Effects of rare earth and acid rain pollution on plant chloroplast ATP synthase and element contents at different growth stages. (2018)

Combined effects of La(III) and acid rain on chloroplast Mg2þ-ATPase activity (mmol Pi mg 1 chl$h 1) in rice during different growth stages

Acid rain pH	La(III) (mM)	Seedling stage		Booting stage		Filling stage	
7.0	0.00	88.5	± 3.1b(100)	88.3	± 2.6b(100)	84.9	± 2.5c(100)
	0.08	92.5	± 2.1a(104)	92.6	± 3.2a(104)	91.2	± 2.6 ab(107)
	1.20	61.4	± 1.8d(69.6)	62.8	± 1.4d(70.9)	61.1	± 1.8g(72.0)
	2.40	56.3	± 1.6e(63.6)	56.5	±1.3de(64.0)	55.4	± 1.6hi(65.2)
4.5	0.00	91.6	± 2.6a(103)	91.0	± 3.2a(103)	89.7	± 2.6b(106)
	0.08	97.9	± 3.4a(111)	97.1	± 3.4a(110)	95.5	± 2.8a(112)
	1.20	77.8	± 2.2c(87.9)	76.3	± 2.2c(86.4)	75.3	±2.2ef(88.6)
	2.40	43.6	± 1.0g(49.2)	42.8	±1.2gh(48.5)	42.0	± 1.2k(49.5)
3.5	0.00	74.4	± 1.7c(84.0)	72.1	± 2.1c(81.6)	72.0	± 2.1f(84.7)
	0.08	78.7	± 2.3c(88.8)	77.8	± 2.2c(88.1)	77.7	±2.2de(91.4)
	1.20	52.0	± 1.8ef(58.8)	51.2	± 1.2ef(58.0)	52.1	± 1.5ij(61.4)
	2.40	41.5	±1.2gh(46.9)	41.2	± 1.0hi(46.6)	40.4	±1.2kl(47.5)
2.5	0.00	49.7	± 1.4f(56.1)	48.0	±1.1fg(54.3)	48.1	± 1.4j(56.6)
	0.08	56.3	± 1.3e(63.5)	55.2	± 1.6e(62.5)	54.9	± 1.2i(64.7)
	1.20	37.2	± 0.9h(42.0)	36.4	± 1.31i(41.2)	36.0	± 1.0l(42.4)
	2.40	29.4	± 0.9i(33.3)	27.7	± 0.8j(31.3)	28.1	±0.8m(33.6)

Data are expressed as mean values ± standard errors from five replicates. Values with the same letter are not significantly different according to Fisher's LSD test ($p < 0.05$).

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Comparative effects of simulated acid rain of different ratios of SO_4^{2-} to NO_3^- on fine root in subtropical plantation of China (2018)

Effects of acid rain with different S/N ratios (S/N) and pH (H) addition on abiotic soil variables (mean ± SD) over four seasons.

		Spring	Summer	Autumn	Winter		Spring		Summer		Autumn	Winter
		TC ($g \cdot kg^{-1}$)					TN ($g \cdot kg^{-1}$)					
CK	30.39	± 1.85ab	41.74 ± 5.02a	28.01 ± 2.81a	32.75	± 5.74ab	3.07	± 0.45ab	3.80	± 0.29c	2.66 ± 0.22a	3.30 ± 0.33a
S1	23.49	± 5.06a	34.19 ± 2.08a	34.07 ± 1.27a	27.18	± 10.15a	2.36	± 0.35a	3.11	± 0.09ab	3.00 ± 0.12a	2.81 ± 0.66a
S2	25.40	± 5.03a	33.78 ± 9.22a	31.11 ± 7.42a	33.15	± 3.88a	2.62	± 0.39ab	3.03	± 0.46a	3.14 ± 0.39a	3.23 ± 0.30a
S3	27.85	± 7.92ab	38.87 ± 7.17a	35.76 ± 4.97a	31.50	± 2.71a	2.77	± 0.53ab	3.51	± 0.15abc	3.35 ± 0.39a	2.89 ± 0.50a
SN1	27.79	± 5.24ab	38.04 ± 2.89a	34.50 ± 3.95a	26.90	± 4.00a	2.77	± 0.23ab	3.36	± 0.06abc	3.05 ± 0.29a	2.70 ± 0.23a
SN2	29.17	± 1.58ab	34.83 ± 1.88a	33.85 ± 4.99a	31.23	± 3.09a	2.84	± 0.37ab	3.33	± 0.39abc	3.27 ± 0.42a	3.13 ± 0.55a
SN3	31.59	± 1.60ab	33.84 ± 0.98a	31.66 ± 3.34a	30.16	± 3.21a	3.02	± 0.44ab	3.61	± 0.36abc	3.32 ± 0.26a	3.19 ± 0.31a
N1	30.05	± 6.01ab	41.36 ± 8.93a	28.71 ± 3.39a	27.56	± 4.67a	3.08	± 0.16ab	3.72	± 0.27bc	2.84 ± 0.46a	2.63 ± 0.21a
N2	34.87	± 2.25b	33.49 ± 2.98a	34.95 ± 4.13a	30.44	± 7.18a	2.96	± 0.13ab	3.12	± 0.42ab	3.15 ± 0.16a	2.90 ± 0.62a
N3	29.61	± 2.33ab	37.10 ± 4.65a	27.54 ± 2.74a	31.83	± 2.61a	3.28	± 0.60b	3.71	± 0.48bc	3.11 ± 0.64a	3.07 ± 0.18a
Analysis of variance (p values)												
S/N		0.041*	0.729	0.242	0.890		0.032*		0.172		0.587	0.758
H		0.396	0.316	0.726	0.169		0.287		0.033*		0.246	0.159
S/N × H		0.601	0.479	0.189	0.981		0.942		0.562		0.984	0.843
Season		0.000***					0.000***					
S/N × H × Season		0.696					0.983					
	AP ($mg \cdot kg^{-1}$)						AK ($mg \cdot kg^{-1}$)					
CK	2.50	± 0.37c	3.11	± 0.66c	2.19	± 0.56ab	2.22	± 0.61ab	35.63	± 8.53a	52.24	± 16.01c	33.18	± 4.88abc	31.36	± 10.38abc
S1	1.90	± 0.50abc	2.58	± 0.74abc	2.39	± 0.33ab	1.47	± 0.51a	26.41	± 5.39a	24.94	± 12.02a	30.08	± 4.82abc	24.24	± 3.12a
S2	2.48	± 0.39c	2.89	± 0.79bc	2.95	± 1.00b	2.18	± 0.67ab	34.41	± 9.16a	44.51	± 8.20bc	35.34	± 5.47bc	37.39	± 6.57bc
S3	2.	±	1.9	± 0.54a	2.4	±	2.4	± 0.33b	31.9	±	34.	±	25.4	±	32.22	±

	07	0.40abc	0		1	0.66ab	1		2	12.49a	56	8.10ab	1	2.25a		2.22abc
SN1	2.11	± 0.09bc	2.57	± 0.28abc	2.30	± 0.10ab	1.58	± 0.35a	29.36	± 4.53a	25.70	± 6.97a	30.56	± 3.88abc	28.67	± 1.51ab
SN2	2.18	± 0.25bc	2.60	± 0.37abc	2.73	± 0.58b	2.12	± 0.27ab	36.67	± 4.01a	39.08	± 1.06abc	34.75	± 4.12abc	31.67	± 4.12abc
SN3	1.74	± 0.33ab	2.27	± 0.21abc	2.08	± 0.19ab	1.67	± 0.18ab	34.40	± 4.05a	33.51	± 5.57ab	27.36	± 2.59ab	27.36	± 2.59ab
N1	2.05	± 0.28abc	1.85	± 0.31a	2.13	± 0.27ab	1.65	± 0.25ab	31.89	± 6.74a	25.66	± 5.87a	30.89	± 4.60abc	39.30	± 5.68c
N2	1.72	± 0.29ab	2.05	± 0.14ab	2.09	± 0.23ab	1.86	± 0.12ab	38.40	± 4.16a	36.17	± 6.11abc	34.32	± 7.84abc	33.87	± 5.20abc
N3	1.49	± 0.14a	2.62	± 0.39abc	1.73	± 0.28a	1.48	± 0.50a	32.92	± 7.14a	47.95	± 12.45bc	37.10	± 6.34c	36.64	± 5.21bc

Analysis of variance (p values)											
S/N	0.048*	0.325	0.050	0.170		0.556	0.612		0.237	0.006**	
H	0.075	0.513	0.105	0.052		0.113	0.002**	0.103	0.239		
S/N × H	0.179	0.064	0.840	0.180		0.980	0.206	0.204		0.024*	
Season	0.000***					0.362					
S/N × H × Season	0.109					0.388					

The values in bracket are standard deviation (n = 3). Capital letters for a given variable indicate significant difference (p b 0.05) among different treatments of one season based on one-way ANOVA, followed by a Duncan test. Two-way ANOVA was applied to indicate significant difference among variances (no CK treatments). *** indicates significant difference at p b 0.001; ** indicates significant difference at p b 0.01; * indicates significant difference at p b 0.05. S/N, the ratio of SO_4^{2-} to NO_3^-; TC, total carbon; TN, total nitrogen; AP, available phosphorus; AK, available potassium. The experimental treatments are: CK = control check; S1 = pH 4.5, S/N 5:1; S2 = pH 3.5, S/N 5:1; S3 = pH 2.5, S/N 5:1; SN1 = pH 4.5, S/N 1:1; SN2 = pH 3.5, S/N 1:1; SN3 = pH 2.5, S/N 1:1; N1 = pH 4.5, S/N 1:5; N2 = pH 3.5, S/N 1:5; N3 = pH 2.5, S/N 1:5.

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Direct effect of acid rain on leaf chlorophyll content of terrestrial plants in China(2017)

Mean effects of acid rain on leaf chlorophyll content (% change per pH unit) across soil acidity preference categories

Soil acidity preference categories	Effect on leaf chlorophyll content		
	n	Mean	s.e.
Calcicole	18	−6.03	1.09
Ubiquist	19	−6.08	1.09
Calcifuge	30	−7.52	1.20
All	67	−6.71	0.68

Mean effects of acid rain on leaf chlorophyll content (% change per pH unit) across functional groups.

Functional group	Effect on leaf chlorophyll content			
	n	Mean	s.e.	
Life form				
Tree	25	−5.63	0.90	
Shrub	7	−7.04	2.75	
Herb	35	−7.42	1.01	
Evergreen	19	−4.06	0.98	
Deciduous	13	−8.67	1.43	
Phylogeny				
Angiosperm	64	−6.84	0.69	
Gymnosperm	3	−3.93	3.93	
Monocotyledon	17	−6.36	1.24	
Dicotyledon	47	−7.02	0.84	

Mean effects of acid rain on leaf chlorophyll content (% change per pH unit) across economic use types.

Economic use type	Effect on leaf chlorophyll content		
	n	Mean	s.e.
Food & timber			
Vegetable	8	−14.24	1.52
Fruit tree	3	−7.83	1.93
Cereal crop	5	−4.29	2.66
Timber tree	12	−3.28	1.09
Ornamental plant			
Ornamental tree	17	−5.15	1.78
Ornamental shrub	5	−7.65	3.54
Ornamental herb	14	−4.67	1.18

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