

## Supplementary Material

### Interactive Role of Silicon on Attenuating Aluminum Toxicity in Sugarcane by Modifying Growth, Root Morphoanatomy, Photosynthetic Pigments, and Gas Exchange Parameters

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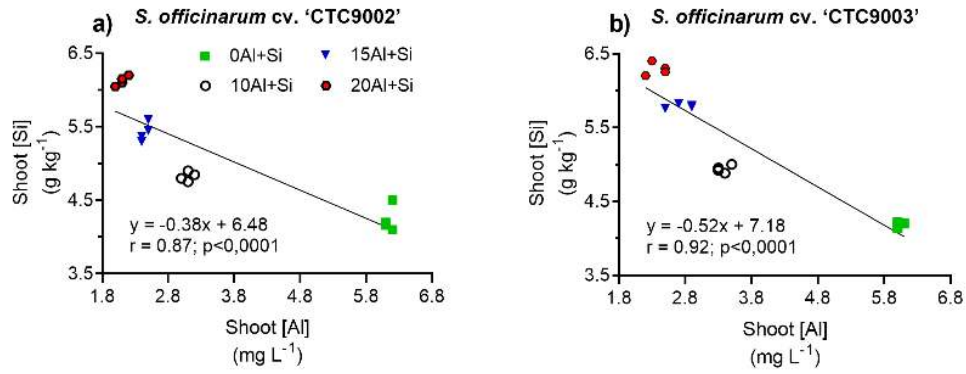


Fig S1 Correlation analysis between [Si] and [Al] in the aerial part of sugarcane seedlings in the cultivars 'CTC9002' a) and 'CTC9003' b). Treatments: without Al stress and Si addition (0Al+Si); with Al stress (10 mg L<sup>-1</sup>) and Si addition (2 mmol L<sup>-1</sup>) (10Al+Si); with Al stress (15 mg L<sup>-1</sup>) and Si addition (2 mmol L<sup>-1</sup>) (15Al+Si) and Al stress (20 mg L<sup>-1</sup>) and Si addition (2 mmol L<sup>-1</sup>) (20Al+Si)

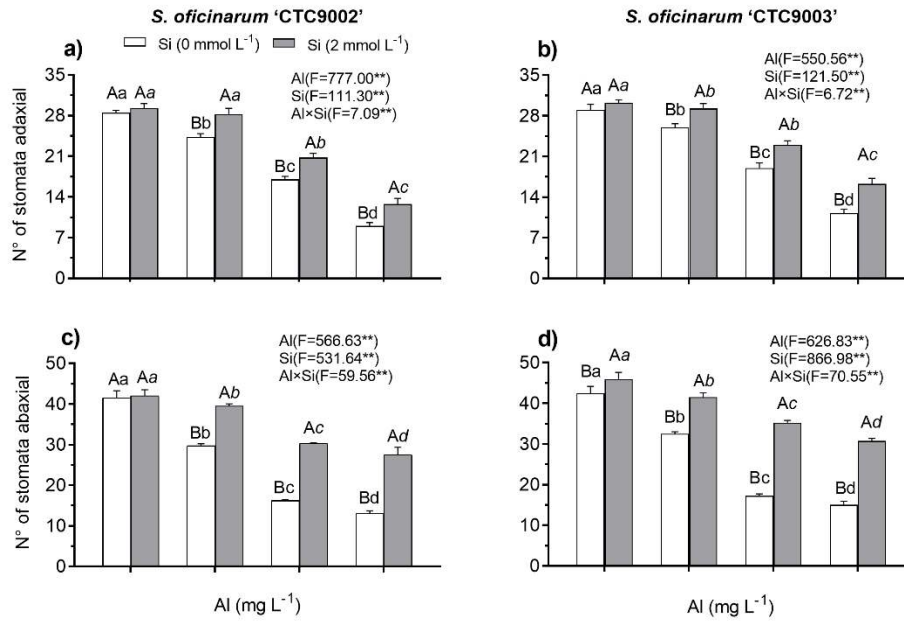


Fig S2 Number of stomata adaxial in cv 'CTC9002' (a) and cv 'CTC9003' (b) and number of stomata abaxial in cv 'CTC9002' (c) and cv 'CTC9003' (d). Treatments: without Al stress and Si addition (0Al+Si); with Al stress (10 mg L<sup>-1</sup>) and Si addition (2 mmol L<sup>-1</sup>) (10Al+Si); with Al stress (15 mg L<sup>-1</sup>) and Si addition (2 mmol L<sup>-1</sup>) (15Al+Si) and Al stress (20 mg L<sup>-1</sup>) and Si addition (2 mmol L<sup>-1</sup>) (20Al+Si). Data are the means (n=4) ± standard deviation (SD). Capital letters indicate differences between the absence and presence of Si in the same Al treatment; lower case normal letters indicate significant differences between Al treatments in the absence of Si and lower-case italic letters indicate statistical differences between Al concentrations in the presence of Si (2 mmol L<sup>-1</sup>), according to the t-student test (LSD) by ANOVA (p<0.05)

Table S1 Aerial dry mass of both sugarcane cultivars. ANOVA multifactorial with four Al concentrations, two Si levels and their interactions

Aerial dry mass (g)					
'CTC9002'					
Variation causes	DF	SS	MS	F (DFn, DFd)	P value
Al concentrations	3	130.77	43.59	F (3, 21) = 197.35**	0.0001
Si supplementation	1	19.96	19.95	F (1, 21) = 90.34**	0.0001
Interaction (Al × Si)	3	10.75	3.65	F (3, 21) = 16.53**	0.0001
Residual	21	4.64	0.22		
'CTC9003'					
Variation causes	DF	SS	MS	F (DFn, DFd)	P value
Al concentrations	3	112.52	37.51	F (3, 21) = 297.53**	0.0001
Si supplementation	1	21.13	21.13	F (1, 21) = 167.58**	0.0001
Interaction (Al × Si)	3	8.65	2.88	F (3, 21) = 22.87**	0.0001
Residual	21	2.64	0.12		

**Note:** \*: indicates significant at  $p < 0.05$  and \*\*: indicates significant at  $p < 0.01$ .

Table S2 Root dry mass of both sugarcane cultivars. ANOVA multifactorial with four Al concentrations, two Si levels and their interactions

<b>Root dry mass (g)</b>					
<b>'CTC9002'</b>					
<b>Variation causes</b>	<b>DF</b>	<b>SS</b>	<b>MS</b>	<b>F (DFn, DFd)</b>	<b>P value</b>
Al concentrations	3	32.17	10.72	F (3, 21) = 45.03**	0.0001
Si supplementation	1	2.45	2.45	F (1, 21) = 10.30**	0.0042
Interaction (Al × Si)	3	1.22	0.41	F (3, 21) = 11.71**	0.0002
Residual	21	5.00	0.24		
<b>'CTC9003'</b>					
<b>Variation causes</b>	<b>DF</b>	<b>SS</b>	<b>MS</b>	<b>F (DFn, DFd)</b>	<b>P value</b>
Al concentrations	3	29.29	9.76	F (3, 21) = 121.63**	0.0001
Si supplementation	1	5.37	5.37	F (1, 21) = 66.91**	0.0001
Interaction (Al × Si)	3	1.47	0.49	F (3, 21) = 6.11**	0.0037
Residual	21	1.69	0.08		

**Note:** \*: indicates significant at  $p < 0.05$  and \*\*: indicates significant at  $p < 0.01$ .

Table S3 Leaf area of both sugarcane cultivars. ANOVA multifactorial with four Al concentrations, two Si levels and their interactions

Leaf area (cm <sup>2</sup> )					
'CTC9002'					
Variation causes	DF	SS	MS	F (DFn, DFd)	P value
Al concentrations	3	1059751.0	353250.3	F (3, 21) = 4469.50**	0.0001
Si supplementation	1	68635.13	68635.13	F (1, 21) = 868.41**	0.0001
Interaction (Al × Si)	3	23040.38	7680.13	F (3, 21) = 97.17**	0.0001
Residual	21	1659.75	79.04		
'CTC9003'					
Variation causes	DF	SS	MS	F (DFn, DFd)	P value
Al concentrations	3	963767.7	321255.7	F (3, 21) = 8200.72**	0.0001
Si supplementation	1	76342.78	76342.78	F (1, 21) = 1948.81**	0.0001
Interaction (Al × Si)	3	27033.34	9011.11	F (3, 21) = 230.03**	0.0001
Residual	21	822.66	39.17		

**Note:** \*: indicates significant at  $p < 0.05$  and \*\*: indicates significant at  $p < 0.01$ .

Table S4 Chlorophyll a content (Chls a) of both sugarcane cultivars. ANOVA multifactorial of with four Al concentration, two Si levels and their interactions

<b>Chls a</b>					
<b>'CTC9002'</b>					
<b>Variation causes</b>	<b>DF</b>	<b>SS</b>	<b>MS</b>	<b>F (DFn, DFd)</b>	<b>P value</b>
Al concentrations	3	20.21	6.74	F (3, 21) = 862.94**	0.0001
Si supplementation	1	4.81	4.81	F (1, 21) = 616.49**	0.0001
Interaction (Al × Si)	3	4.66	1.55	F (3, 21) = 199.06**	0.0001
Residual	21	0.16	0.01		
<b>'CTC9003'</b>					
<b>Variation causes</b>	<b>DF</b>	<b>SS</b>	<b>MS</b>	<b>F (DFn, DFd)</b>	<b>P value</b>
Al concentrations	3	10.90	3.63	F (3, 21) = 339.16**	0.0001
Si supplementation	1	5.19	5.19	F (1, 21) = 484.74**	0.0001
Interaction (Al × Si)	3	4.52	1.51	F (3, 21) = 140.53**	0.0001
Residual	21	0.22	0.01		

**Note:** \*: indicates significant at  $p < 0.05$  and \*\*: indicates significant at  $p < 0.01$ .

Table S5 Chlorophyll b content (Chls b) of both sugarcane cultivars. ANOVA multifactorial with four Al concentrations, two Si levels and their interactions

<b>Chls b</b>					
<b>'CTC9002'</b>					
<b>Variation causes</b>	<b>DF</b>	<b>SS</b>	<b>MS</b>	<b>F (DFn, DFd)</b>	<b>P value</b>
Al concentrations	3	21.98	7.33	F (3, 21) = 2227.68**	0.0001
Si supplementation	1	6.04	6.04	F (1, 21) = 1835.93**	0.0001
Interaction (Al × Si)	3	2.29	0.76	F (3, 21) = 231.95**	0.0001
Residual	21	0.07	0.003		
<b>'CTC9003'</b>					
<b>Variation causes</b>	<b>DF</b>	<b>SS</b>	<b>MS</b>	<b>F (DFn, DFd)</b>	<b>P value</b>
Al concentrations	3	15.66	5.22	F (3, 21) = 1865.43**	0.0001
Si supplementation	1	4.35	4.35	F (1, 21) = 1555.34**	0.0001
Interaction (Al × Si)	3	2.02	0.67	F (3, 21) = 240.23**	0.0001
Residual	21	0.06	0.002		

**Note:** \*: indicates significant at  $p < 0.05$  and \*\*: indicates significant at  $p < 0.01$ .

Table S6 Carotenoids (Cars) of both sugarcane cultivars. ANOVA multifactorial with four Al concentration, two Si levels and their interactions

<b>Cars</b>					
<b>'CTC9002'</b>					
<b>Variation causes</b>	<b>DF</b>	<b>SS</b>	<b>MS</b>	<b>F (DFn, DFd)</b>	<b>P value</b>
Al concentrations	3	11.93	3.98	F (3, 21) = 710.72**	0.0001
Si supplementation	1	2.76	2.76	F (1, 21) = 493.50**	0.0001
Interaction (Al × Si)	3	1.33	0.44	F (3, 21) = 79.46**	0.0001
Residual	21	0.12	0.01		
<b>'CTC9003'</b>					
<b>Variation causes</b>	<b>DF</b>	<b>SS</b>	<b>MS</b>	<b>F (DFn, DFd)</b>	<b>P value</b>
Al concentrations	3	10.83	3.61	F (3, 21) = 412.62**	0.0001
Si supplementation	1	2.00	2.00	F (1, 21) = 228.57**	0.0001
Interaction (Al × Si)	3	1.62	0.54	F (3, 21) = 61.81**	0.0001
Residual	21	0.18	0.01		

**Note:** \*: indicates significant at  $p < 0.05$  and \*\*: indicates significant at  $p < 0.01$ .

Table S7 Anthocyanins (Anths) content of both sugarcane cultivars. ANOVA multifactorial of with four Al concentration, two Si levels and their interactions

<b>Anths</b>					
<b>'CTC9002'</b>					
<b>Variation causes</b>	<b>DF</b>	<b>SS</b>	<b>MS</b>	<b>F (DFn, DFd)</b>	<b>P value</b>
Al concentrations	3	0.002	0.0008	F (3, 21) = 523.64**	0.0001
Si supplementation	1	0.0002	0.0002	F (1, 21) = 96.35**	0.0001
Interaction (Al × Si)	3	0.00007	0.00002	F (3, 21) = 14.92**	0.0001
Residual	21	0.00003	0.000002		

<b>'CTC9003'</b>					
<b>Variation causes</b>	<b>DF</b>	<b>SS</b>	<b>MS</b>	<b>F (DFn, DFd)</b>	<b>P value</b>
Al concentrations	3	0.002	0.0005	F (3, 21) = 598.52**	0.0001
Si supplementation	1	0.0001	0.0001	F (1, 21) = 128.57**	0.0001
Interaction (Al × Si)	3	0.00005	0.00002	F (3, 21) = 18.95**	0.0001
Residual	21	0.00002	0.000001		

**Note:** \*: indicates significant at  $p < 0.05$  and \*\*: indicates significant at  $p < 0.01$ .

**Table S8** Stomatal conductance (*gs*) of both sugarcane cultivars. ANOVA multifactorial with four Al concentration, two Si levels and their interactions

<i>gs</i>					
'CTC9002'					
Variation causes	DF	SS	MS	F (DFn, DFd)	P value
Al concentrations	3	1.72	0.57	F (3, 21) = 1644.15**	0.0001
Si supplementation	1	0.01	0.01	F (1, 21) = 35.73**	0.0001
Interaction (Al × Si)	3	0.02	0.005	F (3, 21) = 15.08**	0.0001
Residual	21	0.007	0.0003		

'CTC9003'					
Variation causes	DF	SS	MS	F (DFn, DFd)	P value
Al concentrations	3	2.76	0.92	F (3, 21) = 529.16**	0.0001
Si supplementation	1	0.09	0.09	F (1, 21) = 53.21**	0.0001
Interaction (Al × Si)	3	0.10	0.03	F (3, 21) = 18.63**	0.0001
Residual	21	0.03	0.002		

**Note:** \*: indicates significant at  $p < 0.05$  and \*\*: indicates significant at  $p < 0.01$ .

**Table S9** Transpiration rate (*E*) of both sugarcane cultivars. ANOVA multifactorial of with four Al concentration, two Si levels and their interactions

<i>E</i>					
'CTC9002'					
Variation causes	DF	SS	MS	F (DFn, DFd)	P value
Al concentrations	3	2.95	0.98	F (3, 21) = 149.21**	0.0001
Si supplementation	1	0.14	0.14	F (1, 21) = 21.15**	0.0001
Interaction (Al × Si)	3	0.02	0.006	F (3, 21) = 6.94**	0.0001
Residual	21	0.14	0.007		
'CTC9003'					
Variation causes	DF	SS	MS	F (DFn, DFd)	P value
Al concentrations	3	2.54	0.85	F (3, 21) = 119.88**	0.0001
Si supplementation	1	0.17	0.17	F (1, 21) = 23.64**	0.0001
Interaction (Al × Si)	3	0.04	0.01	F (3, 21) = 11.89**	0.0001
Residual	21	0.15	0.007		

**Note:** \*: indicates significant at  $p < 0.05$  and \*\*: indicates significant at  $p < 0.01$ .

**Table S10** CO<sub>2</sub> assimilation rate (*A*) of both sugarcane cultivars. ANOVA multifactorial with four Al concentrations, two Si levels and their interactions

<i>A</i>					
'CTC9002'					
Variation causes	DF	SS	MS	F (DFn, DFd)	P value
Al concentrations	3	52.87	17.62	F (3, 21) = 4146.28**	0.0001
Si supplementation	1	15.10	15.10	F (1, 21) = 3551.86**	0.0001
Interaction (Al × Si)	3	7.35	2.45	F (3, 21) = 576.59**	0.0001
Residual	21	0.09	0.004		
'CTC9003'					
Variation causes	DF	SS	MS	F (DFn, DFd)	P value
Al concentrations	3	40.67	13.56	F (3, 21) = 878.47**	0.0001
Si supplementation	1	14.72	14.72	F (1, 21) = 953.59**	0.0001
Interaction (Al × Si)	3	6.74	2.24	F (3, 21) = 145.50**	0.0001
Residual	21	0.32	0.02		

**Note:** \*: indicates significant at  $p < 0.05$  and \*\*: indicates significant at  $p < 0.01$ .

**Table S11** Number of stomata adaxial of both sugarcane cultivars ANOVA multifactorial with four Al concentrations, two Si levels and their interactions

<i>Number of stomata adaxial</i>					
<b>'CTC9002'</b>					
<b>Variation causes</b>	<b>DF</b>	<b>SS</b>	<b>MS</b>	<b>F (DFn, DFd)</b>	<b>P value</b>
Al concentrations	3	1571.34	523.78	F (3, 21) = 777.00**	0.0001
Si supplementation	1	75.03	75.03	F (1, 21) = 111.30**	0.0001
Interaction (Al × Si)	3	14.34	4.78	F (3, 21) = 7.09**	0.0001
Residual	21	14.16	0.67		
<b>'CTC9003'</b>					
<b>Variation causes</b>	<b>DF</b>	<b>SS</b>	<b>MS</b>	<b>F (DFn, DFd)</b>	<b>P value</b>
Al concentrations	3	1238.75	412.92	F (3, 21) = 550.56**	0.0001
Si supplementation	1	91.13	91.13	F (1, 21) = 121.50**	0.0001
Interaction (Al × Si)	3	15.13	5.04	F (3, 21) = 6.72**	0.0024
Residual	21	15.75	0.75		

**Note:** \*: indicates significant at  $p < 0.05$  and \*\*: indicates significant at  $p < 0.01$ .

**Table S12** Number of stomata abaxial of both sugarcane cultivars. ANOVA multifactorial with four Al concentrations, two Si levels and their interactions

<i>Number of stomata abaxial</i>					
<b>'CTC9002'</b>					
<b>Variation causes</b>	<b>DF</b>	<b>SS</b>	<b>MS</b>	<b>F (DFn, DFd)</b>	<b>P value</b>
Al concentrations	3	2400.59	800.20	F (3, 21) = 566.63**	0.0001
Si supplementation	1	750.78	750.78	F (1, 21) = 531.64**	0.0001
Interaction (Al × Si)	3	252.34	84.11	F (3, 21) = 59.56**	0.0001
Residual	21	29.66	1.41		
<b>'CTC9003'</b>					
<b>Variation causes</b>	<b>DF</b>	<b>SS</b>	<b>MS</b>	<b>F (DFn, DFd)</b>	<b>P value</b>
Al concentrations	3	2319.84	773.28	F (3, 21) = 626.83**	0.0001
Si supplementation	1	1069.53	1069.53	F (1, 21) = 866.98**	0.0001
Interaction (Al × Si)	3	261.09	87.03	F (3, 21) = 70.55**	0.0001
Residual	21	25.91	1.23		

**Note:** \*: indicates significant at  $p < 0.05$  and \*\*: indicates significant at  $p < 0.01$ .