Green microalgae in intermittent light: a meta-analysis assisted by machine learning Supplementary materials

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Microalgae | Light | Intermittent | Frequency | Machine learning
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Presentation

Please find the tables agglomerating the literature survey results when dissolved gas was used as monitoring protocol.

References

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Table 1. All data collected from studies conducted in medium frequency with the photosynthesis rate (P_{O_2}) as the output variable. The table lists the study microorganism, the experimental device used to adapt the culture and measure the P_{O_2}, the parameters of the L/D cycles as well as the experimental results with their coefficient of variation if known (N.A. if not available). The photosynthesis rate presented is weighted by the quantity of light. The reference to continuous light appears as CL. (a) Oxygen evolution rate in $gO_2/g/h$; (b) Oxygen evolution rate in $\mu molO_2/g/s$; (c) Oxygen evolution rate in $mgO_2/g/h$; (d) Oxygen evolution rate in $molO_2/g/s$ and (e) Normalized oxygen evolution rate: fraction of the oxygen evolution rate in flashing light on the continuous one.

Studied microalga	Subculturing	Monitoring device	I_{avg} (µmolE/m²/s)	τ_c (ms)	ε (-)	Weighted P_{O_2}	Experimental CV (%)	η (%)	References
Chlamydomonas reinhardtii CC 1690 wild type 21 gr mt +	PBR design: rectangular PBR (70 mL working volume)	Oxygen monitor set-up: small cylindrical stirred vial	650	CL	1	0.943	<10 %	-	(1) [a]
	Optical light path: 3 cm	Light source: halogen lamp	325	6.1	0.5	1.284	<10 %	36	
	Light source: halogen lamp	Protocol: 10 min of dark adaptation, then the sample is exposed for 20 min to increasing light intensities	325	14.5	0.5	1.270	<10 %	35	
	Illumination protocol: culture illuminated with a 16/8 h day-night cycle. During the 16 h period, the cells are exposed to different L/D cycles		325	24.3	0.5	1.322	<10 %	40	
	Cultivation mode: turbidostat (0.17 <OD680nm <0.25)		520	15.2	0.8	1.078	<10 %	14	
Chlamydomonas reinhardtii CC-124 wild type mt-137c	PBR design: flat PBR (375 mL working volume)	Oxygen monitor set-up: consists of 3 chambers (2 water jackets and 1 measurement chamber at the middle)	58	CL	1	0.31	10 %	-	(2) [b]
	Optical light path: 25 mm	Optical light path: 15 mm	58	0.2	0.05	0.22	<10 %	-29	
	Light source: red LEDs (630 nm)	Light source: red LEDs (620 nm)	113	CL	1	0.67	<10 %	-	
	Cultivation mode: turbidostat (set point: 60% of the maximal flux without algae)	Protocol: sample taken from the flat PBR during steady-state operation	113	0.2	0.1	0.46	<10 %	-31	
			227	CL	1	1.24	<10 %	-	
			227	0.2	0.2	0.82	<10 %	-34	
			559	CL	1	1.80	<10 %	-	
			559	0.2	0.5	1.55	<10 %	-14	
Chlamydomonas reinhardtii wild type strain coded 21 gr	PBR design: glass air-lift loop PBR (0.6 L working volume)	Oxygen monitor set-up: small reaction vessel in a closed cabinet	240	CL	1	248	N.A.	-	(3) [c]
	Light source: fluorescent light tubes		158	12.9	0.66	322	N.A.	30	
	Illumination protocol: PBR placed in a closed cabinet. The dark period obtained with a part of the PBR covered with aluminum foil	Light source: halogen lamp	158.4	CL	1	196	N.A.	-	
			158.4	12.9	0.66	321	N.A.	8	
	Cultivation mode: turbidostat (set point: 70% of the maximal flux without algae)		198	CL	1	225	N.A.	-	
			198	12.9	0.66	355	N.A.	4	

			396	CL	1	286	N.A.	-	
			396	12.9	0.66	405	N.A.	-7	
			594	CL	1	295	N.A.	-	
			594	12.9	0.66	409	N.A.	-9	
Scenedesmus almeriensis CCAP 276/24	PBR design: bubble column PBR (1.8 L working volume) Optical light path: 8 cm Light source: fluorescent light tubes Cultivation mode: semi-continuous (C=1.8 g/L)	Oxygen monitor set-up: transparent glass tank Optical light path: 1 cm Light source: white LEDs Protocol: cell concentration of 0.1 g/L	63	CL	1	4.617E-07	N.A.	-	(4) [d]
			63	10	0.05	2.142E-06	N.A.	-77	
			63	1	0.05	6.290E-06	N.A.	-32	
			67.8	CL	1	4.963E-07	N.A.	-	
			67.8	10	0.1	2.052E-06	N.A.	-59	
			101.05	CL	1	7.324E-07	N.A.	-	
			101.05	1	0.05	7.150E-06	N.A.	-51	
			101.05	1	0.05	6.242E-06	N.A.	-57	
			126	CL	1	9.048E-07	N.A.	-	
			126	10	0.1	1.782E-06	N.A.	-80	
			126	1	0.1	3.082E-06	N.A.	-66	
			135.6	CL	1	9.697E-07	N.A.	-	
			135.6	10	0.2	1.723E-06	N.A.	-65	
			135.6	1	0.2	3.435E-06	N.A.	-29	
			202.1	CL	1	1.386E-06	N.A.	-	
			202.1	10	0.1	2.262E-06	N.A.	-84	
			202.1	1	0.1	4.675E-06	N.A.	-66	
			252	CL	1	1.640E-06	N.A.	-	
			252	10	0.2	1.801E-06	N.A.	-78	
			252	1	0.2	4.014E-06	N.A.	-51	
			339	CL	1	1.911E-06	N.A.	-	
			339	10	0.5	1.996E-06	N.A.	-48	
			339	1	0.5	2.560E-06	N.A.	-33	
			404.2	CL	1	2.007E-06	N.A.	-	
			404.2	10	0.2	2.154E-06	N.A.	-79	
			404.2	10	0.2	1.455E-06	N.A.	-86	
			404.2	1	0.2	3.590E-06	N.A.	-64	
			630	CL	1	2.119E-06	N.A.	-	
			630	10	0.5	1.721E-06	N.A.	-59	
			630	1	0.5	2.640E-06	N.A.	-38	

			1010.5	CL	1	2.161E-06	N.A.	-	
			1010.5	10	0.5	2.184E-06	N.A.	-50	
	PBR design: bubble column PBR (2 L working volume)	Oxygen monitor set-up: flat panel PBR	1000	1.000	0.10	-0.0162	N.A.	-102	
	Light source: LEDs	Optical light path: 2 cm	1000	0.500	0.10	-0.0708	N.A.	-107	
	Illumination protocol: PBR placed in a climate chamber	Light source: LEDs	1000	0.333	0.10	0.0343	N.A.	-97	
			1000	0.250	0.10	0.0721	N.A.	-93	
			1000	0.200	0.10	0.1088	N.A.	-89	
			1000	0.167	0.10	0.1112	N.A.	-89	
			1000	0.143	0.10	0.1237	N.A.	-88	
			1000	0.125	0.10	0.1832	N.A.	-82	
			1000	0.111	0.10	0.1729	N.A.	-83	
			500	0.250	0.03	0.0009	N.A.	-100	
			500	0.200	0.03	-0.0800	N.A.	-108	
Tetraselmis chui SAG 19.52			500	0.167	0.03	-0.0683	N.A.	-107	(5) [e]
			500	0.143	0.03	-0.0658	N.A.	-107	
		Protocol: after one day of acclimation in the bubble column PBR, measurement for 10 to 20 min	500	0.125	0.03	-0.0462	N.A.	-105	
	Cultivation mode: continuous (C =0.13 g/L)		500	0.111	0.03	-0.0785	N.A.	-108	
			500	1.000	0.10	-0.0676	N.A.	-107	
			500	0.500	0.10	0.0000	N.A.	-100	
			500	0.333	0.10	0.0374	N.A.	-96	
			500	0.250	0.10	0.0588	N.A.	-94	
			500	0.200	0.10	0.0959	N.A.	-90	
			500	0.167	0.10	0.1105	N.A.	-89	
			500	0.143	0.10	0.1412	N.A.	-86	
			500	0.125	0.10	0.2081	N.A.	-79	
			500	0.111	0.10	0.2098	N.A.	-79	
			1000	1.000	0.100	-0.01622	N.A.	-102	
			1000	0.500	0.100	-0.07083	N.A.	-107	
			1000	0.333	0.100	0.03433	N.A.	-97	
			1000	0.250	0.100	0.07215	N.A.	-93	
			1000	0.200	0.100	0.10883	N.A.	-89	
			1000	0.167	0.100	0.11122	N.A.	-89	
			1000	0.143	0.100	0.12367	N.A.	-88	
			1000	0.125	0.100	0.18320	N.A.	-82	

1000	0.111	0.100	0.17290	N.A.	-83
500	0.250	0.030	0.00090	N.A.	-100
500	0.200	0.030	-0.08004	N.A.	-108
500	0.167	0.030	-0.06830	N.A.	-107
500	0.143	0.030	-0.06577	N.A.	-107
500	0.125	0.030	-0.04620	N.A.	-105
500	0.111	0.030	-0.07853	N.A.	-108

Table 2. All data collected from studies conducted in high frequency with the photosynthesis rate (P_{O_2}) as the output variable. For reasons of readability, the results obtained in the study of Schulze et al. (5) are not presented in this table. The table lists the study microorganism, the experimental device used to adapt the culture and measure the P_{O_2}, the parameters of the L/D cycles as well as the experimental results with their coefficient of variation if known (N.A. if not available). The photosynthesis rate presented is weighted by the quantity of light. The reference to continuous light appears as CL. (a) Oxygen evolution rate in $\mu molO_2/g/s$; (b) Oxygen evolution rate in $\mu MO_2/mM(Chl)/s$ and (c) Oxygen evolution rate in $molO_2/g/s$.

Studied microalga	Subculturing	Monitoring device	I_{avg} (µmolE/m²/s)	Frequency (Hz)	ε (-)	Weighted P_{O_2}	Experimental CV (%)	η (%)	References
Chlamydomonas reinhardtii CC-124 wild type mt-137c	PBR design: flat PBR (375 mL working volume)	Oxygen monitor set-up: consists of 3 chambers (2 water jackets and 1 measurement chamber at the middle)	58	CL	1	0.31	10	-	(2) [a]
	Optical light path: 25 mm	Optical light path: 15 mm	58	10	0.05	0.27	<10 %	-13	
	Light source: red LEDs (630 nm)	Light source: red LEDs (620 nm)	67	CL	1	0.37	<10 %	-	
			67	50	0.05	0.37	<10 %	0	
			114	CL	1	0.68	<10 %	-	
			114	10	0.1	0.55	<10 %	-19	
			118	CL	1	0.70	<10 %	-	
			118	50	0.1	0.70	<10 %	0	
	Cultivation mode: turbidostat (set point: 60% of the maximal flux without algae)	Protocol: sample taken from the flat PBR during steady-state operation	132	CL	1	0.78	<10 %	-	
			132	100	0.1	0.80	<10 %	3	
			227	CL	1	1.24	<10 %	-	
			227	10	0.2	0.87	<10 %	-30	
			232	CL	1	1.26	<10 %	-	
			232	50	0.2	1.02	<10 %	-19	
			238	CL	1	1.28	<10 %	-	
			238	100	0.2	1.36	<10 %	6	
			559	CL	1	1.80	<10 %	-	
			559	10	0.5	1.45	<10 %	-19	
			557	CL	1	1.79	<10 %	-	
			557	50	0.5	1.59	<10 %	-11	
			561	CL	1	1.80	<10 %	-	
			561	100	0.5	1.66	<10 %	-8	
Chlorella vulgaris	PBR design: column PBR (30 mL working volume)	Oxygen monitor set-up: 2 mL cuvette	500	CL	1	49	N.A.	-	(6) [b]
	Optical light path: 1.8 cm		500	5000	0.5	49	N.A.	0	
	Light source: red LEDs (654 nm)		500	1000	0.5	49	N.A.	0	
		Light source: LEDs	500	500	0.5	49	N.A.	0	
	Cultivation mode: batch (culture diluted <20 µM chl a)								

			500	100	0.5	48	N.A.	-2	
			500	50	0.5	45	N.A.	-8	
			500	10	0.5	38	N.A.	-22	
			500	2000	0.2	49	N.A.	0	
			500	400	0.2	49	N.A.	0	
			500	200	0.2	45	N.A.	-8	
			500	40	0.2	34	N.A.	-31	
			500	20	0.2	19	N.A.	-61	
Scenedesmus almeriensis CCAP 276/24	PBR design: bubble column PBR (1.8 L working volume)	Oxygen monitor set-up: transparent glass tank	63	CL	1	4.617E-07	N.A.	-	(4) [c]
	Optical light path: 8 cm	Optical light path: 1 cm	63	10	0.05	5.467E-07	N.A.	18	
	Light source: fluorescent light tubes	Light source: white LEDs	63	50	0.05	6.431E-07	N.A.	39	
			67.8	CL	1	4.963E-07	N.A.	-	
			67.8	10	0.1	6.227E-07	N.A.	26	
			67.8	20	0.1	6.788E-07	N.A.	37	
			67.8	50	0.1	7.197E-07	N.A.	45	
			101.05	CL	1	7.356E-07	N.A.	-	
			101.05	10	0.05	5.130E-07	N.A.	-30	
			101.05	50	0.05	8.844E-07	N.A.	20	
	Cultivation mode: semi-continuous (C=1.8 g/L)	Protocol: cell concentration of 0.1 g/L	126	CL	1	9.048E-07	N.A.	-	
			126	20	0.1	9.572E-07	N.A.	6	
			135.6	CL	1	9.697E-07	N.A.	-	
			135.6	10	0.2	9.904E-07	N.A.	2	
			135.6	50	0.2	1.265E-06	N.A.	31	
			202.1	CL	1	1.386E-06	N.A.	-	
			202.1	10	0.1	2.220E-06	N.A.	60	
			202.1	50	0.1	1.487E-06	N.A.	7	
			252	CL	1	1.640E-06	N.A.	-	
			252	10	0.2	1.376E-06	N.A.	-16	
			252	50	0.2	1.679E-06	N.A.	2	
			339	CL	1	1.911E-06	N.A.	-	
			339	10	0.5	1.422E-06	N.A.	-26	
			339	50	0.5	1.796E-06	N.A.	-6	
			404.2	CL	1	2.007E-06	N.A.	-	

404.2	10	0.2	1.263E-06	N.A.	-37
404.2	20	0.2	1.355E-06	N.A.	-33
630	CL	1	2.119E-06	N.A.	-
630	10	0.5	2.091E-06	N.A.	-1