.096	1783
				x_5x_{11}	0.030	1.985
				x_1x_2	0.117	2743
		5	0.000	x_1	0.007	317.2
				x_2	0.014	2144
				x_5x_{11}	0.031	2.007
				x_1x_2	0.019	3284
				x_4x_7	0.035	2.272

Table S5 Screening Results of Stepwise Regression. ^c

Model description ^a	Dependent variable (y)	Model number	P_F ^b	Independent variable (x)	P_T ^c	VIF ^d
		6	0.000	x_1	0.005	329.7
				x_2	0.010	2213
				x_5x_{11}	0.040	7.715
				x_1x_2	0.013	3383
				x_4x_7	0.076	2.464
				$x_{10}x_{11}$	0.253	7.538
		7	0.000	x_1	0.001	348.7
				x_2	0.007	2214
				x_5x_{11}	0.013	8.216
				x_1x_2	0.010	3388
				x_4x_7	0.026	2.630
				$x_{10}x_{11}$	0.049	194.3
				x_1x_{10}	0.073	105.4
		8	0.000	x_1	0.000	524.6
				x_2	0.002	3075
				x_5x_{11}	0.012	8.267
				x_1x_2	0.002	4659
				x_4x_7	0.013	17.03
				$x_{10}x_{11}$	0.013	220.9
				x_1x_{10}	0.020	119.6
				x_4x_9	0.074	12.71
		9	0.000	x_1	0.001	557.8
				x_2	0.050	5426
				x_5x_{11}	0.166	14.03
				x_1x_2	0.059	8142
				x_4x_7	0.072	21.87
				$x_{10}x_{11}$	0.288	467.3
				x_1x_{10}	0.055	856.9
				x_4x_9	0.115	13.20
				x_{10}	0.252	2108
		10	0.000	x_1	0.000	710.9
				x_2	0.223	6500
				x_5x_{11}	0.053	345.2
				x_1x_2	0.271	9832
				x_4x_7	0.022	22.22
				$x_{10}x_{11}$	0.163	1717
				x_1x_{10}	0.005	3878
				x_4x_9	0.084	13.22
				x_{10}	0.013	9366
				x_5^2	0.025	42.62
		11	0.000	x_1	0.000	711.9
				x_2	0.256	6555

Table S5 Screening Results of Stepwise Regression. ^c

Model description ^a	Dependent variable (y)	Model number	P_F ^b	Independent variable (x)	P_T ^c	VIF ^d
WP-TF-Cd	y_2	1	0.000	x_5x_{11}	0.051	345.5
				x_1x_2	0.318	9934
				x_4x_7	0.016	22.36
				$x_{10}x_{11}$	0.242	1783
				x_1x_{10}	0.003	3909
				x_4x_9	0.034	17.21
				x_{10}	0.011	9368
				x_5^2	0.021	42.64
				x_4x_{10}	0.180	4.637
		2	0.000	x_4x_6	0.000	4.141
		3	0.000	x_1	0.019	4.141
				x_4x_6	0.000	6.417
				x_1	0.001	23.26
		4	0.000	x_1x_6	0.009	33.88
				x_4x_6	0.000	7.831
				x_1	0.000	107.8
				x_1x_6	0.002	34.04
		5	0.000	x_1x_4	0.014	98.15
				x_4x_6	0.002	93.01
				x_1	0.000	197.5
				x_1x_6	0.045	48.95
				x_1x_4	0.008	256.8
		6	0.000	x_6	0.136	98.97
				x_4x_6	0.001	110.0
				x_1	0.000	198.0
				x_1x_6	0.027	53.44
				x_1x_4	0.008	256.8
				x_6	0.110	99.97
WP-BCF-Pb	y_3	1	0.000	x_5x_7	0.254	2.975
				x_1	0.000	1.000
				x_2x_3	0.002	1.788
		2	0.000	x_1	0.000	1.788
				x_2x_3	0.039	77.66
				x_3x_{10}	0.111	80.86
		3	0.000	x_1	0.000	1.900
				x_2x_3	0.033	77.81
				x_3x_{10}	0.101	80.90
				x_4x_{11}	0.217	1.162
		4	0.000	x_1	0.001	2.145
				x_2x_3	0.093	87.58

Table S5 Screening Results of Stepwise Regression. ^c

Model description ^a	Dependent variable (y)	Model number	P_F ^b	Independent variable (x)	P_T ^c	VIF ^d
				x_3x_{10}	0.166	84.65
				x_4x_{11}	0.169	1.176
				x_2	0.211	2.590
		6	0.000	x_1	0.001	2.165
				x_2x_3	0.211	96.84
				x_3x_{10}	0.099	1125
				x_4x_{11}	0.132	1.184
				x_2	0.106	2.885
				x_3x_{11}	0.181	1223
		7	0.000	x_1	0.002	2.433
				x_2x_3	0.057	222.8
				x_3x_{10}	0.031	2362
				x_4x_{11}	0.042	1.653
				x_2	0.210	3.100
				x_3x_{11}	0.051	3179
				x_3x_5	0.142	389.1
		8	0.000	x_1	0.002	2.436
				x_2x_3	0.069	225.4
				x_3x_{10}	0.016	2452
				x_4x_{11}	0.029	1.661
				x_2	0.098	3.415
				x_3x_{11}	0.035	3202
				x_3x_5	0.045	555.6
		9	0.000	x_3	0.144	353.5
				x_1	0.001	2.491
				x_2x_3	0.033	240.9
				x_3x_{10}	0.006	2882
				x_4x_{11}	0.066	1.799
				x_2	0.074	3.428
				x_3x_{11}	0.013	3908
				x_3x_5	0.016	927.9
				x_3	0.044	734.8
				x_3x_4	0.151	107.2
WP-TF-Pb	y_4	1	0.000	x_6	0.000	1.000
		2	0.000	x_6	0.011	45.28
				x_6^2	0.053	45.28
		3	0.000	x_6	0.014	45.86
				x_6^2	0.048	45.29
				x_5	0.190	1.746
		4	0.000	x_6	0.032	49.30
				x_6^2	0.999	69.47
				x_5	0.001	24.22

Table S5 Screening Results of Stepwise Regression. ^c

Model description ^a	Dependent variable (y)	Model number	P_F ^b	Independent variable (x)	P_T ^c	VIF ^d
XQ-BCF-Cd	y_5	5	0.000	x_5x_6	0.002	51.79
				x_6	0.000	7.610
				x_5	0.000	16.49
				x_5x_6	0.000	33.76
		1	0.000	x_7x_{11}	0.000	1.000
		2	0.000	x_7x_{11}	0.000	1.082
				x_2x_{10}	0.000	1.082
		3	0.000	x_7x_{11}	0.045	13.95
				x_2x_{10}	0.000	1.121
				x_{11}	0.013	14.29
		4	0.000	x_7x_{11}	0.003	1490
				x_2x_{10}	0.000	1.240
				x_{11}	0.000	161.2
				x_7	0.001	722.4
		5	0.000	x_7x_{11}	0.001	1490
				x_2x_{10}	0.000	1.240
				x_{11}	0.000	161.7
				x_7	0.000	731.7
				x_1x_6	0.012	3.826
XQ-TF-Cd	y_6	1	0.000	x_4	0.000	1.000
		2	0.000	x_4	0.000	4.072
				x_1	0.055	4.072
		3	0.000	x_4	0.000	5.586
				x_1	0.010	52.51
				x_1x_4	0.031	65.83
		4	0.000	x_4	0.001	8.25
				x_1	0.007	52.86
				x_1x_4	0.059	69.14
				x_7^2	0.159	2.455
		5	0.000	x_4	0.001	8.257
				x_1	0.010	53.78
				x_1x_4	0.068	69.384
				x_7^2	0.214	67.87
				x_7	0.317	71.95
		6	0.000	x_4	0.029	13.29
				x_1	0.008	77.26
				x_1x_4	0.167	79.66
				x_7^2	0.150	71.93
				x_7	0.236	75.26
				x_1^2	0.307	37.85
		7	0.000	x_4	0.026	13.33
				x_1	0.010	142.7

Table S5 Screening Results of Stepwise Regression. ^c

Model description ^a	Dependent variable (y)	Model number	P_F ^b	Independent variable (x)	P_T ^c	VIF ^d
				x_1x_4	0.354	92.63
				x_7^2	0.764	149.6
				x_7	0.946	203.8
				x_1^2	0.161	88.50
				x_6x_7	0.319	18.99
		8	0.000	x_4	0.021	13.09
				x_1	0.003	102.0
				x_1x_4	0.319	87.96
				x_7^2	0.033	4.126
				x_1^2	0.103	64.80
				x_6x_7	0.117	7.012
		9	0.000	x_4	0.006	17.50
				x_1	0.001	121.8
				x_1x_4	0.057	318.9
				x_7^2	0.013	4.388
				x_1^2	0.949	129.1
				x_6x_7	0.052	128.7
				x_5x_6	0.101	162.7
		10	0.000	x_4	0.000	9.791
				x_1	0.001	118.5
				x_1x_4	0.003	128.7
				x_7^2	0.010	4.245
				x_6x_7	0.015	85.95
				x_5x_6	0.019	81.67
		11	0.000	x_4	0.000	10.31
				x_1	0.000	140.6
				x_1x_4	0.002	143.9
				x_7^2	0.005	4.418
				x_6x_7	0.006	108.1
				x_5x_6	0.008	123.0
				x_3	0.159	9.321
		12	0.000	x_4	0.000	12.13
				x_1	0.000	155.3
				x_1x_4	0.000	148.8
				x_7^2	0.001	4.687
				x_6x_7	0.001	117.0
				x_5x_6	0.002	131.9
				x_3	0.019	96.39
				x_3^2	0.042	51.28
		13	0.000	x_4	0.000	12.23
				x_1	0.000	189.7
				x_1x_4	0.022	257.6

Table S5 Screening Results of Stepwise Regression. ^c

Model description ^a	Dependent variable (y)	Model number	P_F ^b	Independent variable (x)	P_T ^c	VIF ^d
XQ-BCF-Pb	y_7		0.000	x_7^2	0.000	5.103
				x_6x_7	0.000	146.6
				x_5x_6	0.000	149.7
				x_3	0.006	110.1
				x_3^2	0.012	138.4
				x_1x_3	0.093	355.8
		1	0.000	x_7	0.000	1.000
		2	0.000	x_7	0.000	3.812
				x_1	0.013	3.812
		3	0.000	x_7	0.000	3.891
				x_1	0.011	3.839
				x_3x_4	0.020	1.187
		4	0.000	x_7	0.000	6.296
				x_1	0.037	4.242
				x_3x_4	0.006	1.198
				x_5x_6	0.022	2.205
		5	0.000	x_7	0.002	50.79
				x_1	0.043	4.281
				x_3x_4	0.026	1.361
				x_5x_6	0.007	2.769
				x_7x_{10}	0.122	35.23
		6	0.000	x_7	0.035	1140
				x_1	0.216	5.453
				x_3x_4	0.012	1.429
				x_5x_6	0.011	2.860
				x_7x_{10}	0.107	3419
				x_{10}^2	0.143	748.4
		7	0.000	x_7	0.020	1185
				x_1	0.804	8.380
				x_3x_4	0.006	1.586
				x_5x_6	0.035	3.214
				x_7x_{10}	0.071	3506
				x_{10}^2	0.095	767.7
				x_2x_6	0.189	2.455
		8	0.000	x_7	0.004	852.8
				x_3x_4	0.003	1.435
				x_5x_6	0.031	3.206
				x_7x_{10}	0.029	2740
				x_{10}^2	0.042	603.1
				x_2x_6	0.069	1.598
		9	0.000	x_7	0.004	2023
				x_3x_4	0.107	2.598

Table S5 Screening Results of Stepwise Regression. ^c

Model description ^a	Dependent variable (y)	Model number	P_F ^b	Independent variable (x)	P_T ^c	VIF ^d
				x_5x_6	0.015	3.404
				x_7x_{10}	0.014	5549
				x_{10}^2	0.055	6577
				x_2x_6	0.039	1.662
				x_{10}	0.165	3164
		10	0.000	x_7	0.003	2065
				x_3x_4	0.181	2.752
				x_5x_6	0.012	3.466
				x_7x_{10}	0.011	5642
				x_{10}^2	0.038	6847
				x_2x_6	0.065	1.733
				x_{10}	0.120	3272
				x_1x_{11}	0.275	7.111
		11	0.000	x_7	0.954	2065
				x_3x_4	0.003	2.922
				x_5x_6	0.298	3.522
				x_7x_{10}	0.008	5654
				x_{10}^2	0.009	7250
				x_2x_6	0.023	1.761
				x_{10}	0.047	3638
				x_1x_{11}	0.065	7.428
				x_8	0.183	9.353
XQ-TF-Pb	y_8	1	0.040	x_5^2	0.040	1.000
		2	0.019	x_5^2	0.010	5.112
				x_6^2	0.056	5.112
		3	0.027	x_5^2	0.374	389.9
				x_6^2	0.146	285.4
				x_5x_6	0.227	1255
		4	0.040	x_5^2	0.357	390.4
				x_6^2	0.120	290.1
				x_5x_6	0.185	1280
				x_3x_7	0.326	6.030
		5	0.053	x_5^2	0.226	442.9
				x_6^2	0.071	342.4
				x_5x_6	0.128	1356
				x_3x_7	0.215	6.638
				x_6x_7	0.303	38.11
		6	0.027	x_5^2	0.309	452.7
				x_6^2	0.018	392.1
				x_5x_6	0.191	1396
				x_3x_7	0.031	24.52
				x_6x_7	0.045	76.71

Table S5 Screening Results of Stepwise Regression. ^c

Model description ^a	Dependent variable (<i>y</i>)	Model number	P_F ^b	Independent variable (<i>x</i>)	P_T ^c	VIF ^d
				x_3x_6	0.072	66.55

^a The model description of the table provides a basic overview of the models, which is included three parts: (i) the location of the test soil, (ii) the indicator name, and (iii) the corresponding heavy metal element.

^b The P_F represents the significance level of the F-test.

^c The P_T represents the significance level of the T-test.

^d The VIF represents the value of the Variation Inflation Factor.

^e The table's green background represents the optimal subset of models.

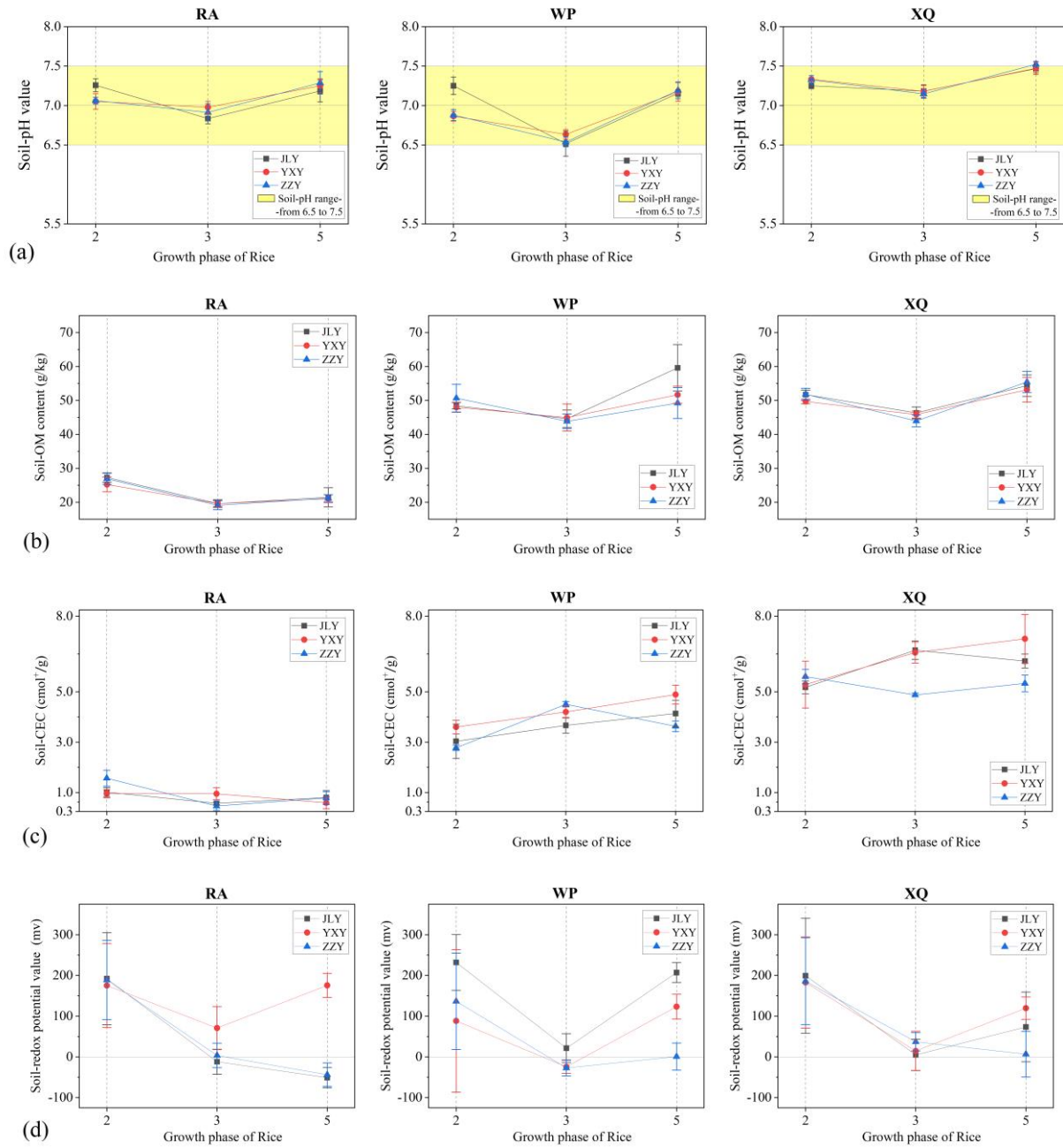


Figure S1. Basic Physicochemical Index of Test Soil During the Rice Growth Process. The X-axis represents the time nodes of the rice growth process in all pictures. "2" denotes the transplanting stage, "3" denotes the booting stage, and "5" denotes the full ripe stage.

Table S6 Soil Physicochemical Index During the Critical Phase of Rice Growth.*

Location name ^a	Index name	Phase 2 ^b	Phase 3 ^b	Phase 5 ^b
RA (n=36)	pH	7.12±0.12 b	6.91±0.10 c	7.24±0.12 a
	Soil-OM (g/kg)	26.5±1.8 a	19.4±1.1 c	21.2±1.7 b
	CEC (cmol ⁺ /g)	1.00±0.44 a	0.609±0.26 b	0.672±0.29 b
	E _h (mv)	185±95 a	20.8±52 b	27.0±113 b
WP (n=36)	pH	7.00±0.20 b	6.56±0.11 c	7.17±0.088 a
	Soil-OM (g/kg)	49.0±2.6 b	44.5±2.8 b	56.9±15 a
	CEC (cmol ⁺ /g)	3.39±0.75 b	4.03±0.44 a	4.32±0.63 a
	E _h (mv)	152±132 a	-10.1±33 b	110±92 a
XQ (n=36)	pH	7.30±0.053 b	7.17±0.065 c	7.49±0.059 a
	Soil-OM (g/kg)	51.1±1.6 b	45.4±1.8 c	54.3±3.13 a
	CEC (cmol ⁺ /g)	5.08±0.83 b	5.84±0.89 a	6.15±0.92 a
	E _h (mv)	189±110 a	18.8±37 b	66.6±73.5 b

* The significance of differences between data was tested using Duncan's method ($p < 0.05$). The data were classified according to soil collection location and compared within each soil Indexes during three critical phases of rice growth.

^a "n" represents the number of samples.

^b Phase 2 represents the rice transplanting stage, Phase 4 represents the full heading stage, and Phase 5 represents the full ripe stage.

Table S7 Metabolic Properties of Various Metals in Rice Plants at the Maturation Stage.*

Location	Variety	The ranking of TF about different elementals ^a	The ranking of BCF about different elementals ^a
RA	JLY	Mg > Zn > Mn > Cd > Ca > Pb > Fe	Ca > Cd > Zn > Mn > Fe > Pb > Mg
	YXY	Mg > Zn > Cd > Mn > Ca > Pb > Fe	Ca > Mn > Zn > Cd > Pb > Fe > Mg
	ZZY	Mg > Zn > Cd > Mn > Ca > Pb > Fe	Ca > Cd > Zn > Mn > Fe > Pb > Mg
WP	JLY	Mg > Mn > Zn > Ca > Cd > Pb > Fe	Cd > Zn > Ca > Mn > Fe > Pb > Mg
	YXY	Mg > Zn > Mn > Ca > Pb > Cd > Fe	Cd > Mn > Ca > Fe > Zn > Pb > Mg
	ZZY	Mg > Zn > Mn > Ca > Pb > Cd > Fe	Cd > Ca > Mn > Zn > Fe > Pb > Mg
XQ	JLY	Mg > Zn > Mn > Ca > Cd > Pb > Fe	Cd > Ca > Mn > Pb > Fe > Zn > Mg
	YXY	Mg > Zn > Mn > Ca > Cd > Pb > Fe	Cd > Ca > Mn > Pb > Fe > Mg > Zn
	ZZY	Mg > Zn > Mn > Ca > Cd > Pb > Fe	Cd > Ca > Mn > Pb > Fe > Zn > Mg

* The table presents the order of BCFs and TFs of various metals in identical rice varieties, with grouping by soil collection location.

^a The significant differences between the three rice varieties in the identical soil are highlighted in bold blue font.