

Supplementary Figures and Tables

Article title: Optimal coordination and reorganization of photosynthetic properties in C₄ grasses

Authors: Haoran Zhou, Erol Akçay, Brent Helliker

Fig. S1 Phylogenetic sampling of the species for measuring photosynthetic traits and the independent evolutionary lineages corresponding to grass lineages. Black represents C₃ species and red represents C₄ species.

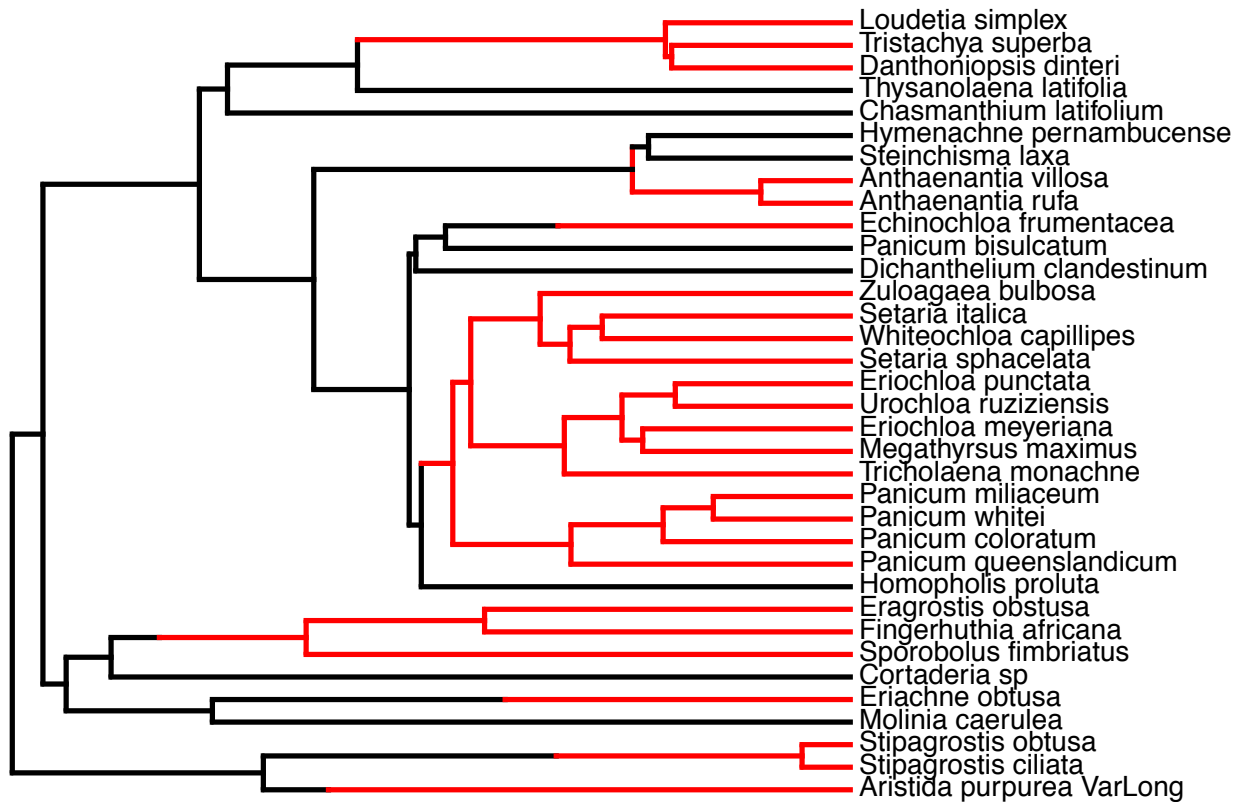


Fig. S2 Modeling results of assimilation rate with varying J_{\max}/V_{cmax} and $V_{\text{pmax}}/V_{\text{cmax}}$ for C_4 under different CO_2 concentration and $\psi_s=-1\text{MPa}$, $\text{VPD}=1.25$, temperature of $25\text{ }^\circ\text{C}$ and light intensity of $2000\text{ }\mu\text{mol m}^{-2}\text{ s}^{-1}$, the common grassland growth condition. Modeling results were obtained by controlling the other parameter at the in vitro measurement level.

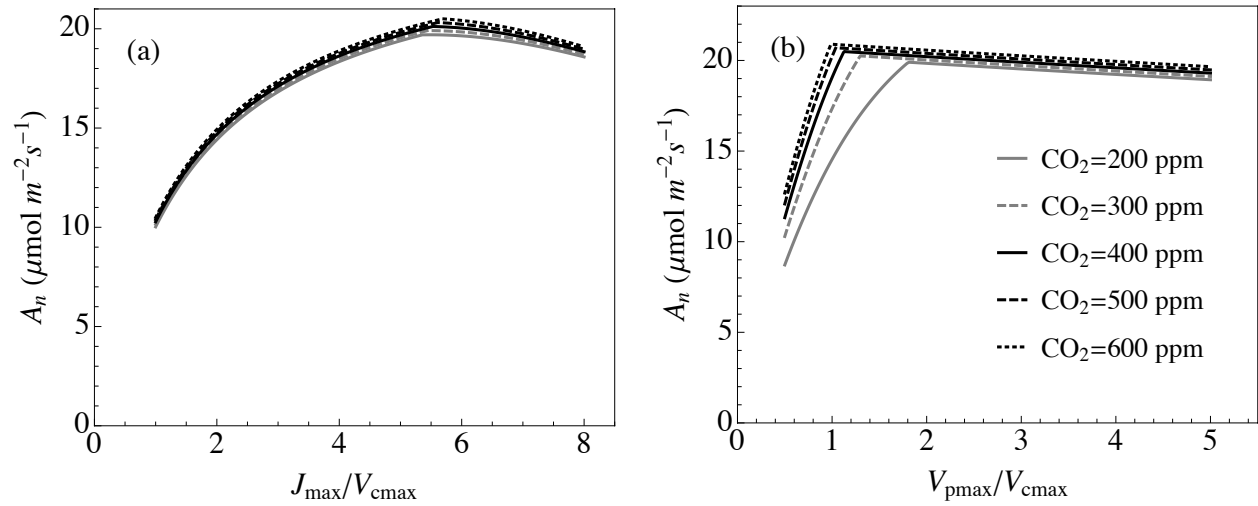


Fig. S3 Modeling results of optimal J_{\max}/V_{cmax} and $V_{\text{pmax}}/V_{\text{cmax}}$ for C_3 (black lines) and C_4 (red lines) under different environmental conditions. (a) Solid line: different CO_2 ; dashed line: different water limitation conditions (1: saturated water; 2: $\psi_s=-0.5$ MPa, $\text{VPD}=0.625$; 3: $\psi_s=-1$ MPa, $\text{VPD}=1.25$ MPa; 4: $\psi_s=-1.5$ MPa, $\text{VPD}=1.875$; 5: $\psi_s=-2$ MPa, $\text{VPD}=2.5$). (b) Solid line: different light intensities; dashed line: different temperature. Modeling results were obtained by controlling the other parameter at the in vitro measurement level.

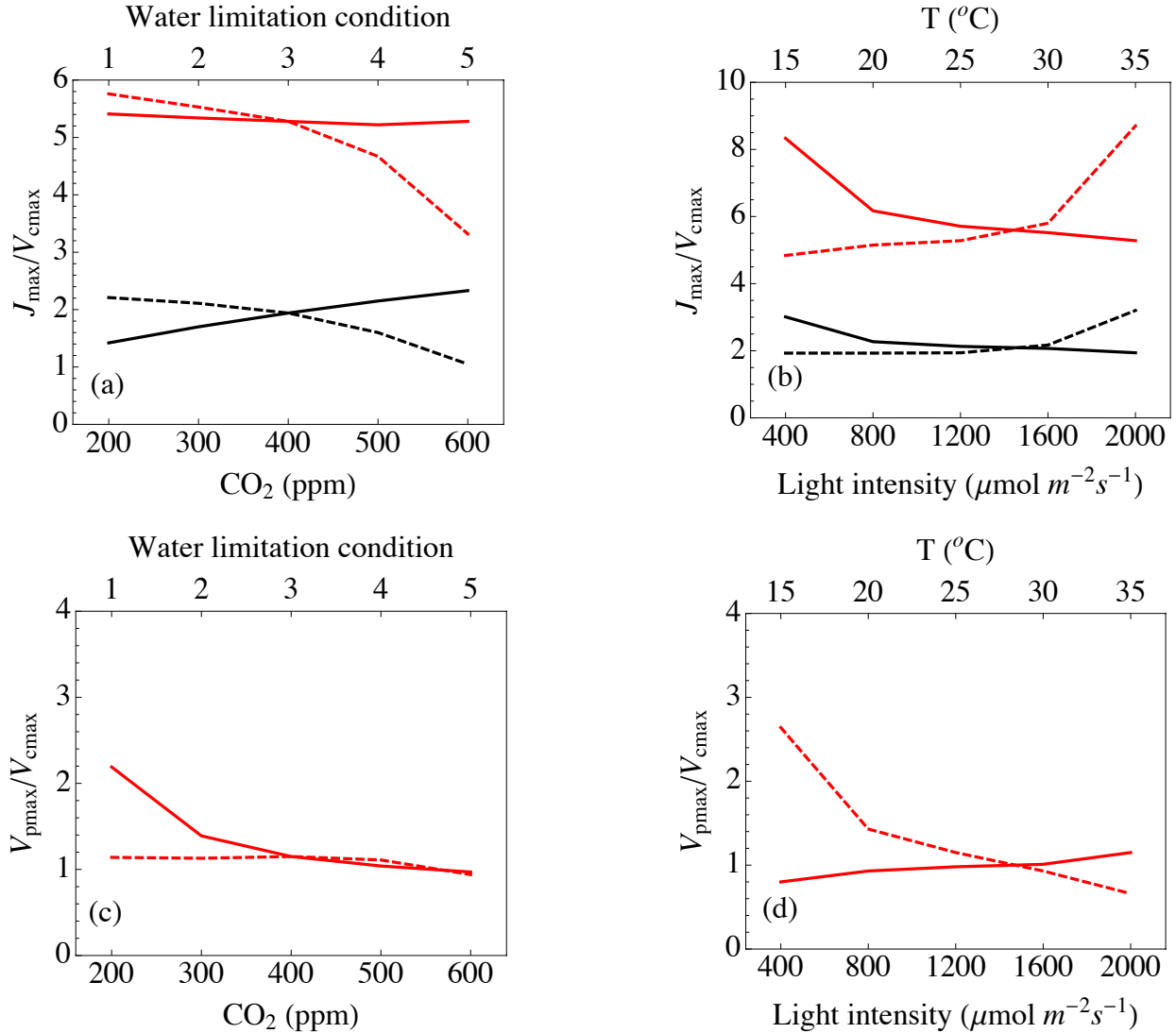


Fig. S4 Sensitivity analysis of total nitrogen and PEPC stoichiometry on optimal J_{\max}/V_{cmax} for C_3 (black dots) and J_{\max}/V_{cmax} (red dots) and $V_{\text{pmax}}/V_{\text{cmax}}$ (red diamonds) for C_4 .

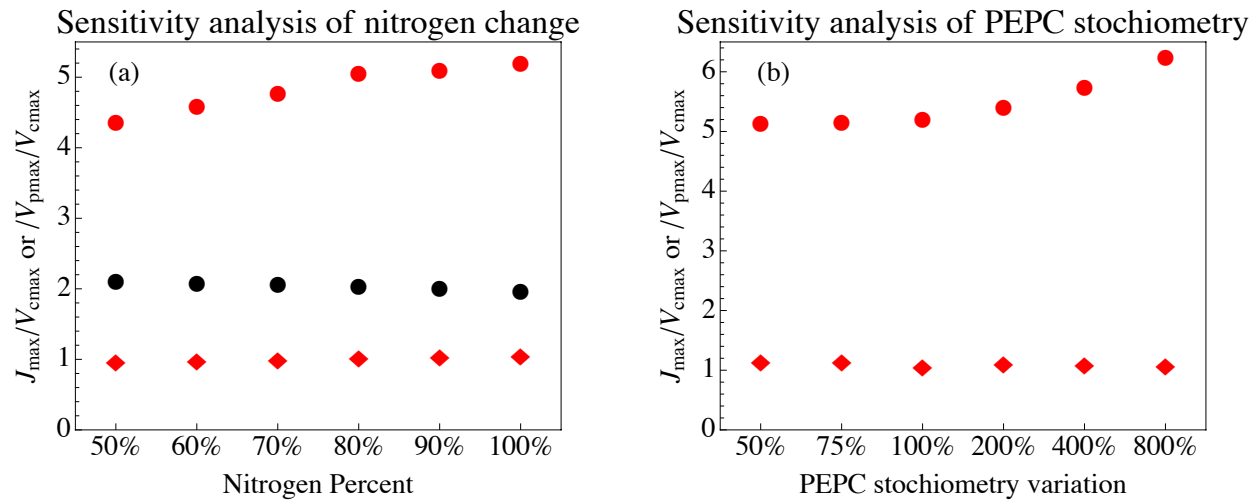


Table S1 The evolutionary models used for the phylogenetic analysis for photosynthetic properties evolutionary differences between C3 and C4 species.

Model	Evolution	Fluctuation rate	Root
Model 1	BM	One	One
Model 2	BM	Two	One
Model 3	BM	One	Two
Model 4	BM	Two	Two
Model 5	OU	One	One
Model 6	OU	One	Two

Table S2 Phylogenetic analysis results for Jmax/Vcmax for C3 and C4 species.

Model	AICw	AIC	AICc	Variance		Mean	
				C ₃	C ₄	C ₃	C ₄
Model 1	0.000	138.66	139.04	0.127		4.349	
Model 2	0.000	103.43	104.20	0.445	.003	5.520	
Model 3	0.000	140.01	140.78	0.124		4.028	4.469
Model 4	0.000	104.15	105.49	0.440	0.002	5.395	5.557
Model 5	0.000	142.80	143.57	0.188		4.375	
Model 6	1.000	16.41	17.75	0.0276		1.593	5.899

Table S3 Phylogenetic analysis results for Vcmax for C3 and C4 species.

Model	AICw	AIC	AICc	Variance		Mean	
				C ₃	C ₄	C ₃	C ₄
Model 1	0.000	306.21	306.58	14.801		32.133	
Model 2	0.167	273.40	274.17	49.056	0.916	24.216	
Model 3	0.000	308.60	308.37	14.536		35.451	30.893
Model 4	0.064	275.31	276.65	49.188	0.908	23.826	24.345
Model 5	0.000	310.22	311.00	32.372		32.725	
Model 6	0.769	270.34	271.67	127.883		59.524	20.782

Table S4 Phylogenetic analysis results for Jmax for C3 and C4 species.

Model	AICw	AIC	AICc	Variance		Mean	
				C ₃	C ₄	C ₃	C ₄
Model 1	0.201	338.96	339.33	33.249		110.379	

Model 2	0.074	340.95	341.73	33.985	32.687	110.690	
Model 3	0.079	340.82	341.59	33.145		107.932	111.346
Model 4	0.029	342.81	344.15	34.153	32.377	108.327	111.775
Model 5	0.032	342.61	343.38	66.102		111.266	
Model 6	0.583	336.83	338.16	83.786		88.935	132.164

Table S5 Phylogenetic analysis results for total chlorophyll for C3 and C4 species.

Model	AICw	AIC	AICc	Variance		Mean	
				C ₃	C ₄	C ₃	C ₄
Model 1	0.293	-58.9	-58.6	0.0003		0.364	
Model 2	0.251	-58.6	-57.8	0.0006	0.0003	0.366	
Model 3	0.285	-58.9	-58.1	0.0003		0.395	0.352
Model 4	0.152	-57.6	-56.3	0.0005	0.0003	0.389	0.357
Model 5	0.011	-52.3	-51.5	0.0012		0.365	
Model 6	0.009	-51.9	-50.5	0.0013		0.399	0.330

Table S6 Phylogenetic analysis results for ETR/J for C3 and C4 species.

Model	AICw	AIC	AICc	Variance		Mean	
				C ₃	C ₄	C ₃	C ₄
Model 1	0.000	-16.61	-16.23	0.001		0.825	
Model 2	0.000	-43.71	-42.94	0.005	8e-05	0.717	
Model 3	0.000	-14.94	-14.17	0.001		0.850	0.815
Model 4	0.000	-41.72	-40.38	0.005	8e-05	0.716	0.717
Model 5	0.000	-12.60	-11.82	0.003		0.817	
Model 6	1.000	-84.01	-82.68	0.004		1.082	0.643

Table S7 Phylogenetic analysis results for chlorophyll a/chlorophyll b for C3 and C4 species.

Model	AICw	AIC	AICc	Variance		Mean	
				C ₃	C ₄	C ₃	C ₄
Model 1	0.000	44.3	44.7	0.008		4.004	
Model 2	0.002	40.8	41.6	0.018	0.003	4.178	
Model 3	0.000	43.6	44.4	0.008		3.842	4.066
Model 4	0.003	40.1	41.5	0.018	0.003	4.054	4.224
Model 5	0.000	49.5	50.3	0.012		3.972	
Model 6	0.995	28.3	29.7	0.008		3.401	4.611

Table S8 Phylogenetic analysis results for ETR for C3 and C4 species.

Model	AICw	AIC	AICc	Variance		Mean	
				C ₃	C ₄	C ₃	C ₄
Model 1	0.397	333.6	334.0	30.844		88.941	
Model 2	0.165	335.4	336.1	37.380	27.334	89.019	
Model 3	0.148	335.6	336.4	30.798		87.900	89.327
Model 4	0.063	337.3	338.6	38.118	26.881	87.284	89.643
Model 5	0.137	335.7	336.5	85.615		87.068	
Model 6	0.091	336.5	337.9	75.383		95.639	78.986

Table S9 Phylogenetic analysis results of evolutionary model fitting for Vpmax for C4 species.

Model	AICw	AIC	AICc	Variance		Mean	
				C ₃	C ₄	C ₃	C ₄
Model 1	0.146	213.05	213.57	7.585		41.583	
Model 4	0.854	209.53	210.62	43.126		41.520	

Table S10 Phylogenetic analysis results of evolutionary model fitting for Vpmax/Vcmax for C4, C3.

Model	AICw	AIC	AICc	Variance		Mean	
				C ₃	C ₄	C ₃	C ₄
Model 1	0.125	6.813	7.333	0.003		1.908	
Model 4	0.875	2.913	4.004	0.015		1.966	

Table S11 Phylogenetic analysis results for Nitrogen for C3 and C4 species.

Model	AICw	AIC	AICc	Variance		Mean	
				C ₃	C ₄	C ₃	C ₄
Model 1	0.184	74.82	75.20	0.013		3.029	
Model 2	0.075	76.61	77.41	0.016	0.016	2.981	
Model 3	0.088	76.29	77.09	0.013		2.907	3.082
Model 4	0.053	77.33	78.71	0.021	0.008	2.712	3.011
Model 5	0.037	78.01	78.81	0.029		3.120	
Model 6	0.562	72.59	73.97	0.021		3.624	2.530