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

The thin-layer cascades

Founded in the 70’s by Prof. C. Sironval
Renovated in 2009
3 modules of 37 m² (3 to 5 m³) operated in semi-continuous mode each year between april and october

Prof. C. Sironval

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

CO\textsubscript{2} injection

Scenedesmus obliquus
SAG 276-10

The centrifuge

Wet biomass
Recorded parameters

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

Measured parameters
Biomass and pH variations
Productivity and light availability

$r^2 = 0.7$

$r^2 = 0.08$

**Experimental Condition**
- Control
- CO$_2$ supplemented

**Graph:**
- Y-axis: productivity (g dw.m$^{-2}$.day$^{-1}$)
- X-axis: integrated daily PAR (µmol photons.m$^{-2}$.day$^{-1}$)

The graph shows a positive correlation between productivity and integrated daily PAR, with a higher $r^2$ value for CO$_2$ supplemented conditions compared to control conditions.
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 in the culture:** steady-state F and maximal fluorescence in the light $F_m'$ → $\phi_{PSII}$ and light-activated thermal dissipation

- **Measurements on site (portable fluorimeter), with short dark-adaptation time (5 min):** fast fluorescence rise curves ($F_v/F_m$ and other derived parameters,) $\phi_{PSII}$ response to light intensity

- **PAM and oxygen measurements in the lab after dark-adaptation (1 h):** Light-saturation curves under $CO_2$-sufficient conditions, $\phi_{PSII}$ and $VO_2$ relationships
Energy quenching (NPQ) and PSII efficiency measured in the culture

Energy dissipation through NPQ is a fast response that occurs at moderate local PAR.
Exponential phase (diluted suspension up to 0.25 g/l)

Linear phase (> 0.25 g/l)
In microalgae, alternative electron transport to $O_2$ can be a major electron flux, active after adaptation to $CO_2$ limitation.

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.

- **Scenedesmus Lab**
  - Low CO$_2$
  - High CO$_2$
  - (constant light of 200 µmol.m$^{-2}$.s$^{-1}$)

- **Scenedesmus Mass Culture**
  - Low CO$_2$
  - High CO$_2$
  - (penthouse, linear phase)
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.