

The effects of light and temperature on microalgal growth and nutrients removal: an experimental and mathematical approach

Electronic Supplementary Information (ESI)

Table S1. Values of temperature, average daily light irradiance and specific growth rate used to determine optimal light and temperature conditions for *C. vulgaris*, *P. subcapitata*, *S. salina* and *M. aeruginosa* cultivation through mathematical modelling

T (°C)	I ($\mu\text{E m}^{-2} \text{s}^{-1}$)	μ (d^{-1})				Reference
		<i>C. vulgaris</i>	<i>P. subcapitata</i>	<i>S. salina</i>	<i>M. aeruginosa</i>	
15	15	0.142	0.099	0.126	0.203	p.s.
	36	0.328	0.256	0.119	0.160	p.s.
	75	0.170	0.246	0.133	0.294	p.s.
	180	0.357	0.601	0.438	0.486	p.s.
25	15	0.267	0.230	0.214	0.296	p.s.
	15		0.201			1
	21	0.544				1
	21	0.456	0.370	0.327	0.401	p.s.
	25	0.400	0.441	0.430	0.415	2
	30	0.387	0.324			1
	35	0.875	0.775	0.700	0.702	2
	36	0.425				1
	36	0.704	0.321			p.s.
	40	0.367	0.324			1
	42		0.465			1
	50	0.479				3
	50	0.495	0.487	0.344	0.435	2
	53	0.469	0.354			1
	56	0.659	0.635			1
	60	0.868	0.976	0.932	0.810	2
	70	0.751	0.672	0.729	0.653	2
	72		0.417			1
	74	0.485	0.543			1
	75	0.528		0.517	0.521	p.s.
	96	0.738				1
	105	1.111	0.990			p.s.
	120			1.131	1.025	2
	126		0.421			1
	138	1.301				4
	180		1.135	1.141	1.014	p.s.
	193	1.097				4
35	15	0.067	0.019	0.140	0.185	p.s.
	36	0.193	0.062	0.308	0.332	p.s.
	75	0.424	0.577	0.392	0.307	p.s.
	180	0.745	0.572	0.596	0.528	p.s.

T – temperature; I – average daily light irradiance; p.s. – present study.

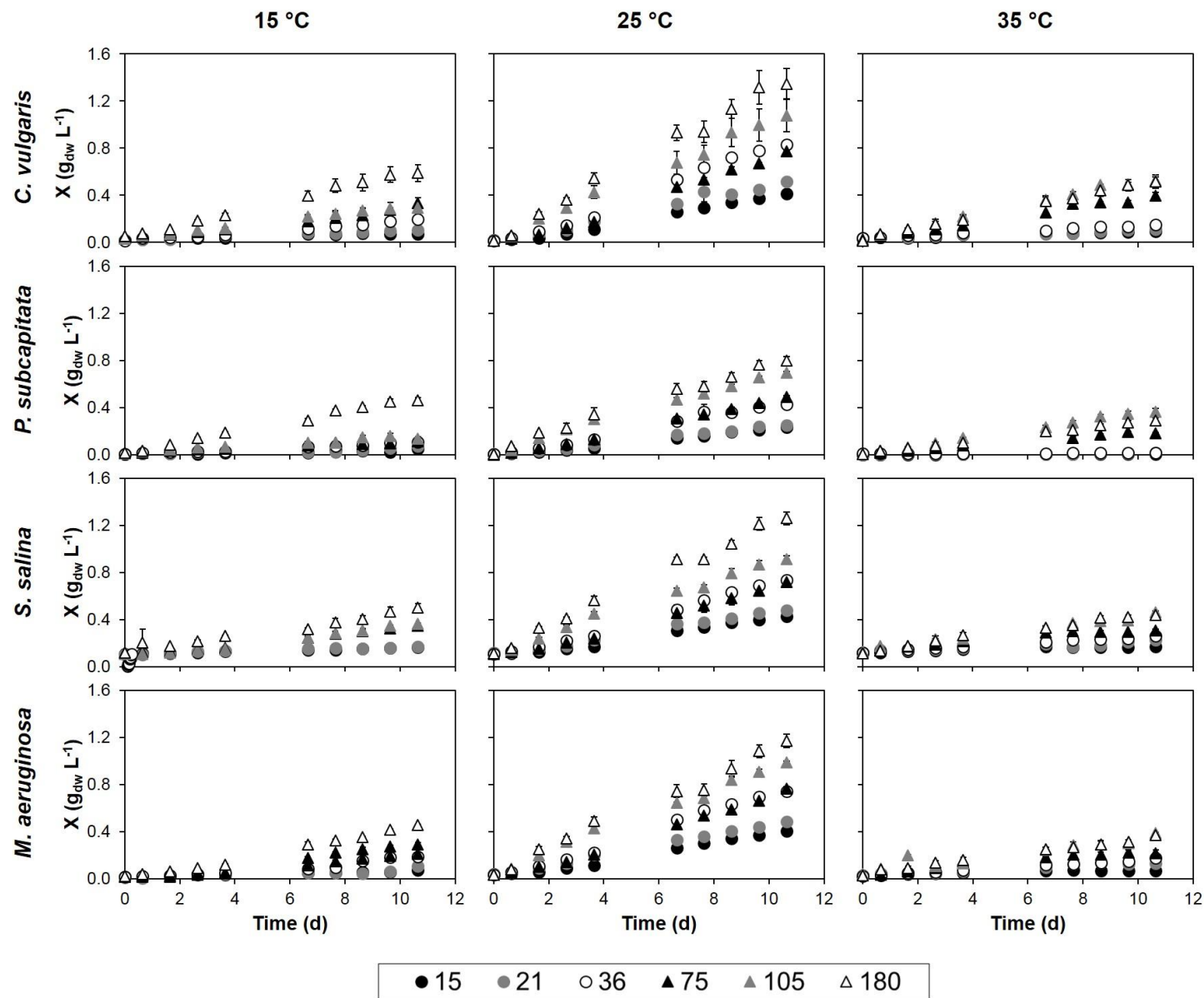


Fig. S1. Growth curves obtained for *C. vulgaris*, *P. subcapitata*, *S. salina* and *M. aeruginosa* under different light (average daily light irradiances, in μE m⁻² s⁻¹) and temperature conditions. Error bars correspond to the standard deviation of two independent experiments.

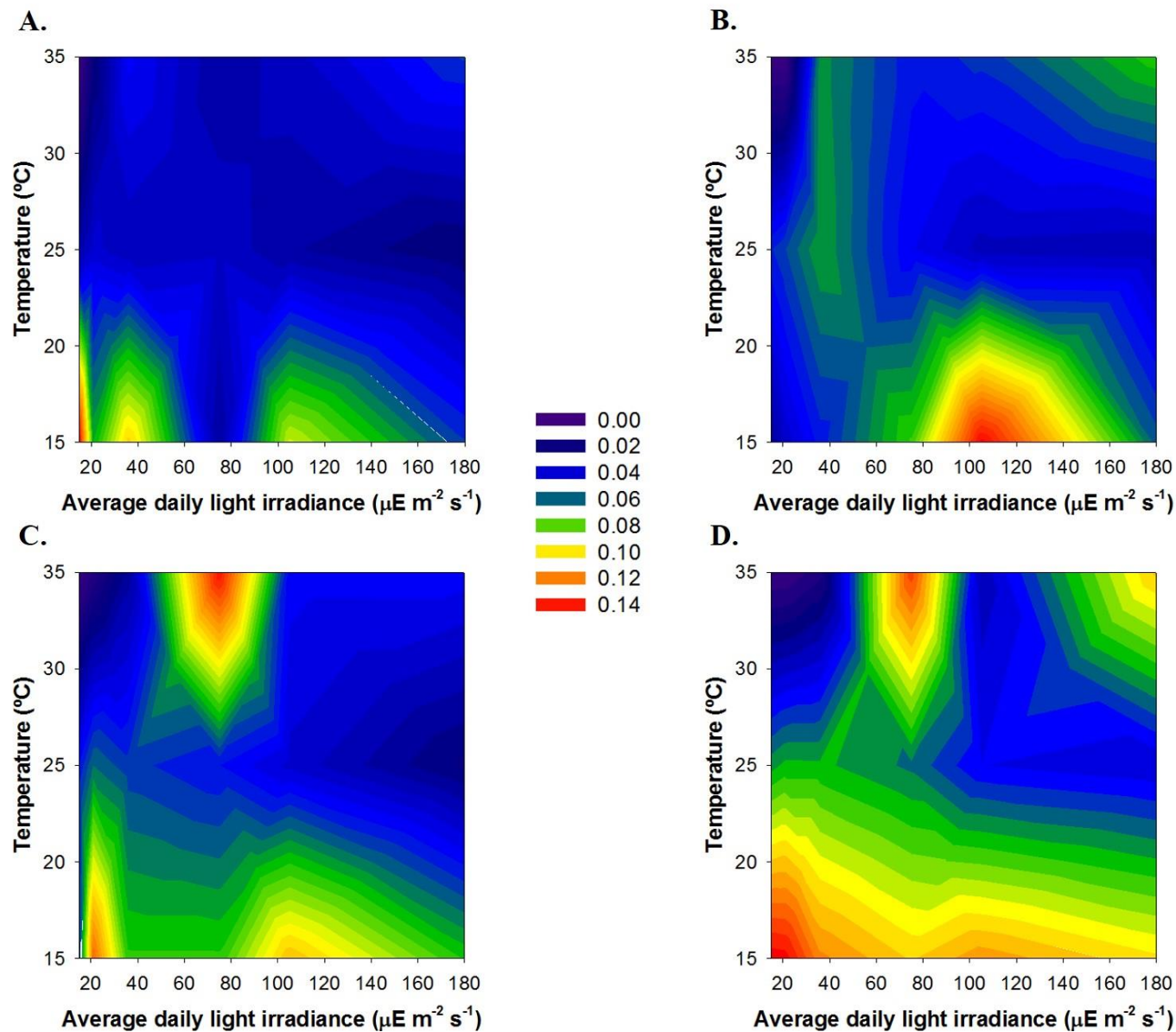


Fig. S2. Influence of average daily light irradiance and temperature on mass fractions of nitrogen (α_N , in $\text{g}_N \text{g}_{dw}^{-1}$) incorporated in the biomass of *C. vulgaris* (A), *P. subcapitata* (B), *S. salina* (C) and *M. aeruginosa* (D).

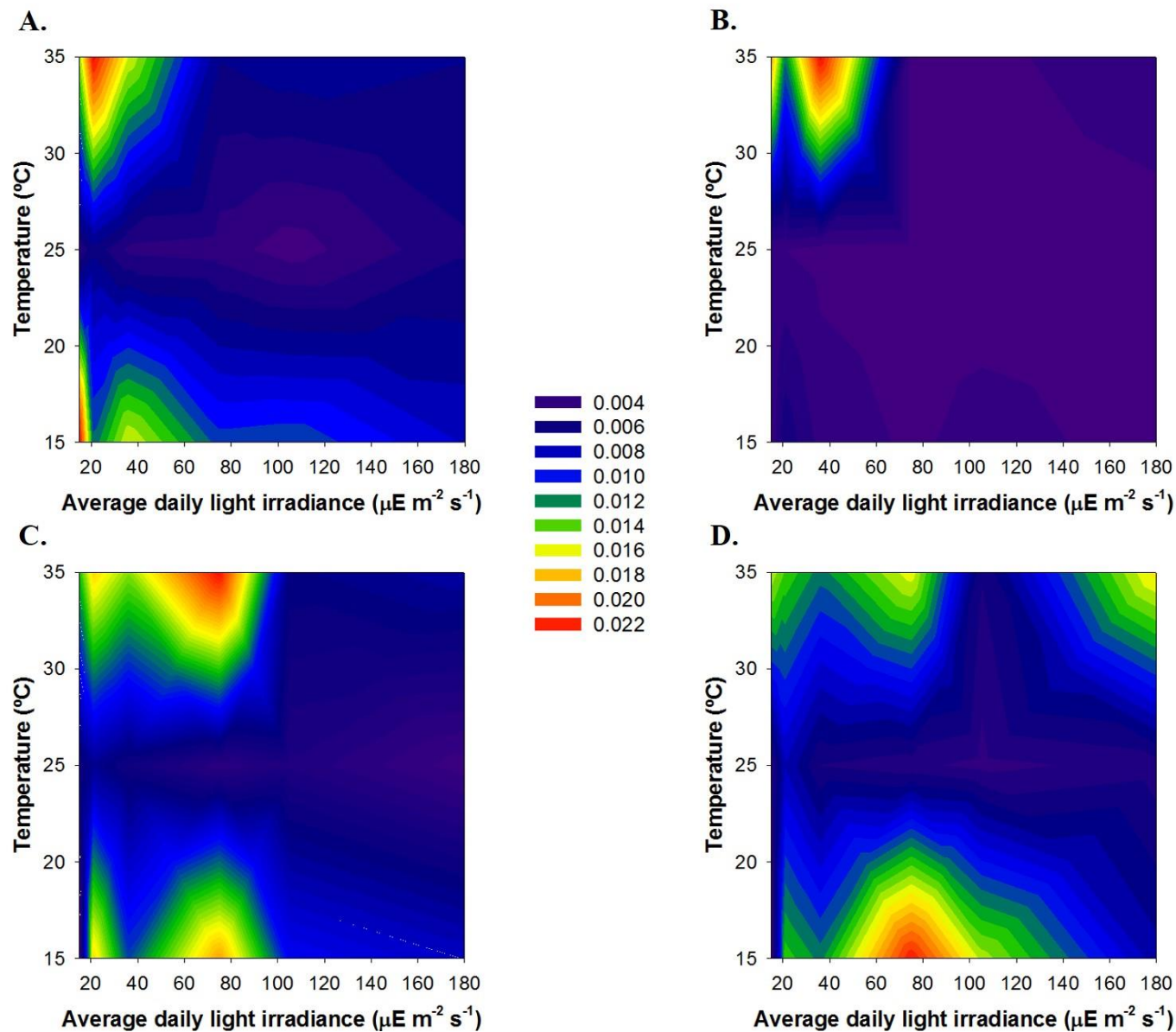


Fig. S3. Influence of average daily light irradiance and temperature on mass fractions of phosphorus (α_P , in $\text{g}_P \text{g}_{dw}^{-1}$) incorporated in the biomass of *C. vulgaris* (A), *P. subcapitata* (B), *S. salina* (C) and *M. aeruginosa* (D).

Multiple linear regression analysis

To evaluate the effect of each variable (average daily light irradiance and temperature) on nitrogen and phosphorus mass fractions, a multiple linear regression analysis was performed according to the model⁵:

$$y = \beta_0 + \sum_{i=1}^k \beta_i x_i + \sum_{i=1}^k \beta_{ii} x_i^2 + \sum_{1 \leq i \leq j}^k \beta_{ij} x_i x_j + \varepsilon \quad (\text{S1})$$

where y is the dependent variable k is the number of variables, β_0 is the constant term, β_i represents the coefficients of the linear parameters, x_i represents the variables, β_{ii} represents the coefficients of the quadratic parameter, β_{ij} represents the coefficients of the interaction parameters and ε is the residual associated to the experiments.

To transform each real value into coordinates with dimensionless values, real values were standardized according to Equation S2:

$$z_i = \left(\frac{x_i - \mu}{\sigma} \right) \quad (\text{S2})$$

where z_i is the standard variable, μ is the mean of x_i values and σ is the standard deviation.

The significance of the regression coefficients was evaluated through the calculation of their confidence interval. The parameter β_i is valid if:

$$|\beta_i| > \frac{t_{n-k-1}^{\alpha/2} \sigma}{\sqrt{S_{xx_i}}} \quad (\text{S3})$$

where t is the Student t distribution, n is the number of points, α is the significance level and S_{xx_i} is the sum of squares related to x_i given by $\sum_{j=1}^n (x_{ij} - \bar{x}_i)^2$.

Table S2 presents the β_i coefficients considered statistically significant to describe the behaviour of nitrogen and phosphorus mass fractions in response to different light and temperature conditions, according to the expression:

$$\alpha = \beta_0 + \beta_1 T + \beta_2 I + \beta_3 T^2 + \beta_4 I^2 + \beta_5 TI \quad (\text{S4})$$

where T is temperature and I is average daily light irradiance.

Table S2. Regression coefficients considered statistically significant determined through multiple linear regression to evaluate the response of nitrogen and phosphorus mass fractions to different light and temperature conditions

		β_0	β_1	β_2	β_3	β_4	β_5
α_N	<i>C. vulgaris</i>	0.0425	-0.0155	n.a.	n.a.	n.a.	n.a.
	<i>P. subcapitata</i>	0.0459	n.a.	n.a.	n.a.	n.a.	n.a.
	<i>S. salina</i>	0.0476	-0.0234	n.a.	n.a.	n.a.	n.a.
	<i>M. aeruginosa</i>	0.0490	-0.0378	-0.0405	n.a.	n.a.	0.0482
α_P	<i>C. vulgaris</i>	0.00991	-0.0361	n.a.	0.0371	n.a.	-0.00328
	<i>P. subcapitata</i>	0.00853	-0.00639	-0.00973	n.a.	n.a.	0.0111
	<i>S. salina</i>	0.00982	-0.0295	n.a.	0.0306	n.a.	n.a.
	<i>M. aeruginosa</i>	0.00978	-0.0365	n.a.	0.0371	n.a.	n.a.

n.a. – not applicable ($p > 0.05$).

Table S3. Values of temperature, average daily light irradiance and specific growth rate used to validate the models determined for *C. vulgaris*, *P. subcapitata*, *S. salina* and *M. aeruginosa* (validation data set)

T (°C)	I ($\mu\text{E m}^{-2} \text{s}^{-1}$)	μ (d^{-1})				Reference
		<i>C. vulgaris</i>	<i>P. subcapitata</i>	<i>S. salina</i>	<i>M. aeruginosa</i>	
15	21	0.131	0.245	0.311	0.375	p.s.
	105	0.313	0.453	0.165	0.275	p.s.
25	15	0.267				1
	21		0.516			1
	36		0.662			1
	36			0.620	0.560	p.s.
	42	0.428				1
	72	0.523				1
	75		0.668			p.s.
	96		0.496			1
	105			0.918	0.857	p.s.
	120	1.169	1.130			2
	180	1.190				p.s.
35	21	0.080	0.047	0.220	0.226	p.s.
	105	0.769	0.558	0.392	0.857	p.s.

T – temperature; I – average daily light irradiance; p.s. – present study.

References

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