

Supplementary Material to “High-dimensional elementomes outperform CNP models in explaining photosynthetic traits”

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Appendix S1

Table S1. Photosynthetic parameters averaged for each bryophyte species (standard deviation in parenthesis). $A_{\max}$ is the maximum rate of net photosynthesis (in $\text{nmol CO}_2 \text{ g}^{-1} \text{ s}^{-1}$), A_{qe} is the apparent quantum yield (in $\text{nmol CO}_2 \text{ g}^{-1} (\mu\text{mol photons m}^{-2})^{-1}$), LCP is the light compensation point (in $\mu\text{mol photons m}^{-2} \text{ s}^{-1}$), and R_{dark} is dark respiration (in $\text{nmol CO}_2 \text{ g}^{-1} \text{ s}^{-1}$).

Species	Type	n	$A_{\max}$	A_{qe}	LCP	R_{dark}
<i>Apopellia endiviifolia</i>	liverwort	14	39.9 (28.6)	0.026 (0.013)	17.4 (10.3)	15.7 (8.3)
<i>Brachytecium rivulare</i>	moss	8	39.1 (26.9)	0.019 (0.006)	13.8 (3.4)	9.8 (4.3)
<i>Chiloscyphus polyanthos</i>	liverwort	2	29.4 (1.9)	0.024 (0.01)	12.6 (3.0)	10.3 (0.9)
<i>Conocephalum conicum</i>	liverwort	9	71.4 (66.9)	0.021 (0.006)	12.2 (6.3)	16.5 (10.3)
<i>Cratoneuron filicinum</i>	moss	5	48.4 (24.6)	0.017 (0.003)	12.7 (3.8)	11.2 (6.1)
<i>Didymodon tophaceus</i>	moss	6	34.8 (4.2)	0.026 (0.014)	10.4 (3.9)	9 (1.9)
<i>Eucladium verticillatum</i>	moss	3	19.3 (6.4)	0.024 (0.014)	11 (6.1)	5.1 (3.9)
<i>Fissidens grandifrons</i>	moss	2	10.7 (3.8)	0.023 (0.006)	10.3 (2.5)	2.8 (0.5)
<i>Fissidens taxifolius</i>	moss	2	17.8 (3.4)	0.041 (0.001)	6.3 (3.0)	5.2 (1.6)
<i>Fontinalis antipyretica</i>	moss	2	36.6 (14.3)	0.014 (0.001)	16.1 (3.0)	9.3 (2.2)
<i>Lophocolea bidentata</i>	liverwort	2	44.9 (25.5)	0.034 (0.018)	9.2 (3.4)	13.9 (5.7)
<i>Lunularia cruciata</i>	liverwort	2	70.1 (33.3)	0.018 (0.005)	10.6 (0.3)	13.4 (2.7)
<i>Marchantia polymorpha</i>	liverwort	2	30.7 (7.9)	0.016 (0.002)	19.2 (2.5)	10.3 (2.6)
<i>Oxyrrhynchium speciosum</i>	moss	9	32.6 (18.9)	0.026 (0.01)	17 (25.0)	10.5 (10.6)
<i>Palustriella commutata</i>	moss	5	67.7 (23.9)	0.023 (0.007)	7.4 (3.0)	12.4 (7.6)
<i>Philonotis fontana</i>	moss	1	43.6	0.008	44.7	18.2
<i>Philonotis marchica</i>	moss	1	115.5	0.020	7.4	16.6
<i>Plagiochila porelloides</i>	liverwort	2	17.7 (3.9)	0.033 (0.003)	9.4 (2.5)	6.5 (2.4)
<i>Plagiomnium rostratum</i>	moss	1	33.6	0.020	11.7	8.9
<i>Plagiomnium undulatum</i>	moss	8	33.1 (15.7)	0.039 (0.014)	6.9 (2.8)	8.5 (3.8)
<i>Porella platyphylla</i>	liverwort	2	21 (2.6)	0.017 (0.001)	14.2 (1.7)	6.1 (1.3)
<i>Ptychostomum pseudotriquetrum</i>	moss	4	49.4 (14.2)	0.013 (0.002)	16.3 (3.9)	11.1 (4.1)
<i>Rhynchostegium riparioides</i>	moss	6	23.8 (5.7)	0.017 (0.004)	12.3 (2.0)	5.6 (1.9)
<i>Riccardia chamedryfolia</i>	liverwort	1	36.3	0.032	9.2	12.6
<i>Scapania undulata</i>	liverwort	1	25.1	0.015	18.6	8.3
<i>Thamnobryum alopecurum</i>	moss	5	9.4 (2.1)	0.056 (0.019)	4.1 (2.5)	2 (0.9)

Table S2. Summary of elemental concentrations and isotopic ratios. CV is the coefficient of variation. Elements are arranged in descending order of their mean concentrations.

Variable	Mean	Minimum	Maximum	CV (%)
$\delta_{13}\text{C}$	-34.3	-50.25	-25.52	
$\delta_{15}\text{N}$	0.12	-7.82	7.69	
C (mg g ⁻¹)	428.32	261.06	509.09	9
N (mg g ⁻¹)	23.23	8.54	43.67	31
K (mg g ⁻¹)	18.97	1.89	131.11	109
Ca (mg g ⁻¹)	6.02	1.20	24.08	68
Na (mg g ⁻¹)	3.01	0.14	18.25	135
S (mg g ⁻¹)	2.03	0.18	8.99	115
Mg (mg g ⁻¹)	1.54	0.38	10.59	82
P (mg g ⁻¹)	1.45	0.13	6.16	72
Fe (mg g ⁻¹)	0.68	0.03	8.01	165
Al (mg g ⁻¹)	0.47	0.04	1.70	79
Mn (μg g ⁻¹)	46.83	2.27	829.32	192
Zn (μg g ⁻¹)	39.13	5.43	466.4	134
B (μg g ⁻¹)	16.98	1.41	348.13	203
Cu (μg g ⁻¹)	7.25	1.53	94.68	135
Pb (μg g ⁻¹)	4.08	0.19	139.22	359
Cr (μg g ⁻¹)	3.65	1.45	16.09	56
Ni (μg g ⁻¹)	3.09	0.88	21.98	97
Co (μg g ⁻¹)	0.72	0.05	12.32	262
As (μg g ⁻¹)	0.41	0.05	3.18	114
Cd (μg g ⁻¹)	0.26	0	4.12	217
Hg (μg g ⁻¹)	0.03	0	0.70	250

Table S3. Standardised coefficients and standard errors (in parenthesis) of averaged best model subsets (i.e., those with $\Delta AIC < 2$) of photosynthetic parameters maximum rate of net photosynthesis (A_{max}), apparent quantum yield (A_{qe}), light compensation point (LCP), and dark respiration (R_{dark}). Statistically significant effects ($P < 0.05$) are indicated in bold.

variable	A_{max}	A_{qe}	LCP	R_{dark}
$\delta_{13}C$	0.185 (0.072)	-0.050 (0.078)		0.124 (0.069)
$\delta_{15}N$	0.077 (0.084)	-0.258 (0.082)		-0.006 (0.027)
C		0.151 (0.106)		0.139 (0.078)
N	0.520 (0.089)	-0.252 (0.088)	0.006 (0.031)	0.355 (0.067)
P	0.060 (0.171)	0.006 (0.035)		0.002 (0.020)
K	0.381 (0.126)	-0.053 (0.110)	-0.246 (0.117)	
Ca	0.004 (0.022)	-0.151 (0.102)	0.012 (0.042)	0.030 (0.061)
Mg	-0.150 (0.082)	0.047 (0.080)		-0.192 (0.075)
S	-0.305 (0.148)		0.740 (0.134)	0.446 (0.133)
Na				0.024 (0.062)
Fe	-0.008 (0.030)			0.005 (0.025)
Mn	-0.013 (0.036)		0.228 (0.073)	0.094 (0.080)
Zn	-0.196 (0.056)	0.185 (0.066)		-0.116 (0.050)
Cu	0.135 (0.065)	-0.149 (0.074)	0.212 (0.066)	0.142 (0.058)
B	0.086 (0.060)	0.007 (0.028)		0.192 (0.052)
Ni	-0.001 (0.011)	0.439 (0.079)	-0.331 (0.082)	-0.093 (0.081)
Al	-0.013 (0.039)			
Co	-0.028 (0.054)	-0.489 (0.081)	0.430 (0.093)	0.084 (0.096)
Cr	0.119 (0.068)	0.006 (0.030)	-0.018 (0.049)	0.166 (0.062)
As	0.029 (0.059)			0.181 (0.065)
Cd	0.010 (0.036)		0.049 (0.077)	
Hg		0.124 (0.065)	-0.003 (0.020)	
Pb		-0.167 (0.068)	0.035 (0.064)	
C×N				
C×P				
N×P	-0.059 (0.185)			

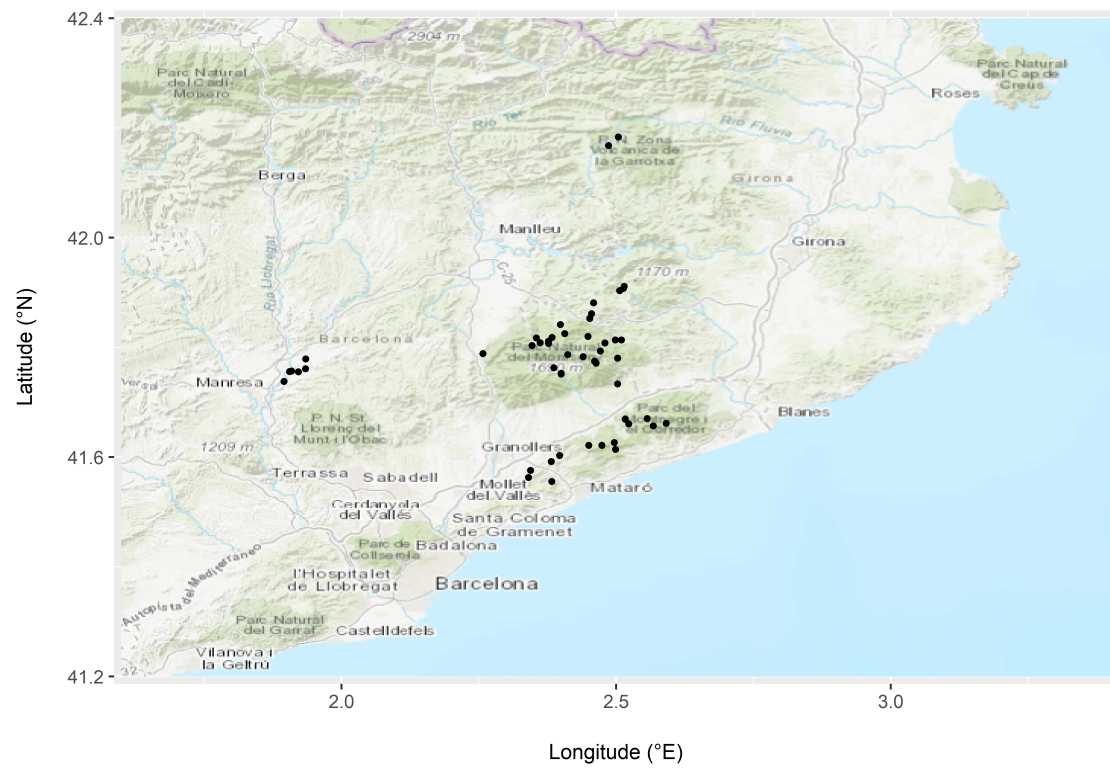


Figure S1. Location of the 51 sampled springs.

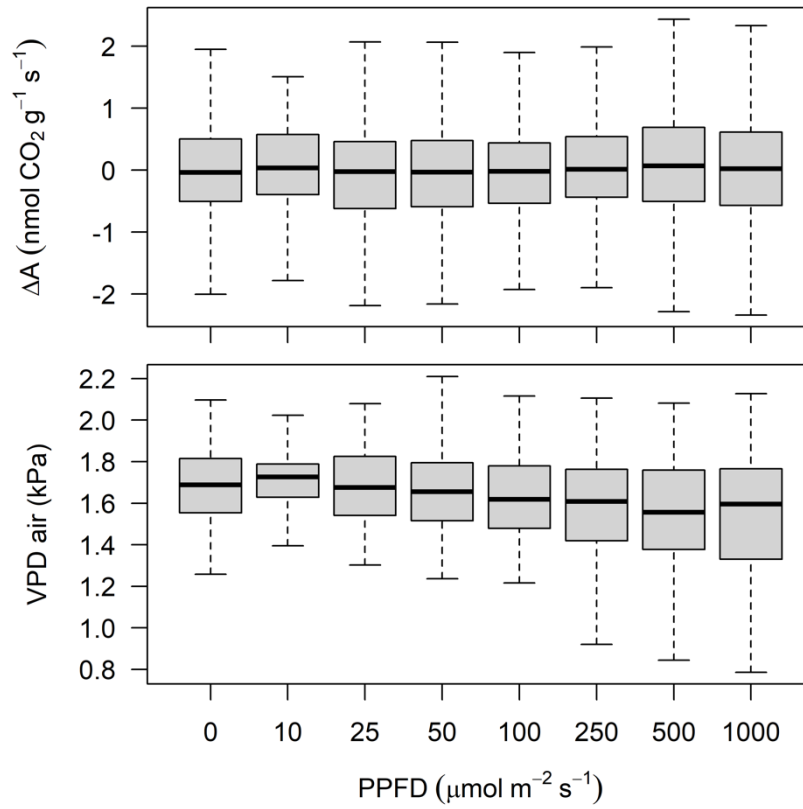


Figure S2. (top) Difference in net assimilation rates between each gas exchange measurement and the preceding one within each PPFD level (measuring time was 4–6 minutes; measuring frequency was 1–2 samples per minute). (bottom) Vapour pressure deficit of the air cuvette for each PPFD level.

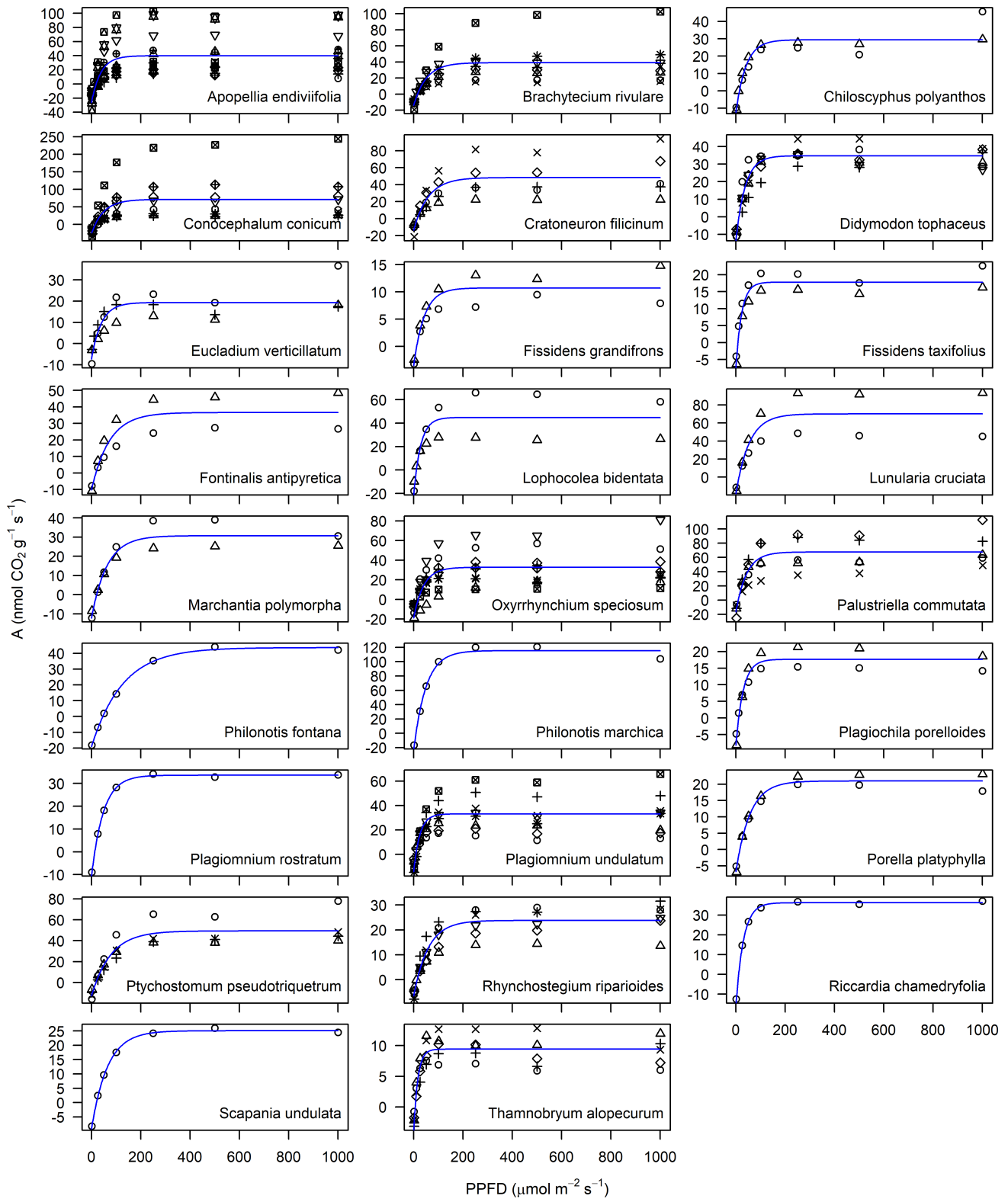


Figure S3. Light response curves (net CO₂ uptake [A] against photosynthetic photon flux density [PPFD] levels) in 26 bryophyte species. Within each panel (species), different symbols indicate different replicates, and blue lines are averaged model fits.

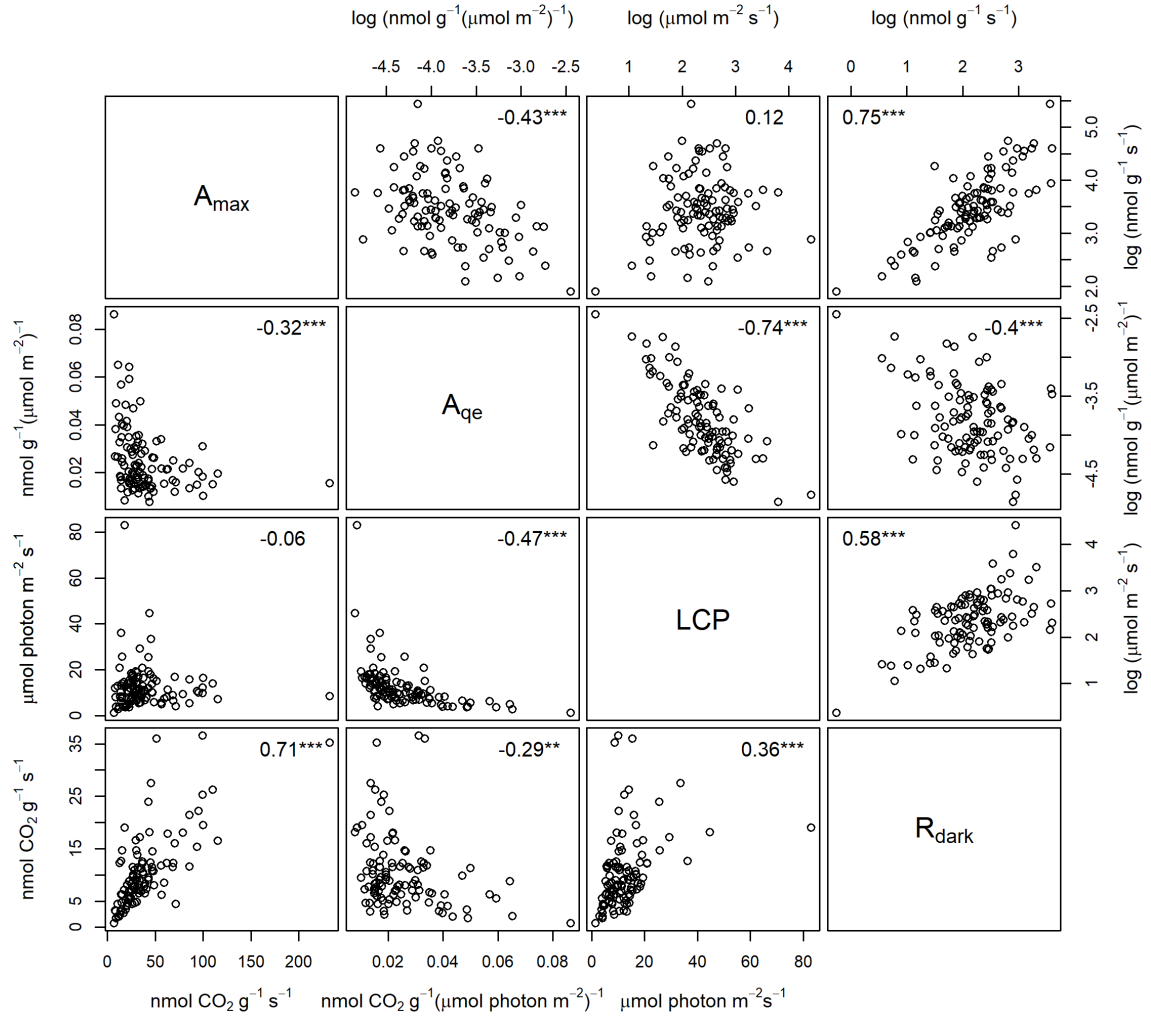


Figure S4. Correlation between photosynthetic parameters of bryophyte samples ($A_{\max}$, maximum rate of net photosynthesis; A_{qe} , apparent quantum yield; LCP, light compensation point; R_{dark} , dark respiration). The upper diagonal shows log-transformed data and the lower diagonal, untransformed data. Pearson's product moment correlation coefficients are shown in the upper right corner of the panels, followed by their statistical significance (***, $P < 0.001$; **, $P < 0.01$; *, $P < 0.05$; no stars, $P > 0.05$).

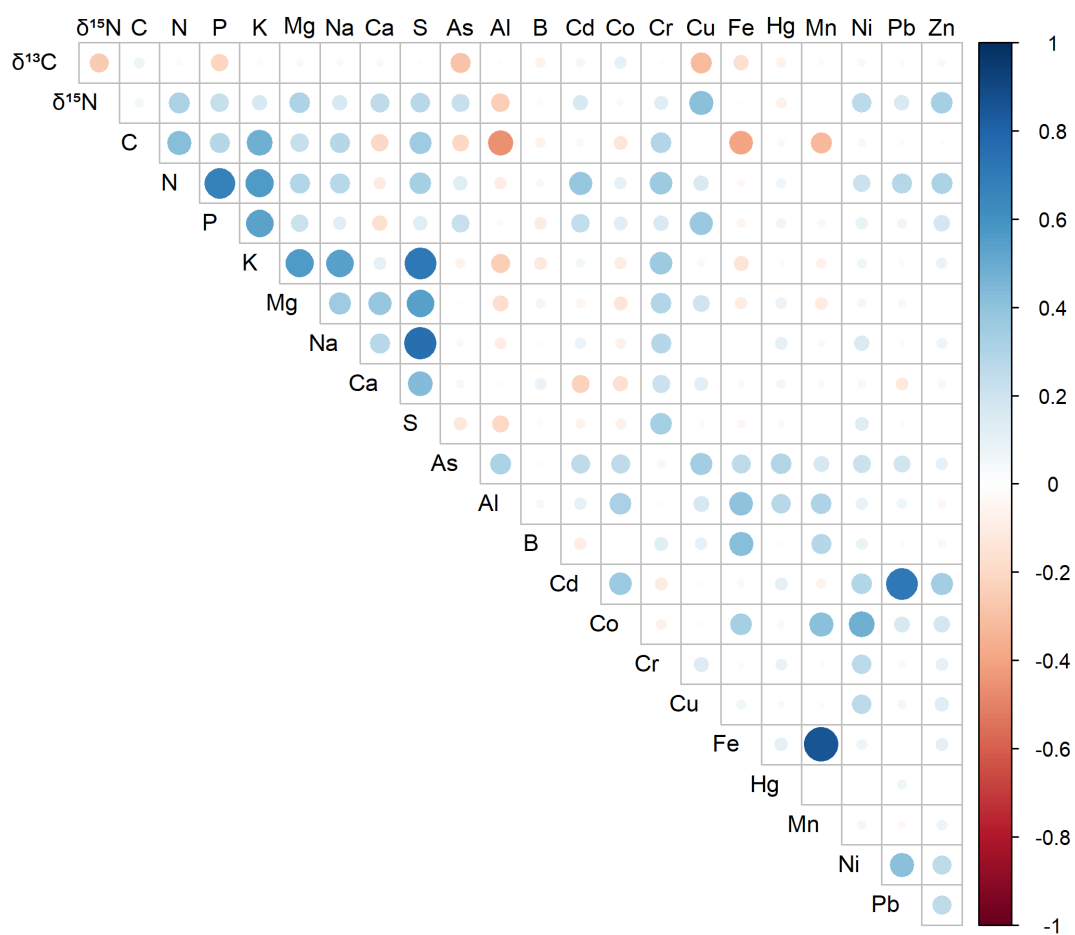


Figure S5. Pearson product-moment correlation coefficient of elemental variables.

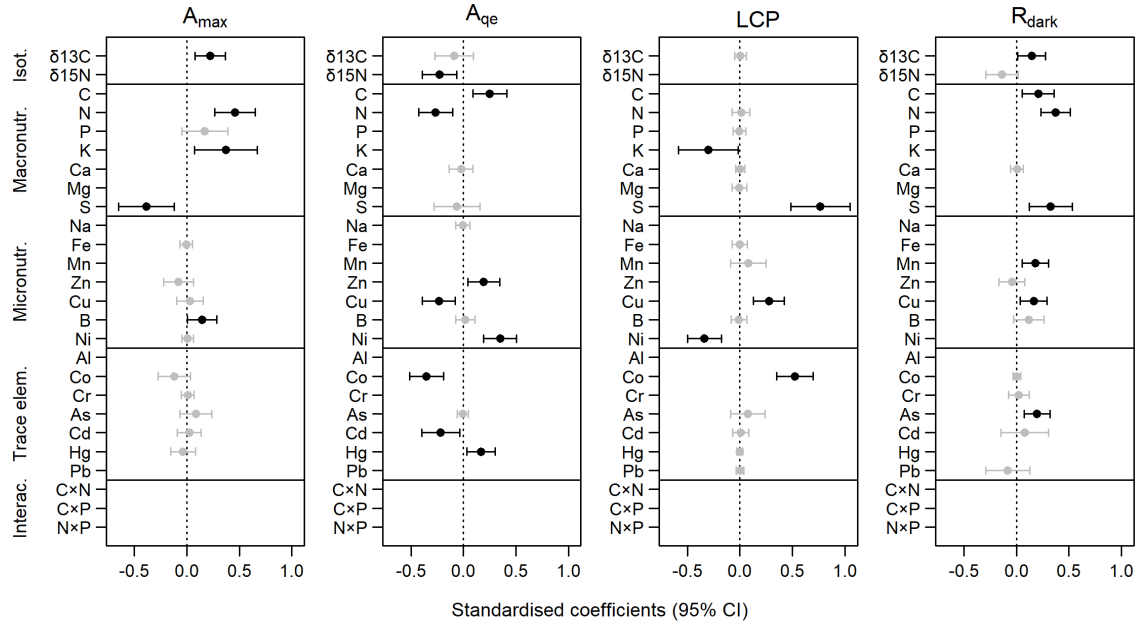


Figure S6. Coefficients in averaged best models ($\Delta\text{AIC} < 2$) of maximum rate of net photosynthesis ($A_{\max}$), apparent quantum yield (A_{qe}), light compensation point (LCP), and dark respiration (R_{dark}), computed from a modified dataset where element concentrations > 3 SD above the mean were set to 3 SD above the mean. Symbols in black indicate that effects are statistically significant ($P < 0.05$), and in grey, that $P > 0.05$. Variables with no symbol were not retained in the best model subsets. Elementome variables are grouped by type: isotopes, macronutrients, micronutrients, trace elements and interactions.