Supplementary Information for Publication

Integrating Soil pH, Clay, and Neutralizing Value of Lime into a New Lime Requirement Model for Acidic Soils in China

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Table S1. Descriptive statistics of soil and lime properties.

Properties	Mean	Standard deviation	Median	Minimum	Maximum
Soil (n = 17)					
pH (soil: water 1:5)	5.05	0.13	5.09	4.39	6.19
OM (g kg^{-1})	20.51	2.28	19.44	5.10	37.07
Clay (%)	38.05	3.68	41.40	4.40	60.40
Silt (%)	22.94	2.16	23.00	5.60	38.00
Sand (%)	39.01	4.81	35.60	19.60	76.60
Quicklime (n = 10)					
[Ca+ Mg] (%)	64.14	1.56	63.03	58.93	72.07
Hydrated lime (n = 10)					
[Ca+ Mg] (%)	55.52	1.16	55.50	47.55	59.93
Limestone (n = 10)					
[Ca+ Mg] (%)	42.41	1.87	41.77	28.74	50.04
Dolomite (n = 9)					
[Ca+ Mg] (%)	38.19	2.47	37.70	29.14	53.19

[Ca+Mg] is the content of calcium plus magnesium in lime.

Table S2. Selected physical and chemical properties of acidic soil.

Soil	Location	pH	OM (g kg^{-1})	Clay (%)	Silt (%)	Sand (%)
S1	Yongzhou, Hunan (26.77° N, 111.87° E)	4.48	30.79	57.4	22.0	20.6
S2	Hainan (19.77° N, 109.57° E)	4.57	12.48	42.4	29.0	28.6
S3	Guiyang, Guizhou (26.60° N, 106.73° E)	5.45	37.07	43.4	32.0	24.6
S4	Guangzhou, Guangdong (21.45° N, 110.79° E)	4.48	21.62	60.4	19.0	20.6
S5	Guangzhou, Guangdong (23.17° N, 112.56° E)	4.62	9.58	25.8	5.6	68.6
S6	Yongzhou, Hunan (26.77° N, 111.88° E)	4.77	29.45	44.4	31.0	24.6
S7	Shaoyang, Hunan (26.98° N, 111.97° E)	5.19	9.86	13.4	10.0	76.6
S8	Danzhou, Hainan (19.77° N, 109.57° E)	4.61	26.72	4.40	23.0	72.6
S9	Haikou, Hainan (19.99° N, 110.34° E)	6.19	19.44	32.0	8.4	59.6
S10	Yingtan, Jiangxi (28.27° N, 117.08° E)	4.66	11.99	43.4	20.0	36.6
S11	Yingtan, Jiangxi (28.27° N, 117.08° E)	6.06	14.22	39.4	25.0	35.6
S12	Yinngtan, Jiangxi (28.27° N, 117.08° E)	5.10	16.05	39.4	24.0	36.6
S13	Yueyang, Hunan (29.06° N, 113.00° E)	4.39	5.10	45.4	32.0	22.6
S14	Yongzhou, Hunan (26.77° N, 111.88° E)	5.52	28.28	25.4	20.0	54.6
S15	Yongzhou, Hunan (26.77° N, 111.88° E)	5.09	30.53	29.4	30.0	40.6
S16	Guiyang, Guizhou (26.65° N, 106.80° E)	5.21	16.57	41.4	38.0	20.6
S17	Guiyang, Guizhou (26.42° N, 106.68° E)	5.38	28.89	59.4	21.0	19.6

Table S3. Calcium, and magnesium in lime samples.

No.	Lime sample	Lime source	Ca (%)	Mg (%)	Location
1	Q1	Quick lime	57.15	2.45	Jinan, Shandong
2	Q2	Quick lime	61.46	0.76	Anshun, Guizhou
3	Q3	Quick lime	57.12	2.77	Yongan, Fujian
4	Q4	Quick lime	61.81	2.02	Laizhou, Shandong
5	Q5	Quick lime	58.90	0.27	Guilin, Guangxi
6	Q6	Quick lime	58.64	0.29	Baise, Guangxi
7	Q7	Quick lime	67.59	4.48	Dengfeng, Henan
8	Q8	Quick lime	64.32	2.68	Dengfeng, Henan
9	Q9	Quick lime	66.01	3.62	Linyi, Shandong
10	Q10	Quick lime	65.87	3.23	Yantai, Shandong
11	H1	Hydrated lime	54.97	2.34	Jinan, Shandong
12	H2	Hydrated lime	55.86	2.52	Luoyang, Henan
13	H3	Hydrated lime	47.31	0.24	Longyan, Fujian
14	H4	Hydrated lime	52.61	2.69	Yantai, Shandong
15	H5	Hydrated lime	59.44	0.49	Jian, Jiangxi
16	H6	Hydrated lime	54.66	0.23	Shangrao, Jiangxi
17	H7	Hydrated lime	59.31	0.21	Guilin, Guangxi
18	H8	Hydrated lime	54.82	0.87	Laibin, Guangxi
19	H9	Hydrated lime	53.45	0.52	Qingyuan, Guangdong
20	H10	Hydrated lime	52.39	0.28	Linyi, Shandong
21	L1	Limestone	40.77	0.70	Yongan, Fujian
22	L2	Limestone	49.84	0.20	Sanmenxia, Henan
23	L3	Limestone	39.95	1.02	Nanping, Fujian
24	L4	Limestone	41.82	0.25	Linyi, Shandong
25	L5	Limestone	43.93	2.03	Dengfeng, Henan
26	L6	Limestone	28.36	0.38	Laizhou, Shandong
27	L7	Limestone	48.30	0.33	Shangrao, Jiangxi
28	L8	Limestone	45.16	0.18	Nanning, Guangxi
29	L9	Limestone	40.08	0.39	Linyi, Shandong
30	L10	Limestone	39.11	1.28	Jinan, Shandong
31	D1	Dolomite	27.19	10.51	Jinan, Shandong
32	D2	Dolomite	21.24	12.72	Guizhou
33	D3	Dolomite	20.08	11.96	Longyan, Fujian
34	D4	Dolomite	21.54	7.60	Laizhou, Shandong
35	D5	Dolomite	44.77	0.16	Nanning, Guangxi
36	D6	Dolomite	40.40	0.13	Laibin, Guangxi
37	D7	Dolomite	35.41	17.78	Jinan, Shandong
38	D8	Dolomite	22.07	11.13	Dengfeng, Henan
39	D9	Dolomite	38.44	0.56	Putian, Fujian

1 **Table S4.** The data used in model validation (The following five criteria were applied to select appropriate data: (1) the authors should use inorganic lime, including calcium oxide,
2 calcium hydroxide, calcium carbonate, quicklime, hydrated lime, limestone, or dolomite, to increase soil pH; (2) the studies should be conducted in fields, and include no liming control
3 and liming treatment; (3) the soil pH of each treatment should be clearly revealed in text, tables or could be obtained from figures; (4) the soil pH in treatment without liming should be
4 less than 7.00, and the pH of soil which applied liming material should be less than 7.50; (5) the content of clay in soil and the main composition of liming material should be shown
5 clearly in reports; (6) the NV of lime was calculated by $NV = 0.27 \times [Ca + Mg] + 7.56$, which derived in section 3.1).

NO.	Location	Crop	Lime source	Main component	[Ca+Mg] (%)	Clay (<0.002mm) %	Initial pH (1:2.5)	Target pH (1:2.5)	Application rate (t ha^{-1})	Reference
1	Zhejiang	Barley	Limestone	53% CaO, 2.2% MgO	38.22	39.10	5.60	6.34	1.88	[64]
2	Zhejiang	Barley	Limestone	53% CaO, 2.2% MgO	38.22	39.10	5.60	6.45	3.75	[64]
3	Zhejiang	Barley	Limestone	53% CaO, 2.2% MgO	38.22	39.10	5.60	7.47	7.50	[64]
4	Zhejiang	Barley	Hydrated lime	95% Ca(OH)$_2$	54.35	39.10	5.60	5.62	1.39	[64]
5	Zhejiang	Barley	Hydrated lime	95% Ca(OH)$_2$	54.35	39.10	5.60	6.49	2.78	[64]
6	Zhejiang	Barley	Hydrated lime	95% Ca(OH)$_2$	54.35	39.10	5.60	7.25	5.55	[64]
7	Zhejiang	Barley	Limestone	53% CaO, 2.2% MgO	38.22	39.10	5.10	7.44	7.50	[64]
8	Zhejiang	Barley	Hydrated lime	95% Ca(OH)$_2$	54.35	39.10	5.10	5.43	1.39	[64]
9	Zhejiang	Barley	Hydrated lime	95% Ca(OH)$_2$	54.35	39.10	5.10	7.32	5.55	[64]
10	Fujian	Pakchoi	Quicklime	CaO	71.43	35.50	5.90	6.93	1.50	[65]
11	South of China	Tobacco	Quicklime	CaO	71.43	25.00	6.69	6.93	0.83	[66]
12	South of China	Tobacco	Quicklime	CaO	71.43	31.40	6.35	6.86	0.83	[66]
13	Zhejiang	Soybean	Limestone	CaCO$_3$	40.00	40.30	5.08	6.43	4.50	[67]
14	Fujian	Tobacco	Dolomite	CaMg(CO$_3$)$_2$	40.00	24.00	4.78	5.32	1.50	[68]
15	Hunan	Rice	Limestone	CaCO$_3$	40.00	19.70	5.41	6.20	2.00	[52]
16	Hunan	Rice	Limestone	CaCO$_3$	40.00	19.70	5.41	6.40	4.00	[52]
17	Hunan	Rice	Limestone	92% CaCO$_3$	36.80	46.00	4.70	5.28	2.25	[50]
18	Hunan	Rice	Limestone	92% CaCO$_3$	36.80	46.00	4.70	6.00	4.50	[50]
19	Hunan	Rice	Limestone	92% CaCO$_3$	36.80	46.00	4.70	6.40	7.50	[50]
20	Hunan	Rice	Quicklime	CaO	71.43	48.90	5.85	6.12	0.90	[69]

NO.	Location	Crop	Lime source	Main component	[Ca+Mg] (%)	Clay (<0.002mm) %	Initial pH (1:2.5)	Target pH (1:2.5)	Application rate (t ha^{-1})	Reference
21	Jiangxi	Rice	Hydrated lime	Ca(OH)$_2$	54.40	12.70	4.50	5.41	2.25	[51]
22	Jiangxi	Rice	Hydrated lime	Ca(OH)$_2$	54.40	12.70	4.50	5.45	2.25	[51]
23	Jiangxi	Rice	Hydrated lime	Ca(OH)$_2$	54.40	18.52	5.35	6.30	2.23	[70]
24	Jiangsu	Rice	Hydrated lime	Ca(OH)$_2$	54.40	21.52	6.05	6.80	2.23	[70]

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7 **Table S5.** Descriptive statistics of neutralizing value (mmol kg^{-1}) of lime.

Lime source	Mean	Standard deviation	Median	Minimum	Maximum	Relative value
Quicklime	24.68	0.42	24.69	21.98	27.16	1.00
Hydrated lime	23.58	0.32	23.80	21.26	24.94	0.96
Limestone	18.34	0.79	18.65	12.94	23.17	0.74
Dolomite	18.20	0.58	18.79	15.49	19.71	0.74

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9 **Table S6.** The RMSE, MAPE, and ME between the actual LR and predicted LR.

LR (t ha^{-1})	RMSE			MAPE			ME		
	Equation (8)	Equation (9)	Equation (10)	Equation (8)	Equation (9)	Equation (10)	Equation (8)	Equation (9)	Equation (10)
0 < LR ≤ 3	0.65	0.80	0.67	24.54	32.93	25.81	0.11	− 0.03	0.16
3 < LR ≤ 6	0.82	0.80	0.80	14.78	14.06	13.92	0.06	0.22	0.23
6 < LR ≤ 9	0.99	0.92	0.94	10.64	9.78	9.97	− 0.28	− 0.40	− 0.42
9 < LR ≤ 12	1.40	1.58	1.61	12.16	14.32	14.55	− 1.22	− 1.21	− 1.25
0 < LR ≤ 12	0.82	0.87	0.83	18.01	21.11	18.11	− 0.02	− 0.06	0.01

10 RMSE is the root mean squared error, MAPE is the mean absolute percentage error, ME is the mean error

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12   **Table S7.** The RMSE, MAPE, and ME between the actual LR in field condition and predicted LR.

LR	RMSE			MAPE			ME		
(t ha⁻¹)	Equation (8)	Equation (9)	Equation (10)	Equation (8)	Equation (9)	Equation (10)	Equation (8)	Equation (9)	Equation (10)
$0 < LR \le 2$	0.93	0.78	0.78	65.73	45.11	45.41	0.75	0.63	0.63
$2 < LR \le 4$	1.02	0.96	0.97	29.09	28.27	28.80	0.76	0.73	0.75
$4 < LR \le 6$	0.27	0.03	0.04	9.79	2.82	3.15	0.48	0.14	0.16
$6 < LR \le 8$	1.40	1.11	1.12	13.14	11.92	11.67	0.99	0.89	0.88
$0 < LR \le 8$	0.98	0.83	0.84	37.62	28.30	28.61	0.74	0.62	0.62

13   RMSE is the root mean squared error, MAPE is the mean absolute percentage error, ME is the mean error