Photosynthetic adaptations during cultivation of *Scenedesmus* in open thin-layer cascade system in Liège

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The ‘penthouse’ culture system in the University of Liège, Belgium

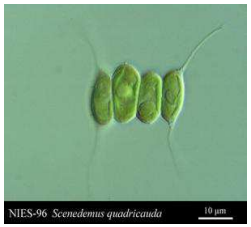
Founded in the 70’s by Prof. C. Sironval
Renovated in 2009
3 modules of 37 m^2 (3 to 5 m^3) operated in semi-continous mode each year between april and october

Prof. C. Sironval

Thin-layer cascade in the Institute of Microbiology, Trebon, Czech Republic

The tanks

CO_2 injection

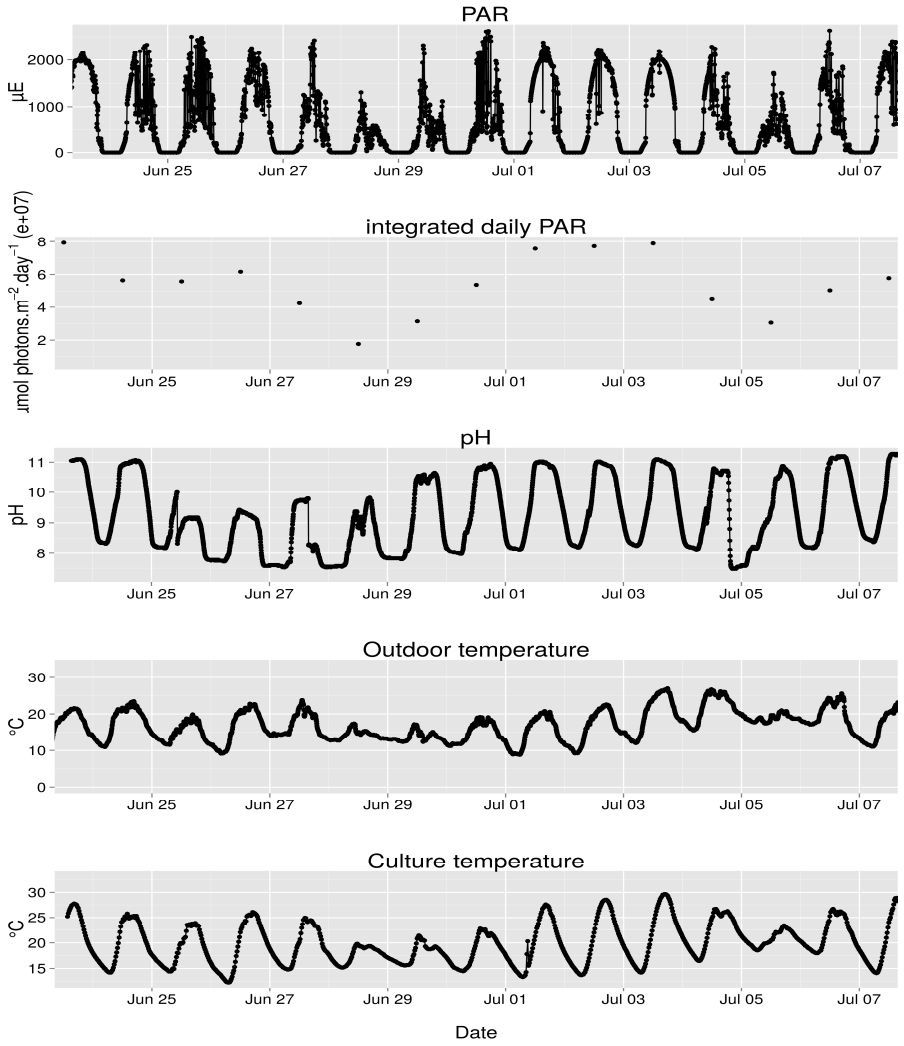


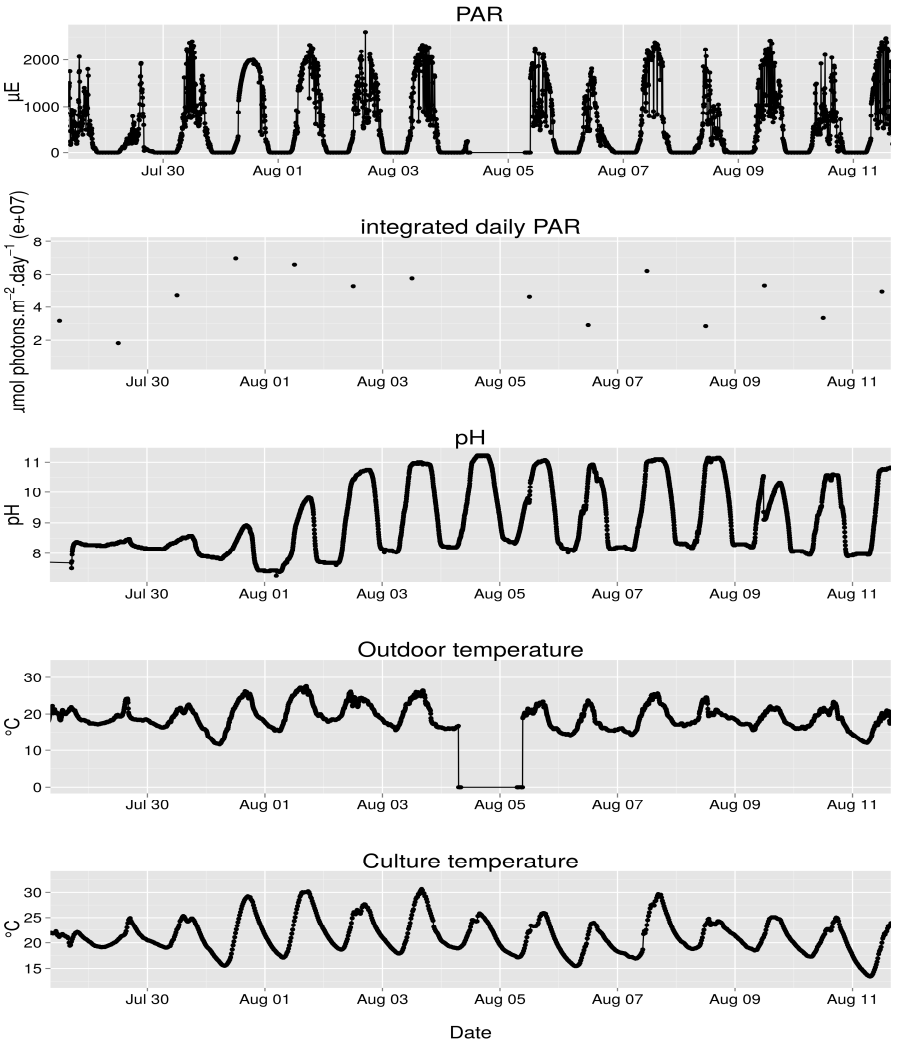
Scenedesmus obliquus
SAG 276-10

The centrifuge

Wet biomass

Recorded parameters

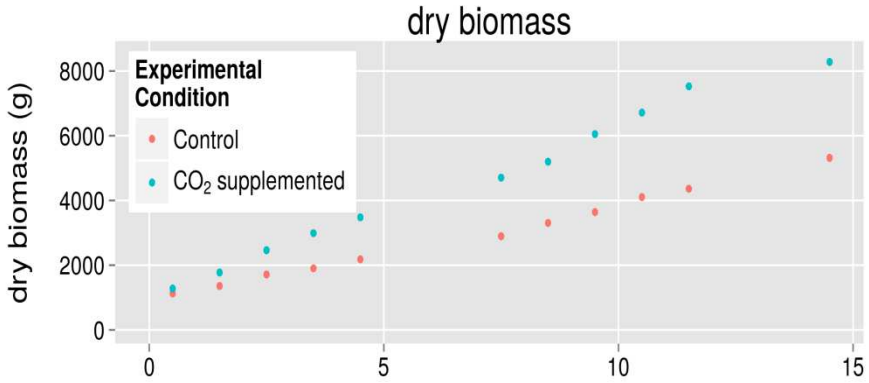


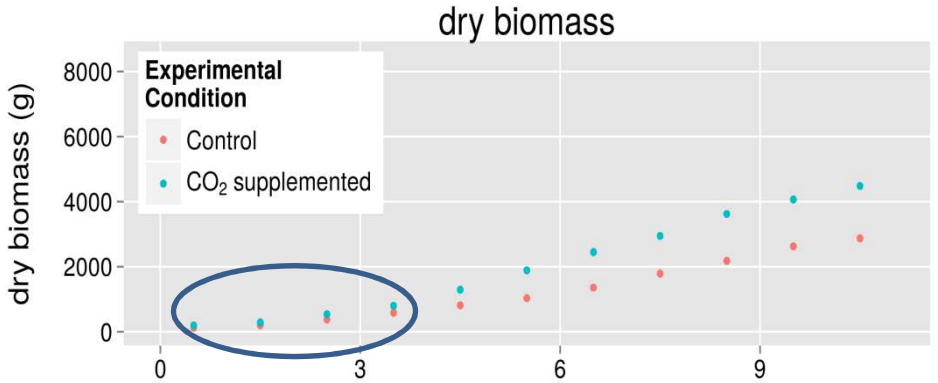


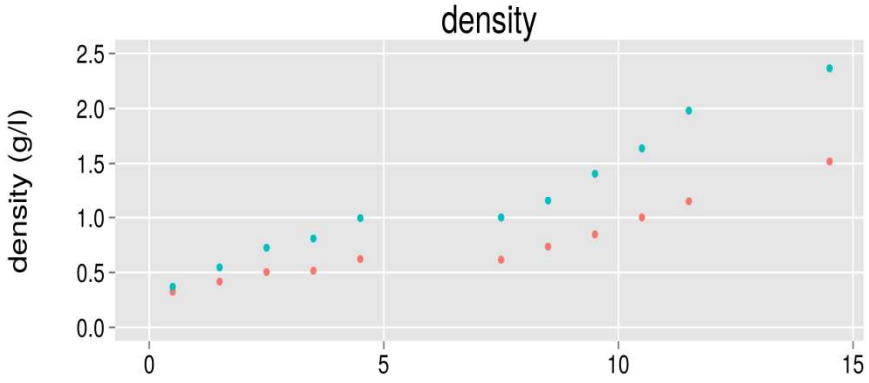
Measured parameters

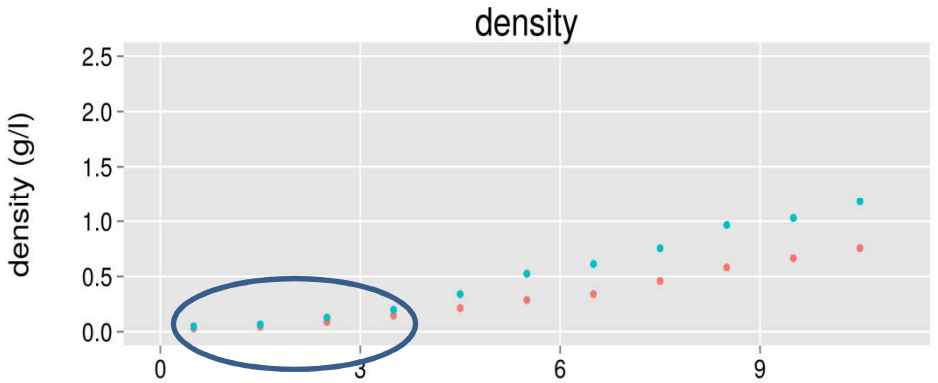
Biomass density, total volume, nutrient status (nitrate, phosphate)

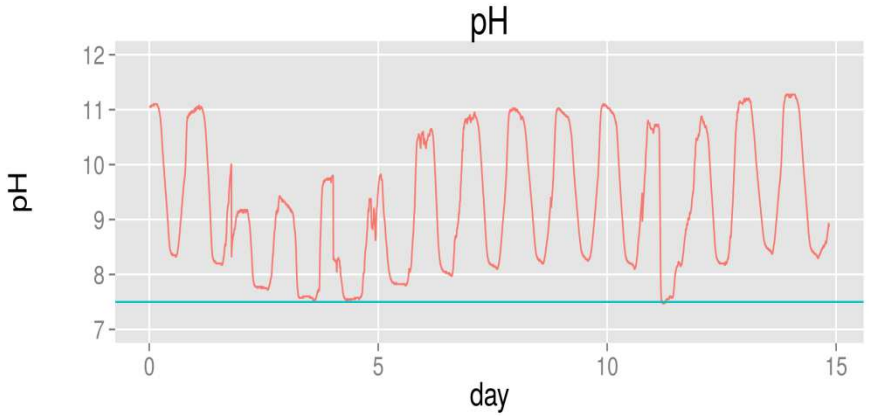
Biomass and pH variations

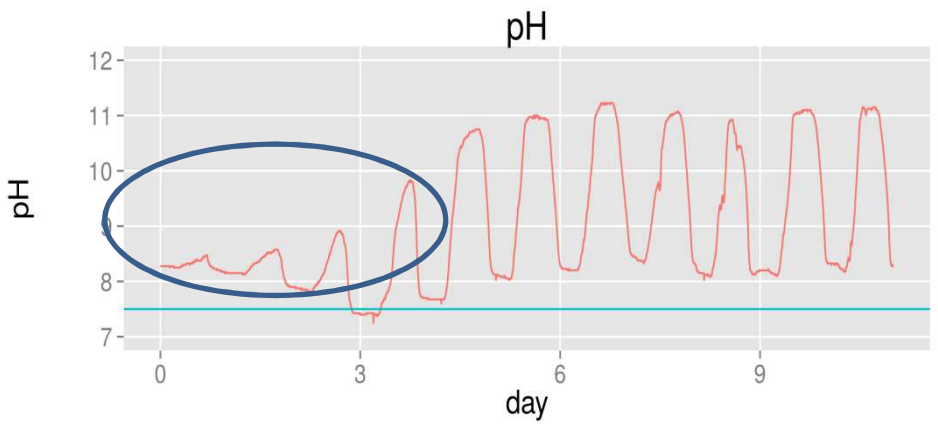




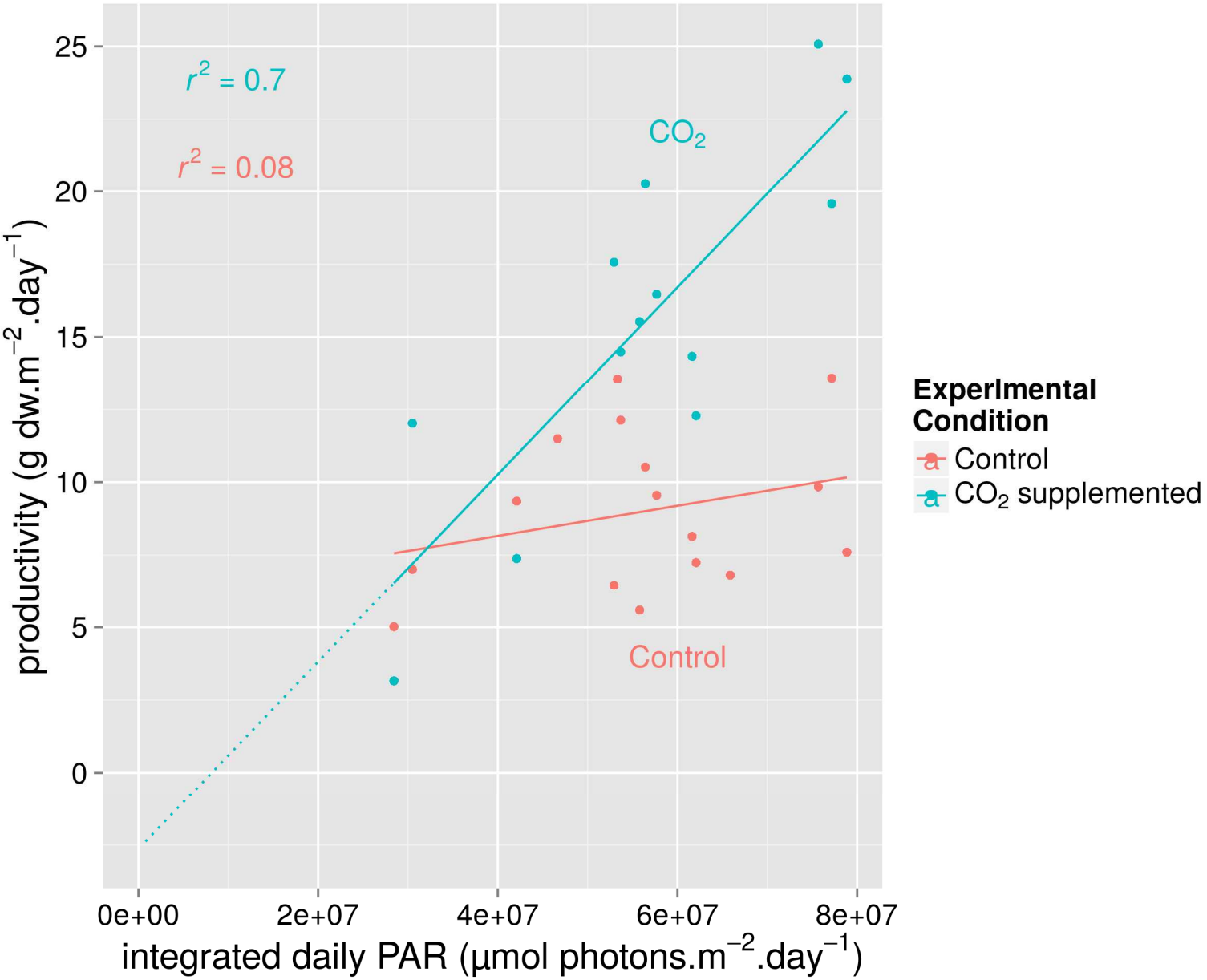


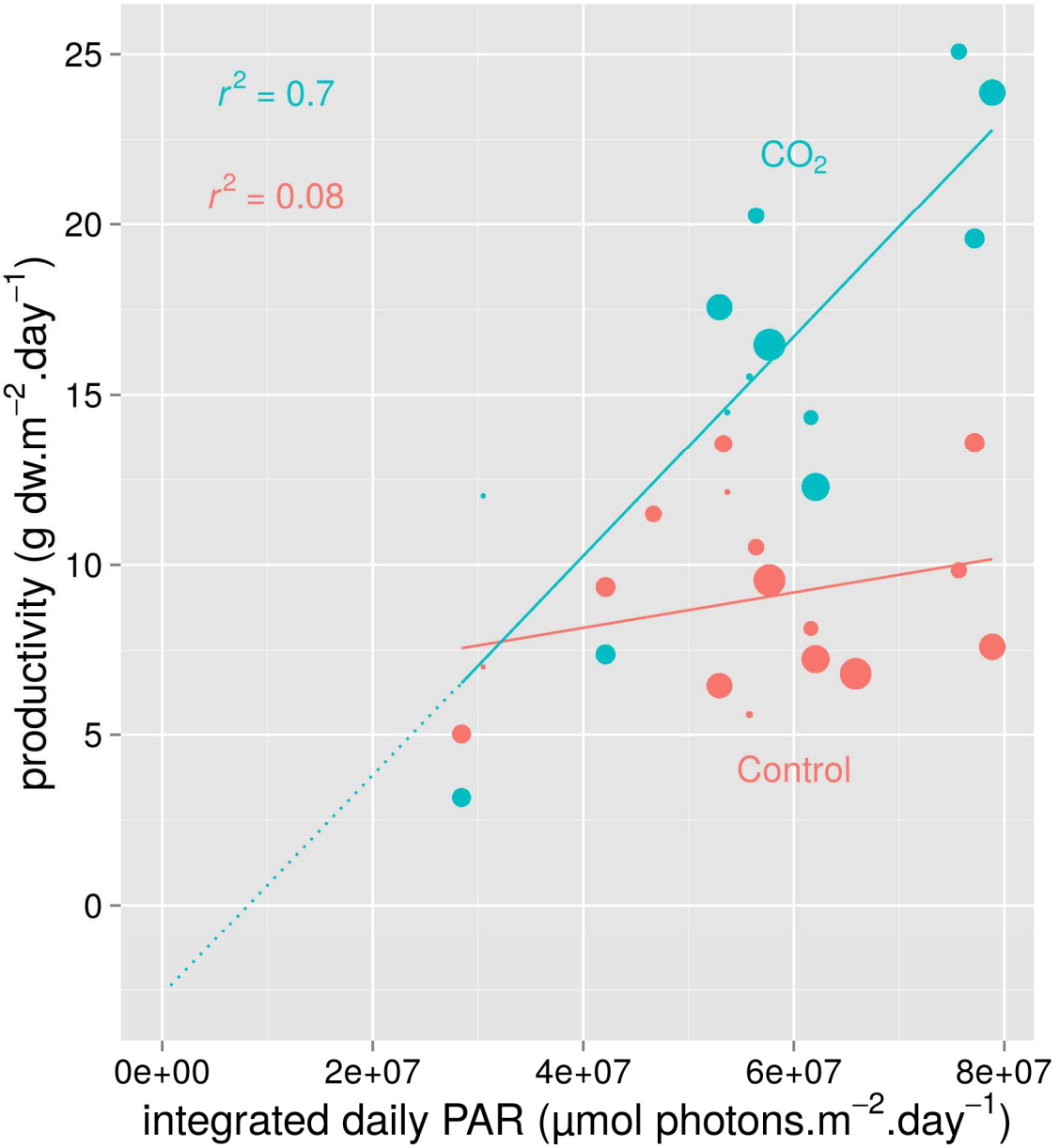






Productivity and light availability





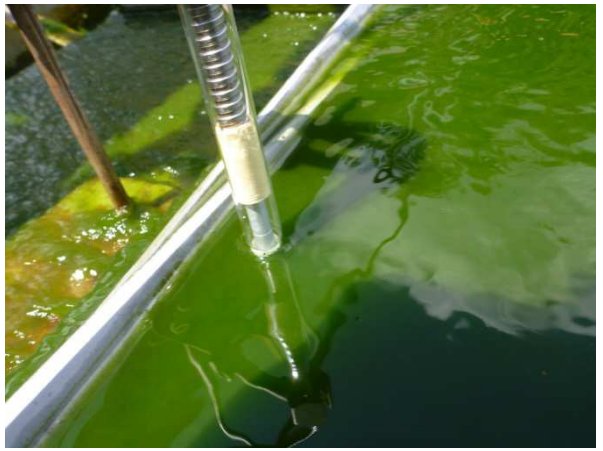
Biomass/light ratio:

- **Theoretical maximum:**
  1,5 g / mol photon (Zijfers *et al.* 2010)
- **Observed in this work:**
  0,3 g / mol photon

Photosynthetic parameters: from the penthouse to the lab

- PAM measurements <u>in the culture</u>:

steady-state F and maximal fluorescence in the light Fm' $\rightarrow$ ϕPSII and light-activated thermal dissipation

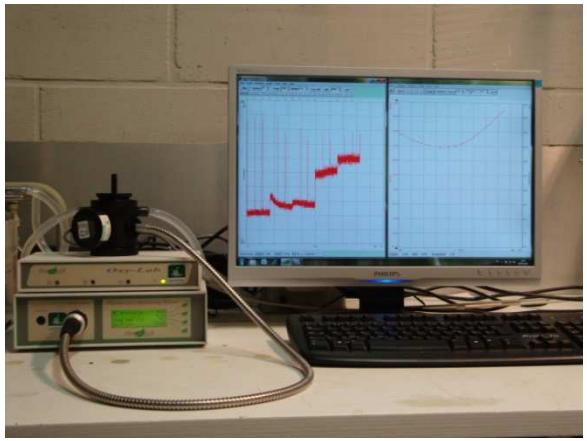


- Measurements <u>on site</u> (portable fluorimeter), <u>with short dark-adaptation</u> time (5 min) :

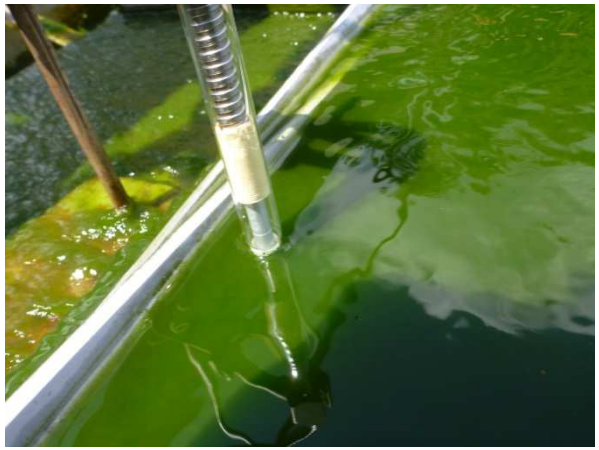
fast fluorescence rise curves (Fv/Fm and other derived parameters,) ϕPSII response to light intensity

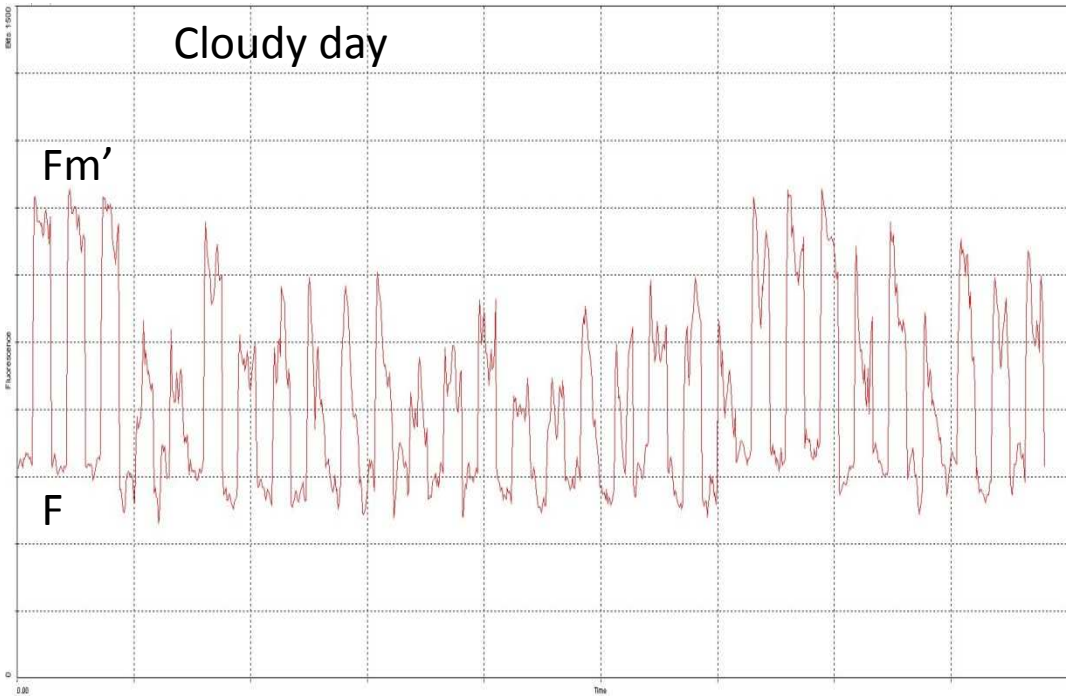
- PAM and oxygen measurements <u>in the lab</u> after dark-adaptation (1 h):

Light-saturation curves under CO_2-sufficient conditions, ϕPSII and VO2 relationships

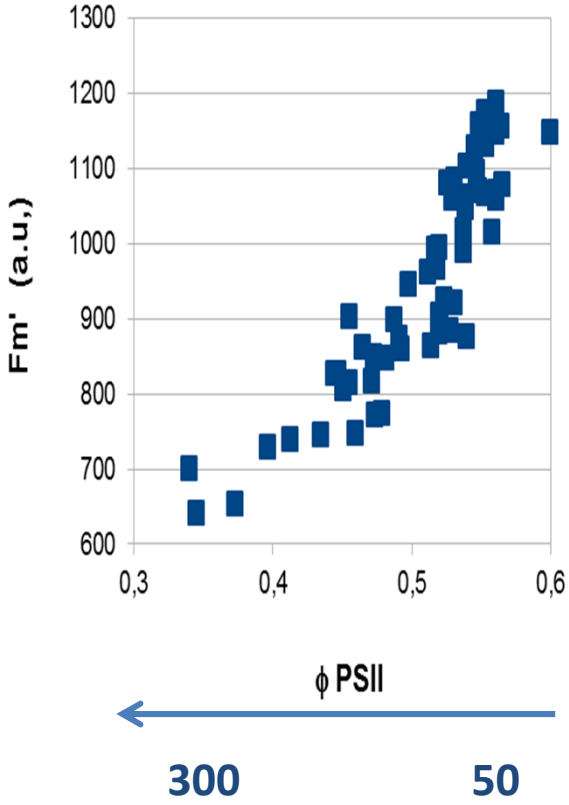


Energy quenching (NPQ) and PSII efficiency measured in the culture



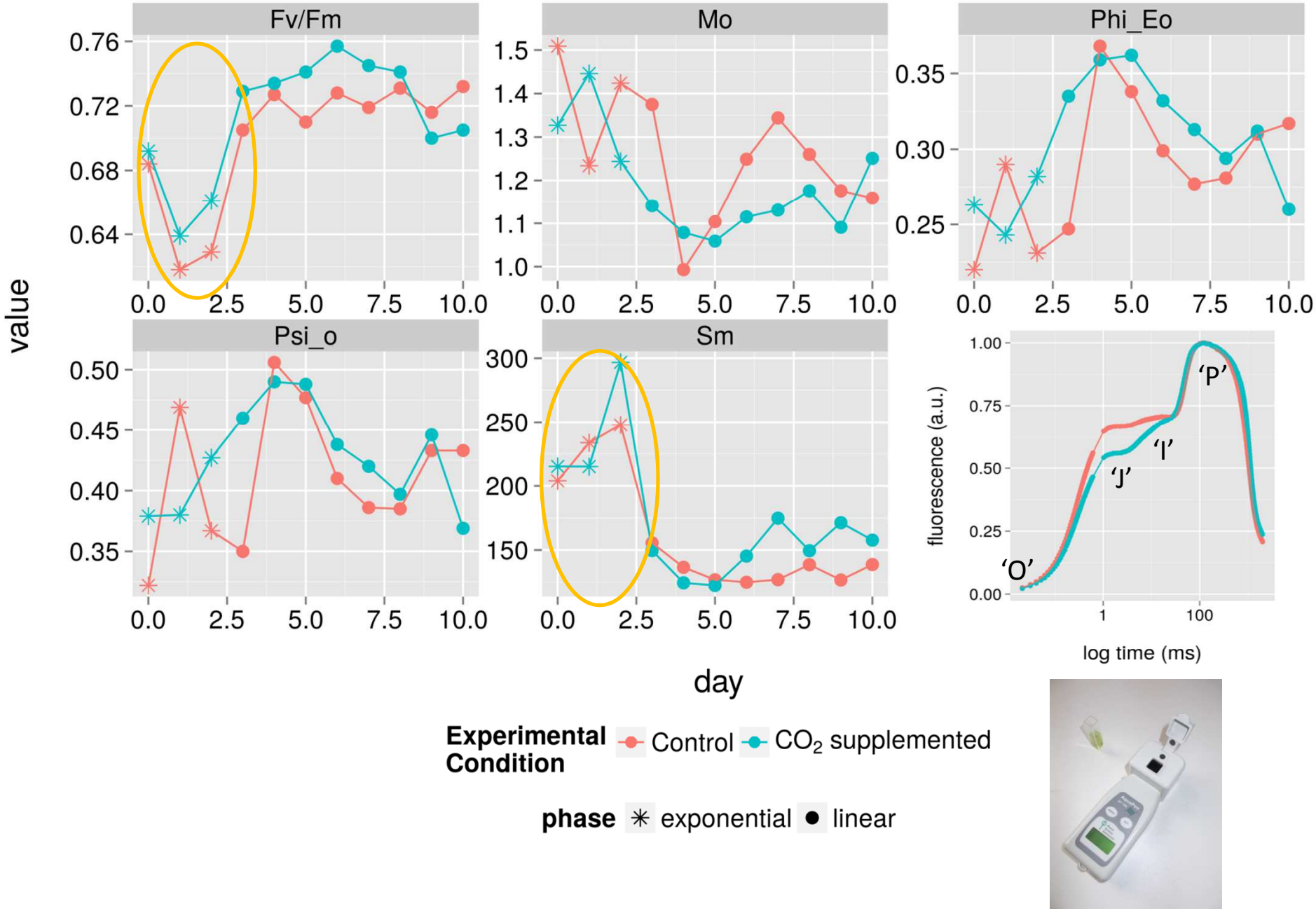


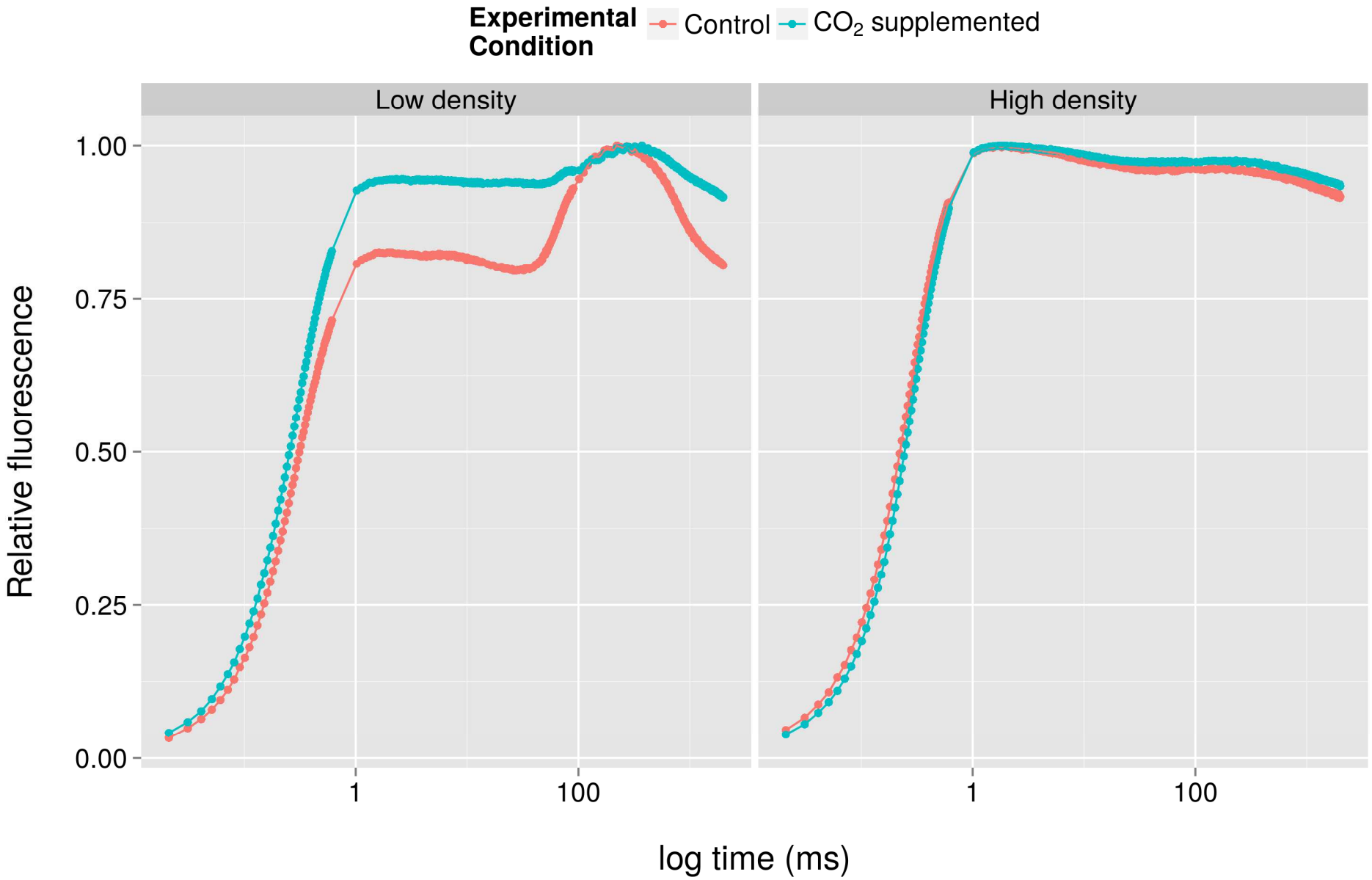
NPQ

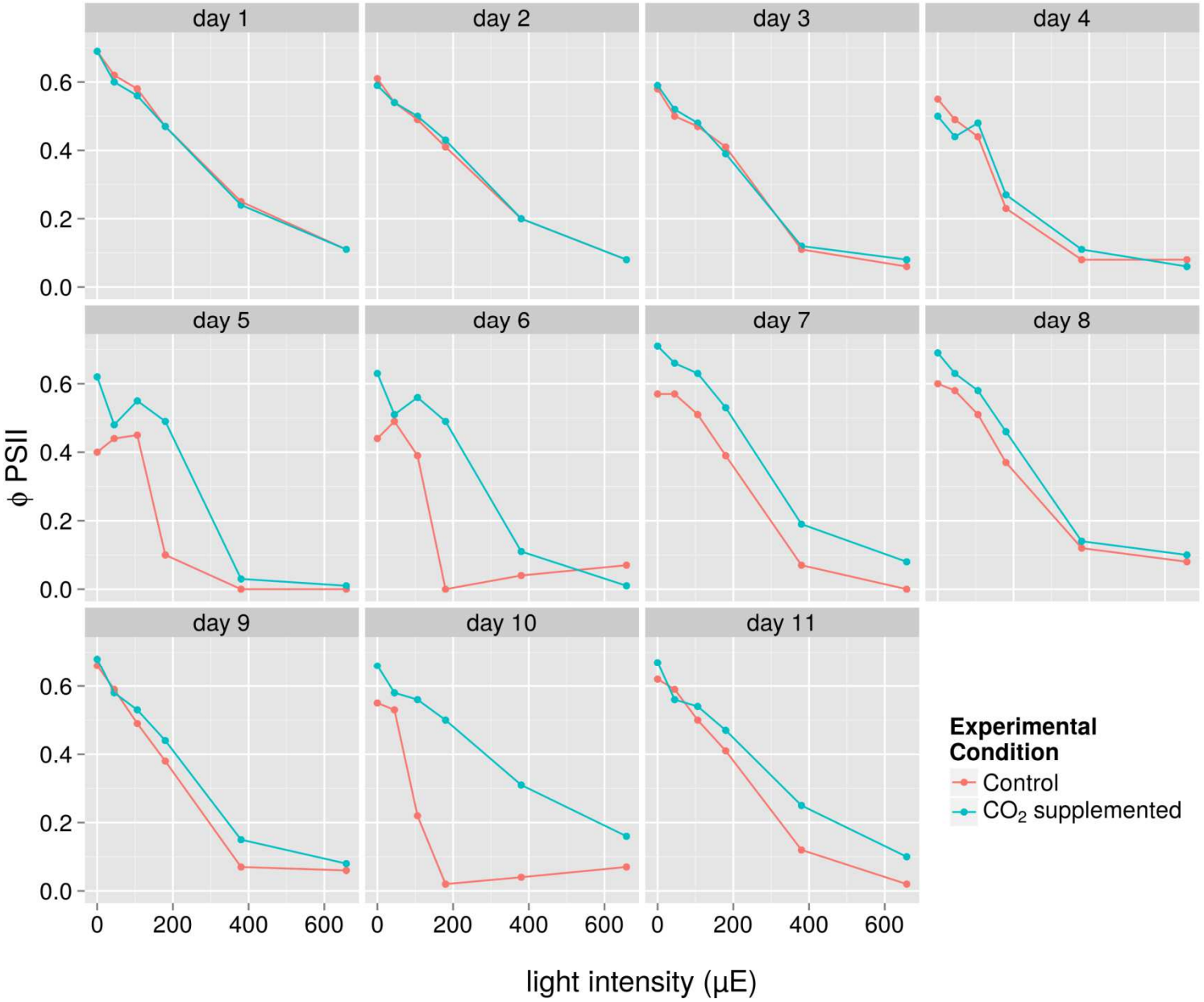


PAR inside the culture (probe level)

Energy dissipation through NPQ is a fast response that occurs at moderate local PAR

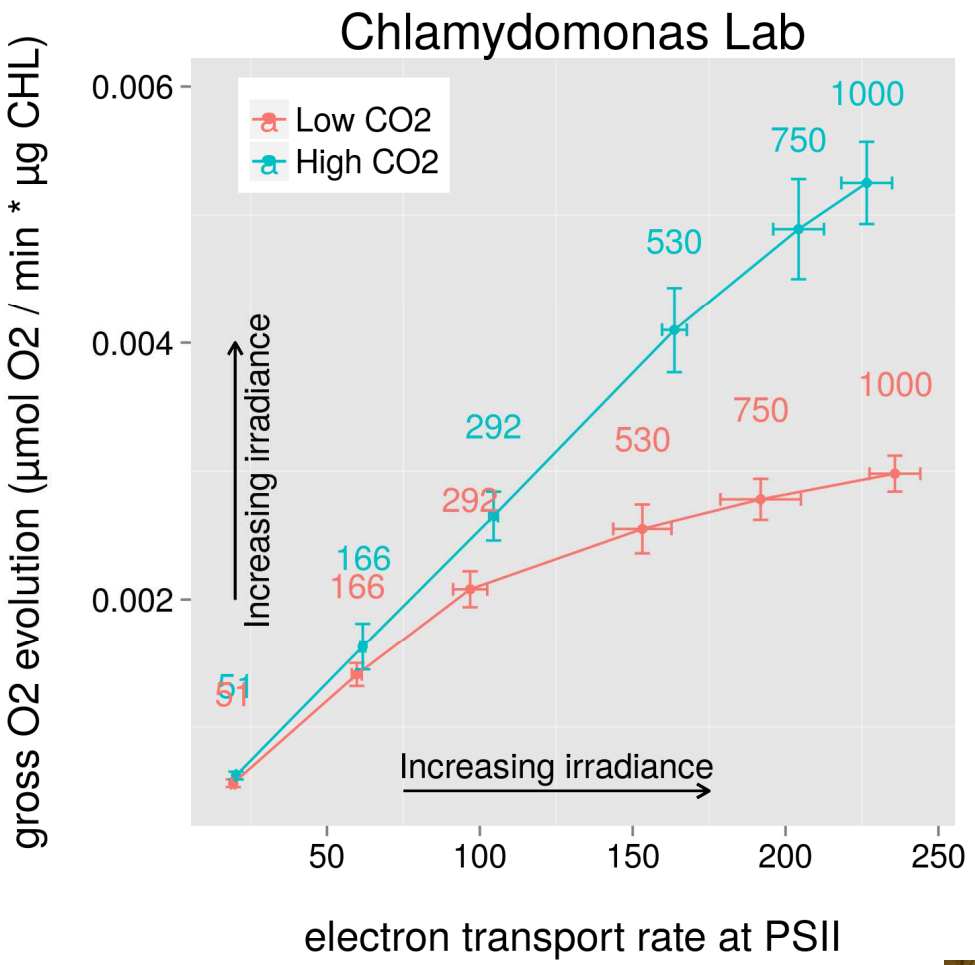

Fv/Fm
Mo
Phi_Eo
Psi_o
Sm
value
day
0.76
0.72
0.68
0.64
1.5
1.4
1.3
1.2
1.1
1.0
0.35
0.30
0.25
0.50
0.45
0.40
0.35
300
250
200
150
0.0
2.5
5.0
7.5
10.0
fluorescence (a.u.)
1.00
0.75
0.50
0.25
0.00
'O'
'J'
'I'
'P'
1
100
log time (ms)
Experimental Condition
Control
CO2 supplemented
phase
exponential
linear

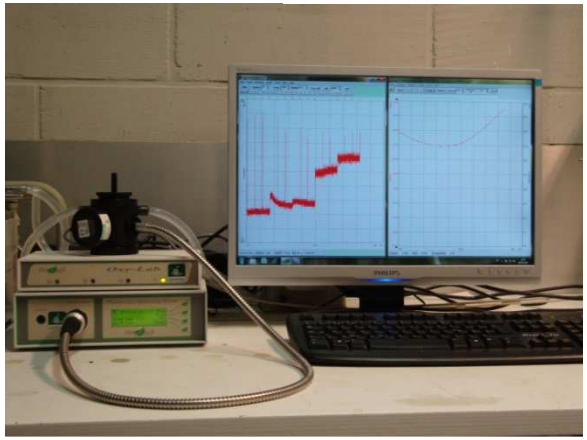

Experimental Condition
Control
CO2 supplemented
Low density
High density
Relative fluorescence
1.00
0.75
0.50
0.25
0.00
1
100
log time (ms)

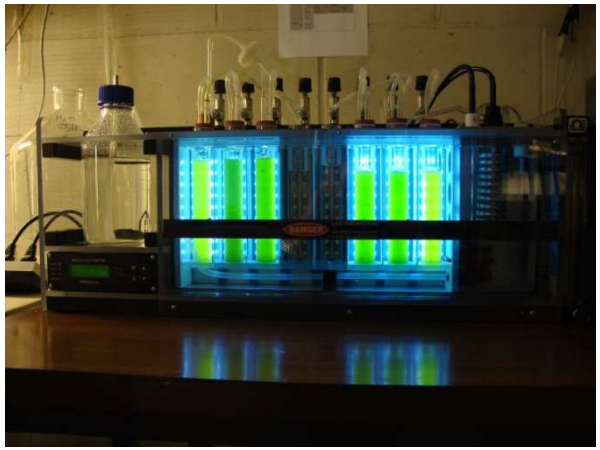


Exponential phase (diluted suspension up to 0,25 g/l)

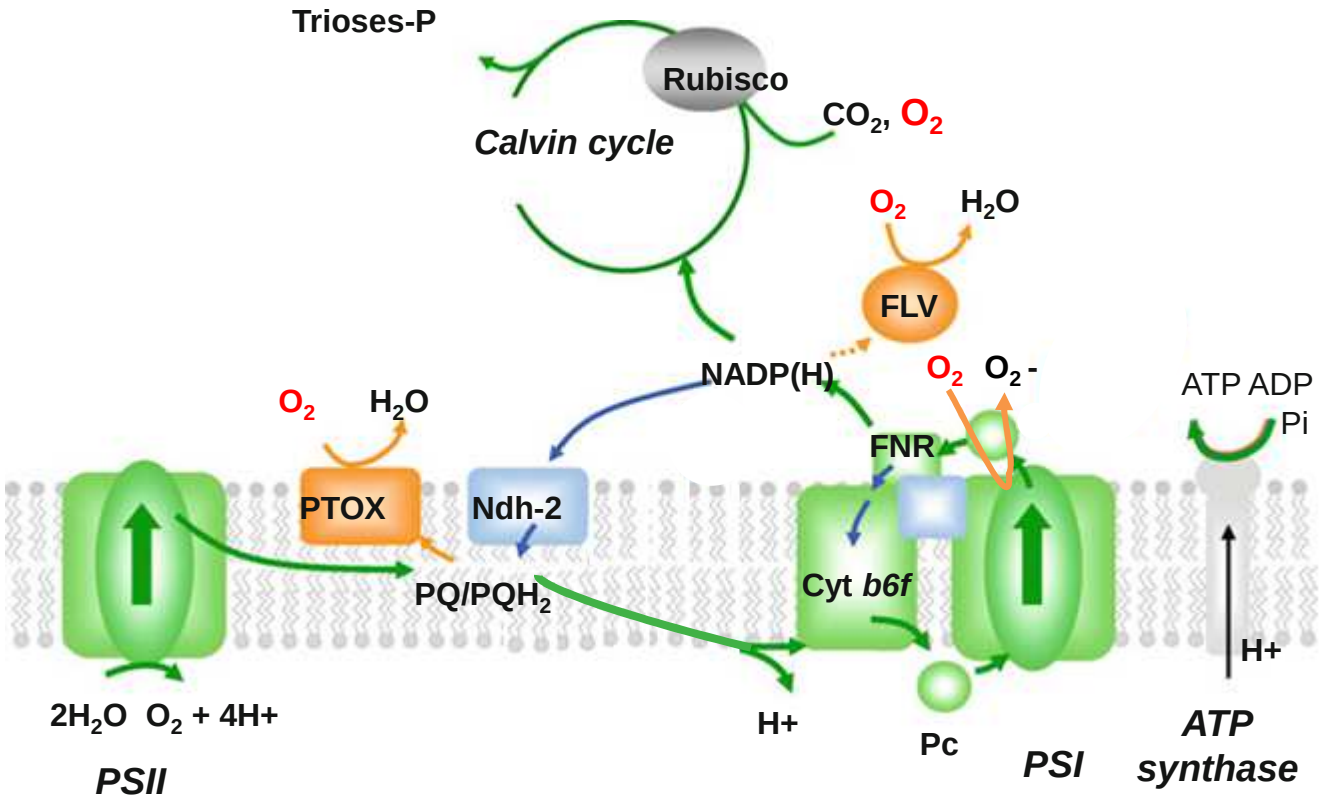
Linear phase (> 0,25 g/l)


Chlamydomonas Lab
gross O2 evolution (µmol O2 / min * µg CHL)
0.006
0.004
0.002
Low CO2
High CO2
1000
750
530
292
166
51
1000
750
530
292
166
51
Increasing irradiance
Increasing irradiance
50
100
150
200
250
electron transport rate at PSII



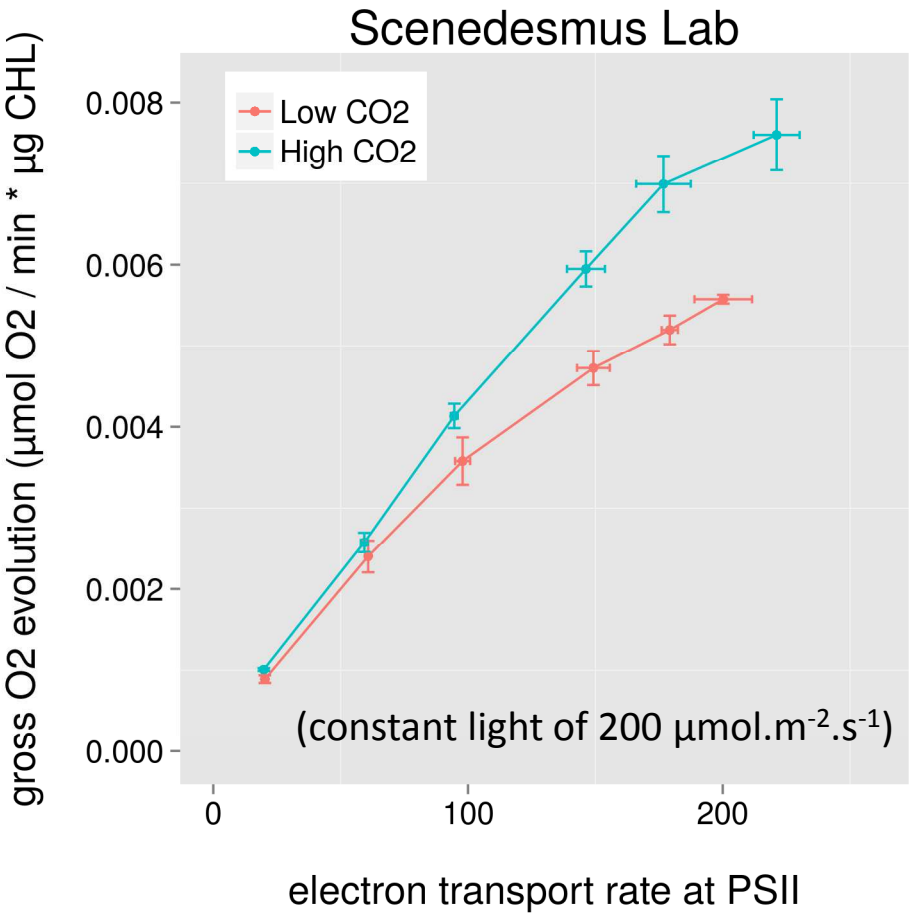


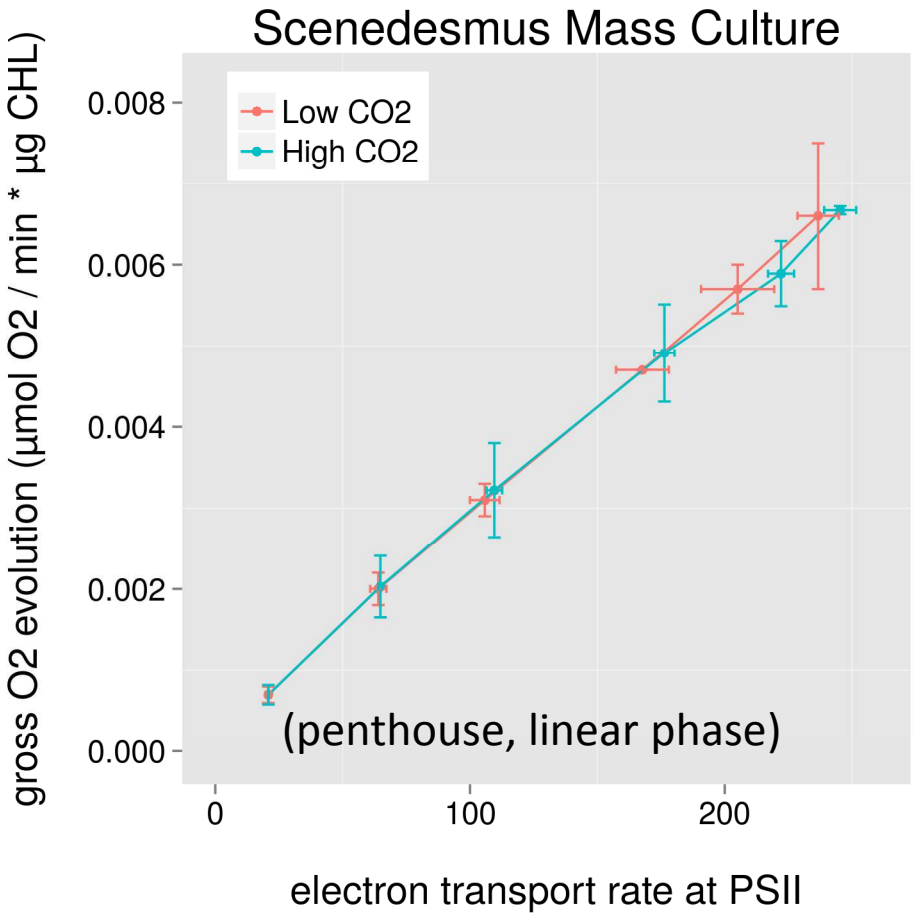
In microalgae, alternative electron transport to O_2 can be a major electron flux, active after adaptation to CO_2 limitation



Modified from Peltier et al. (2010) Photosynth. Res. 106:19

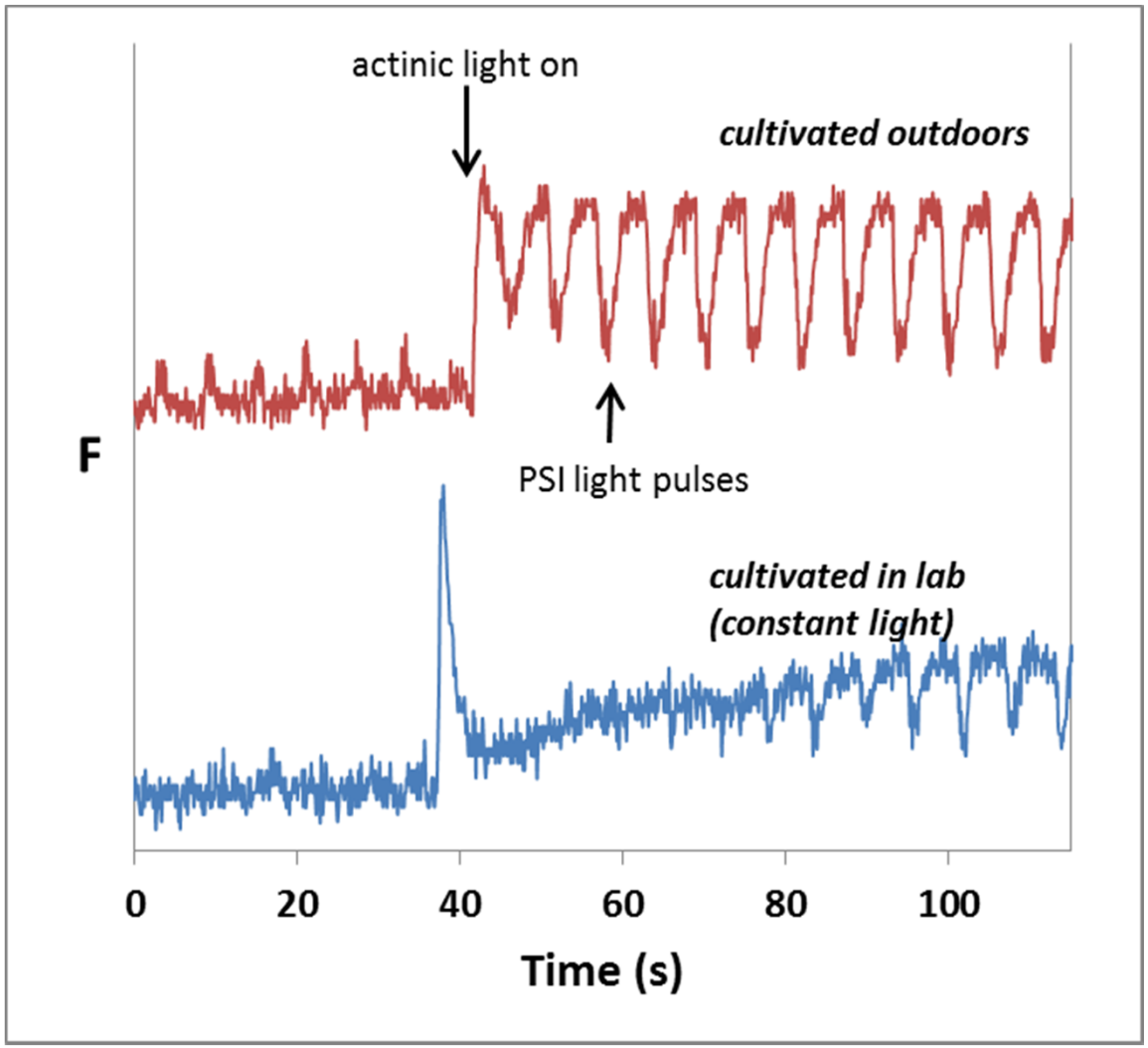
In outdoor conditions, no evidence was found for persisting alternative electron transport to O_2 in CO_2-limited *Scenedesmus*





→ Fluorescence-based measurement of ETR was a good indicator of photosynthetic capacity in these conditions

After growth in outdoor conditions, photosynthetic induction is much faster than for microalgae cultivated in the lab in constant light.



Conclusions at this stage

- Clear distinctions appear between exponential and linear phase outdoors: during exponential phase at low biomass density, full exposure to sunlight can induce ‘stress’ with a decreased PSII efficiency and changes in PSII heterogeneity
- In the linear phase, no evidence for alternative electron transport to O_2 at limiting CO_2 appears but NPQ is an important and fast response to light fluctuations inside the culture
- No evidence is found either for stable modifications of the photosynthetic apparatus to low CO_2
- Cells cultivated outdoors are much more responsive to light than lab-cultivated cells in terms of fast photosynthetic induction.