

Composite Lighting Design for Maximal Algae Growth and CO₂ Assimilation

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Which Algae do Work with?

- Those accumulating hydrocarbons
- Those accumulating fatty acids
- Those accumulating starch
- Those producing hydrogen gas





Photobioreactor Design



Scale Up
Investigations:

H/D

Flow Velocity

Bubble Size

Mixing Rate

Initial Density

Light Levels



Photobioreactor Design



Scale Up
Investigations:

H/D

Flow Velocity

Bubble Size

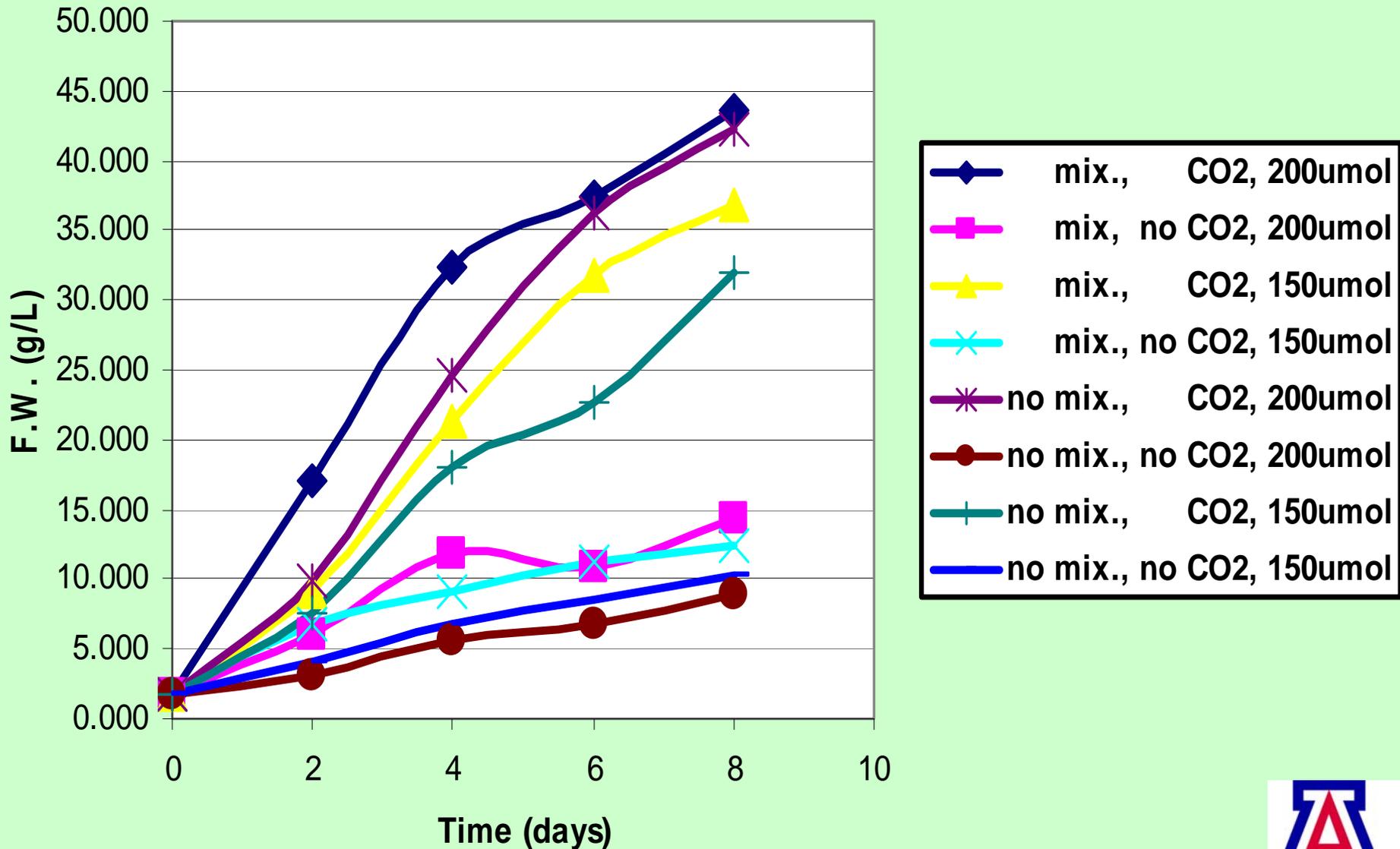
Mixing Rate

Initial Density

Light Levels



B. braunii growth optimization



HYBRID SOLAR AND ELECTRIC LIGHTING (HYSEL) FOR SPACE LIFE SUPPORT



J.L. Cuello, T. Nakamura, D. Larson,
K. Jordan, E. Ono and H. Watanabe

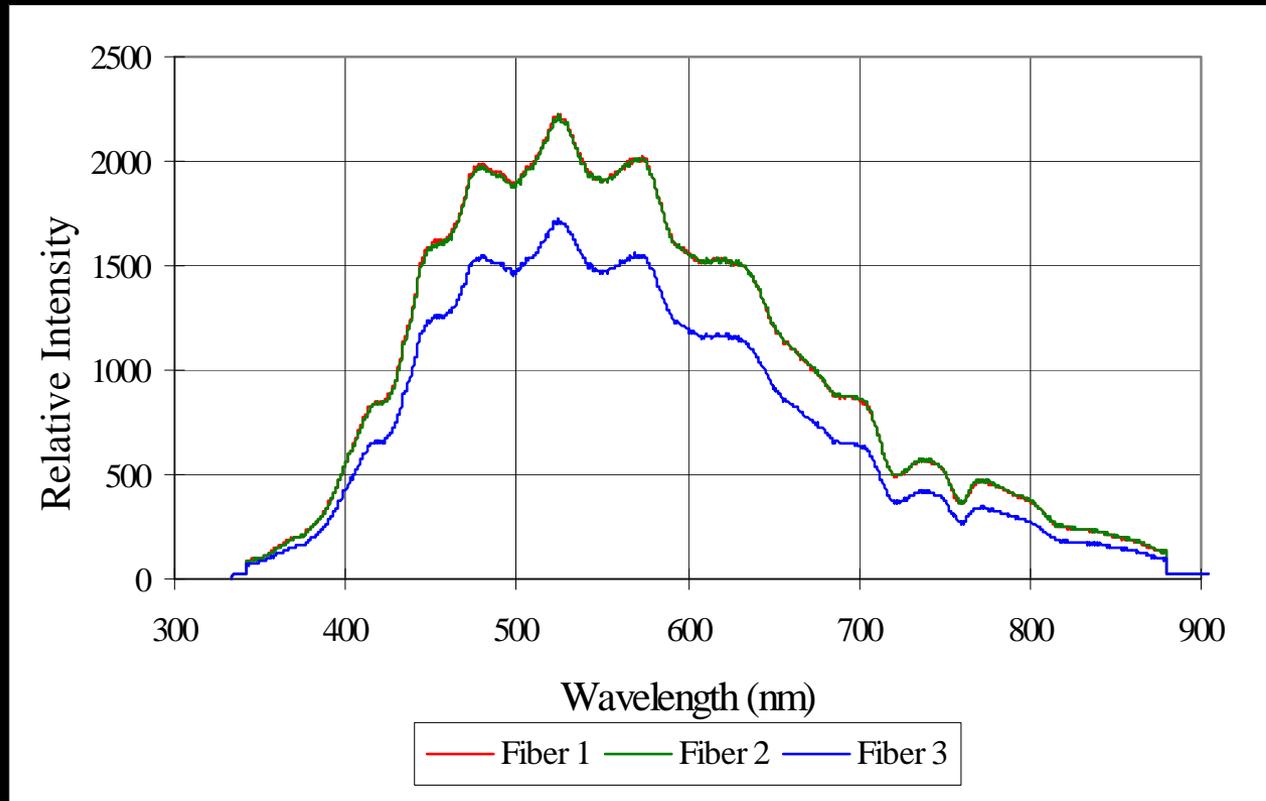
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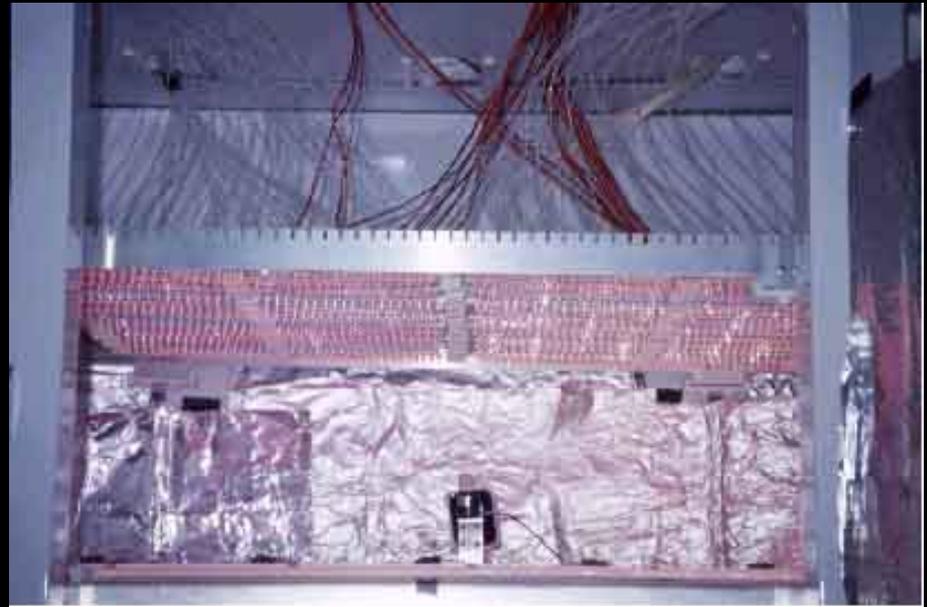




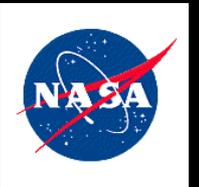
Concentrator's Spectral Output



HYSEL System -- LED

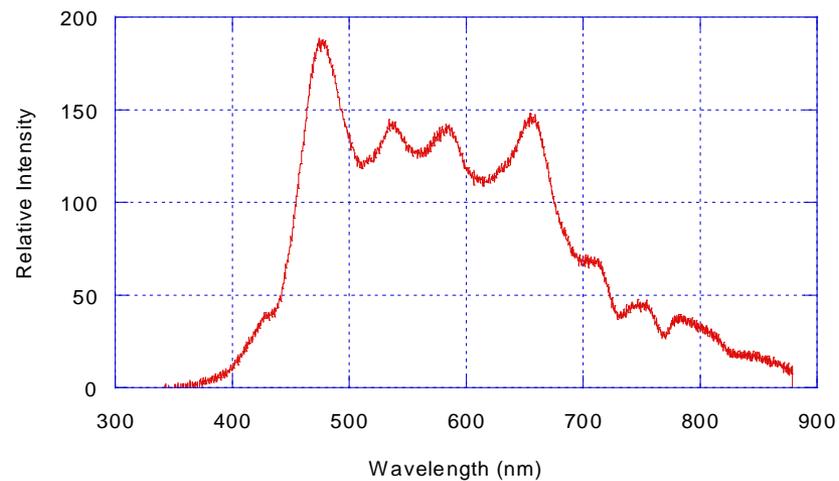
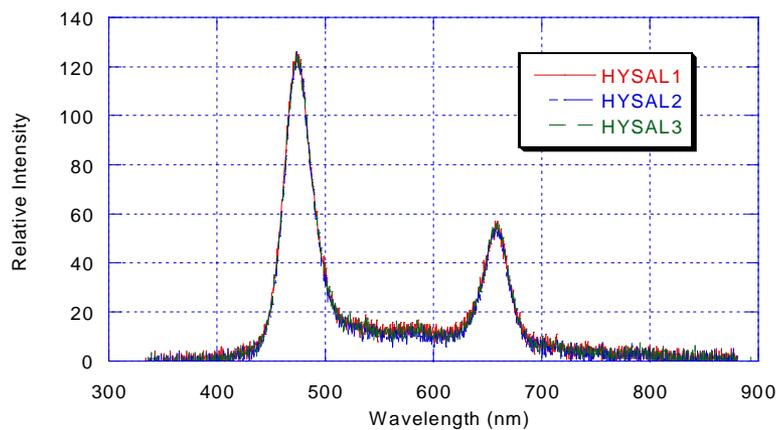


HYSEL System -- LED



HYSEL System's Spectral Output

HYSEL - LED



HYSEL System -- XMH

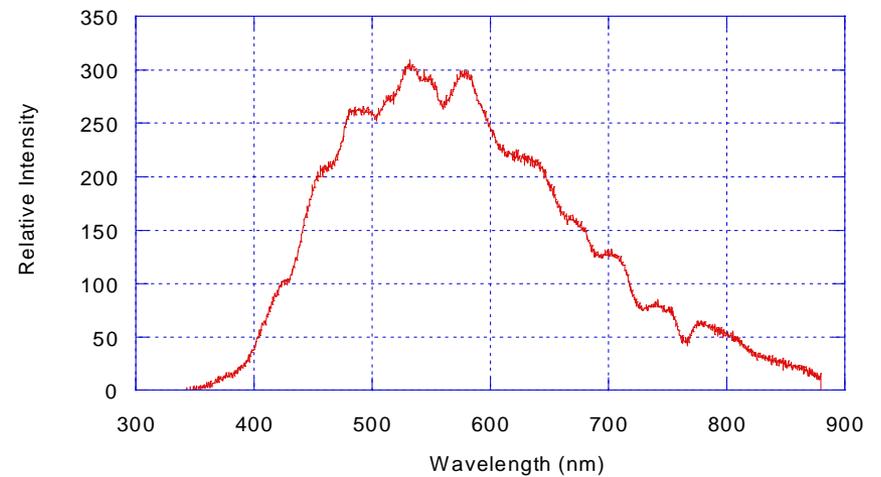
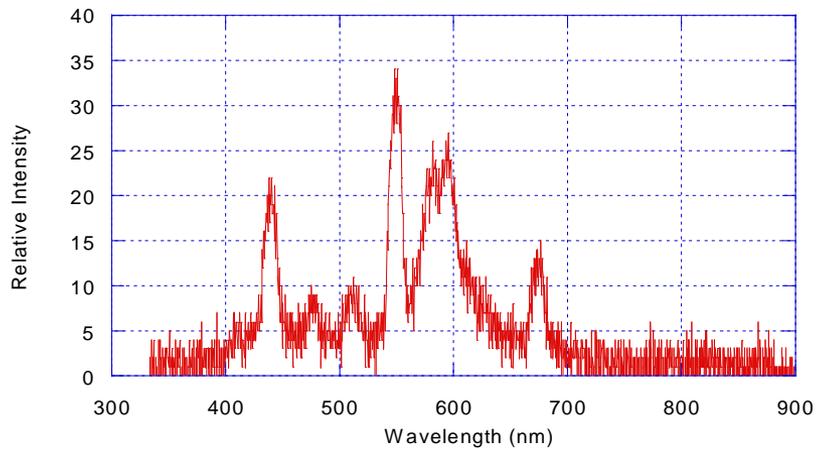


HYSEL System -- XMH

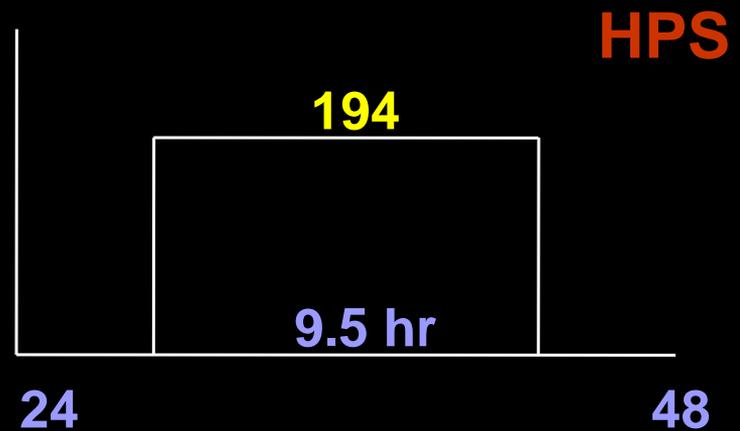
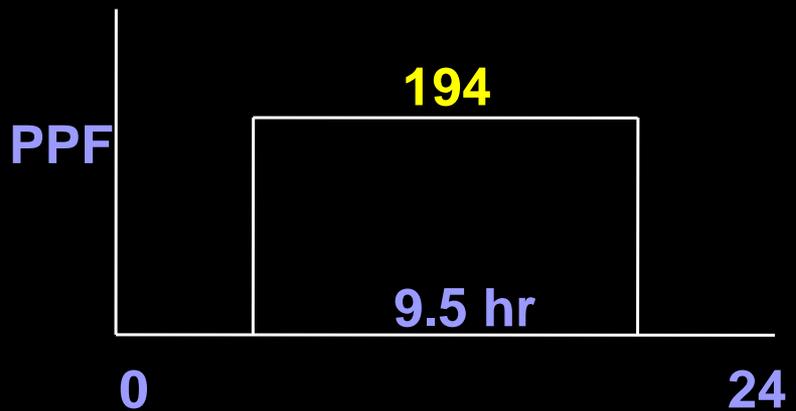
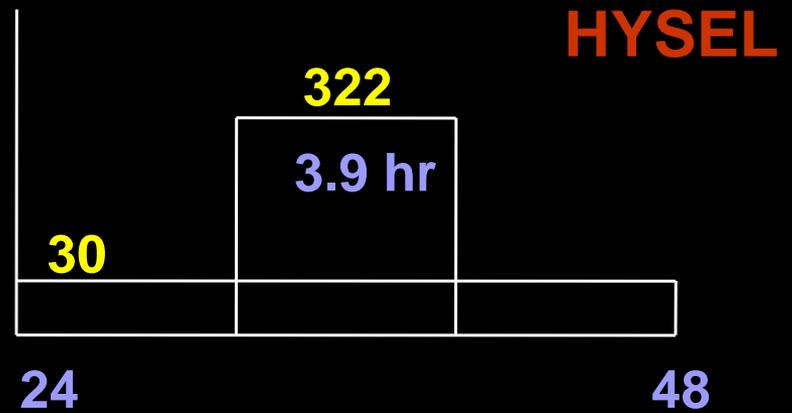
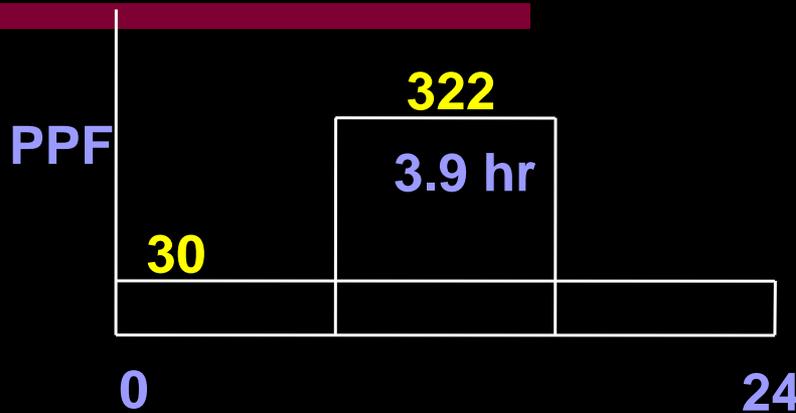


HYSEL System's Spectral Output

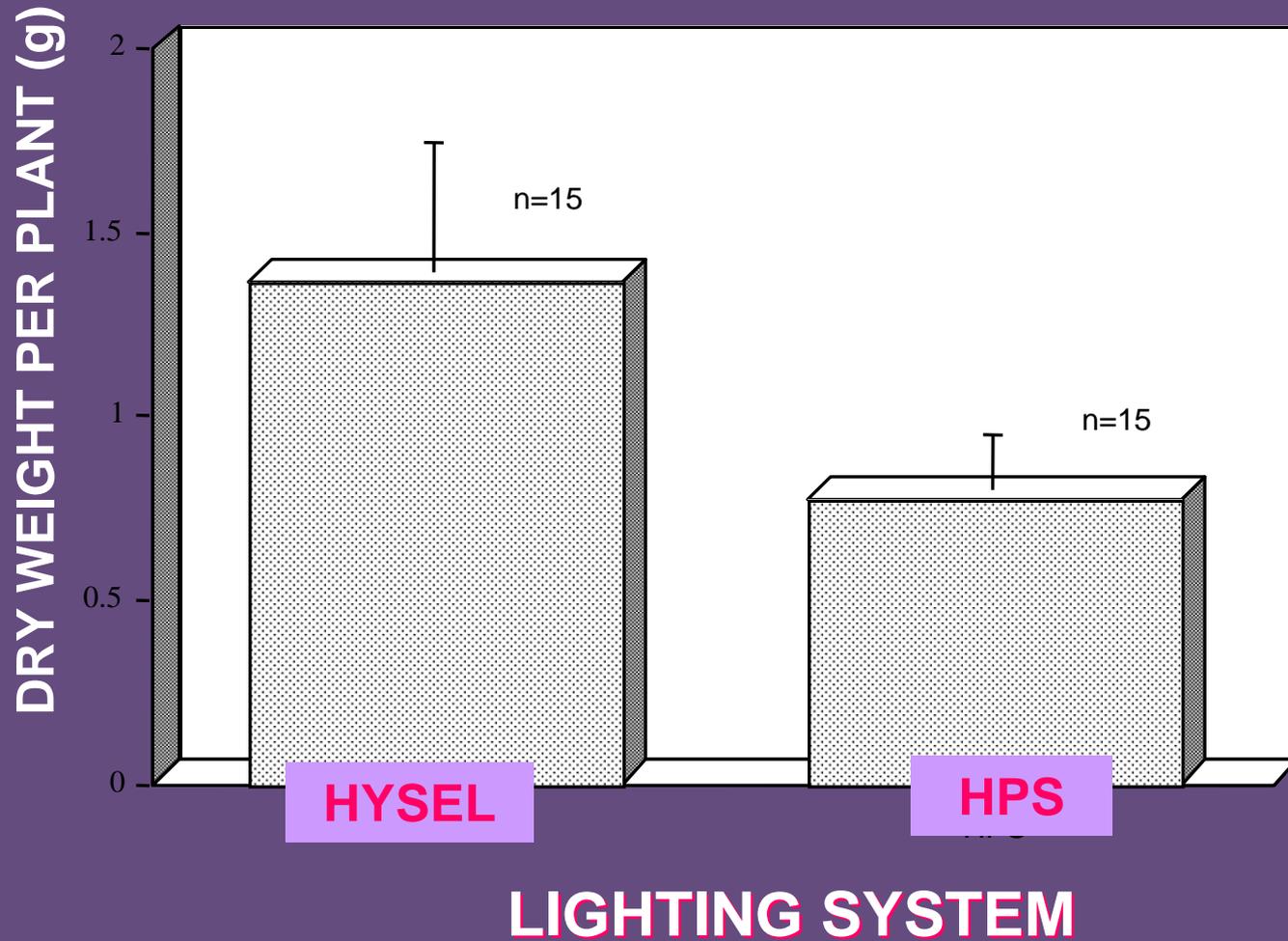
HYSEL - XMH



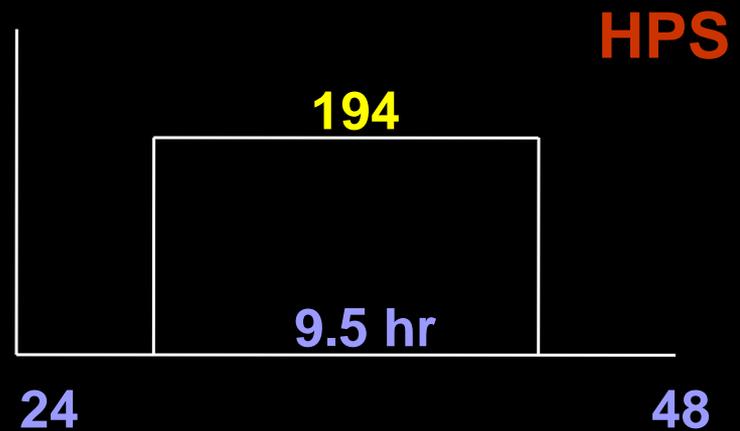
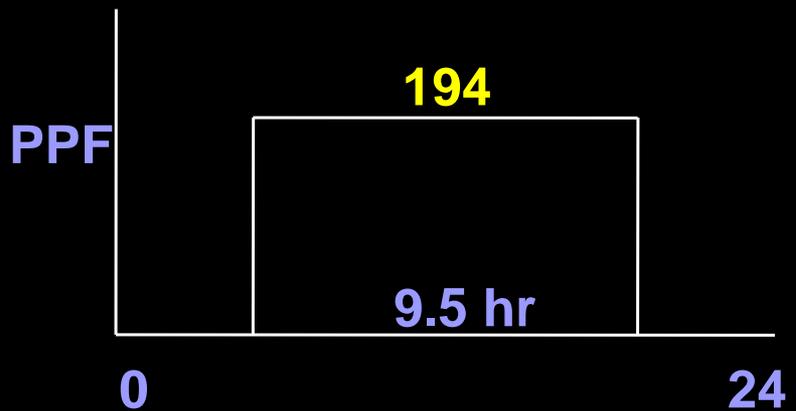
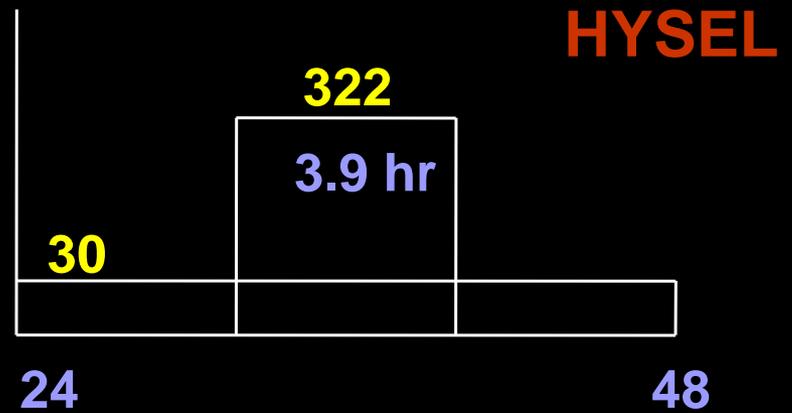
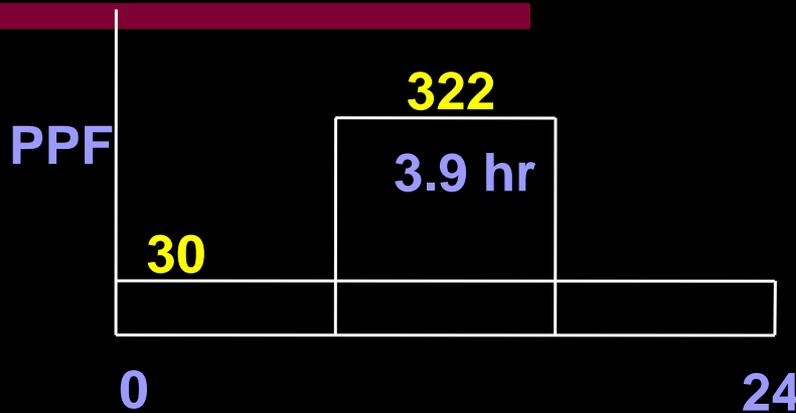
Lighting Profiles



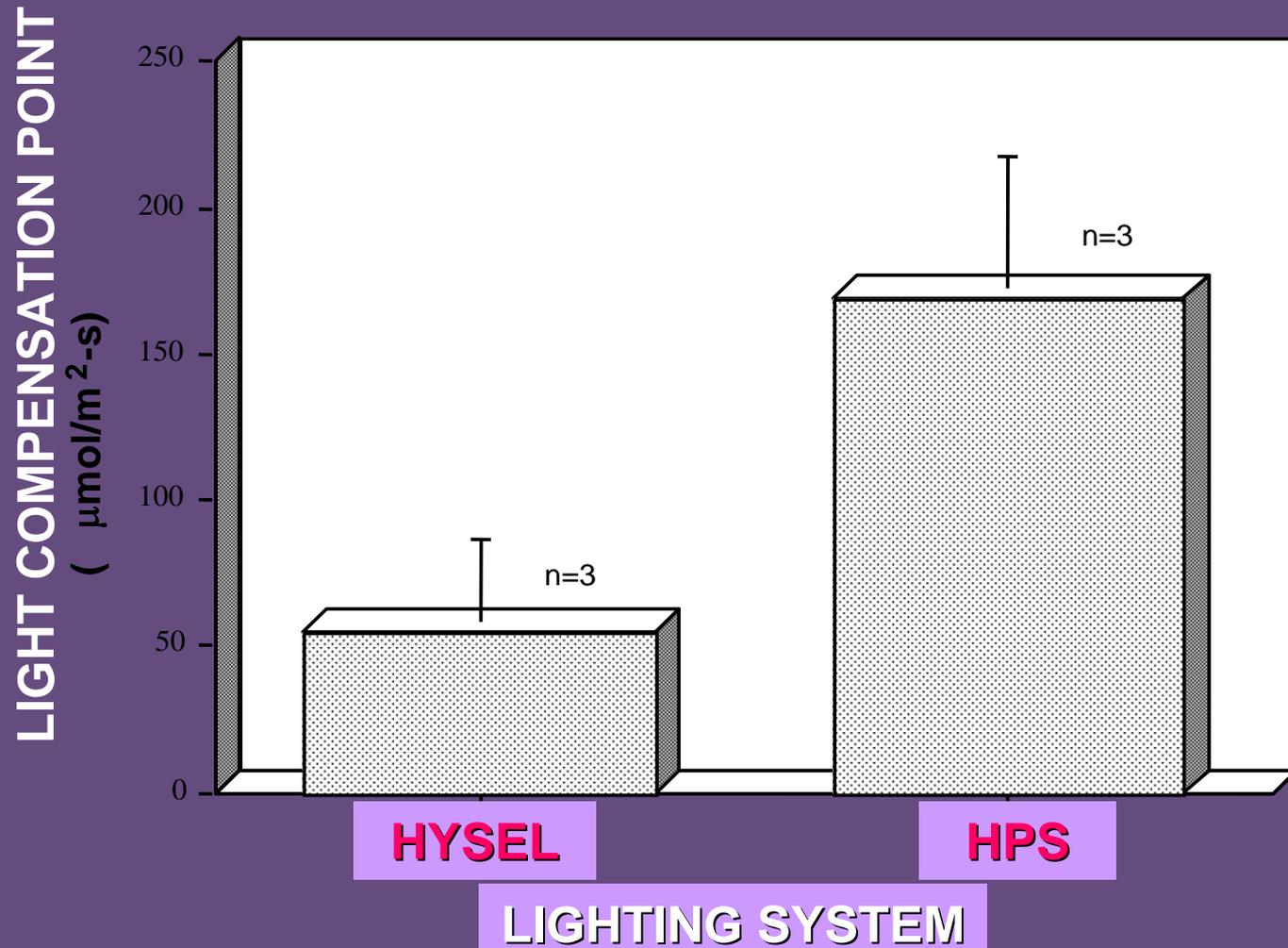
Dry Weight



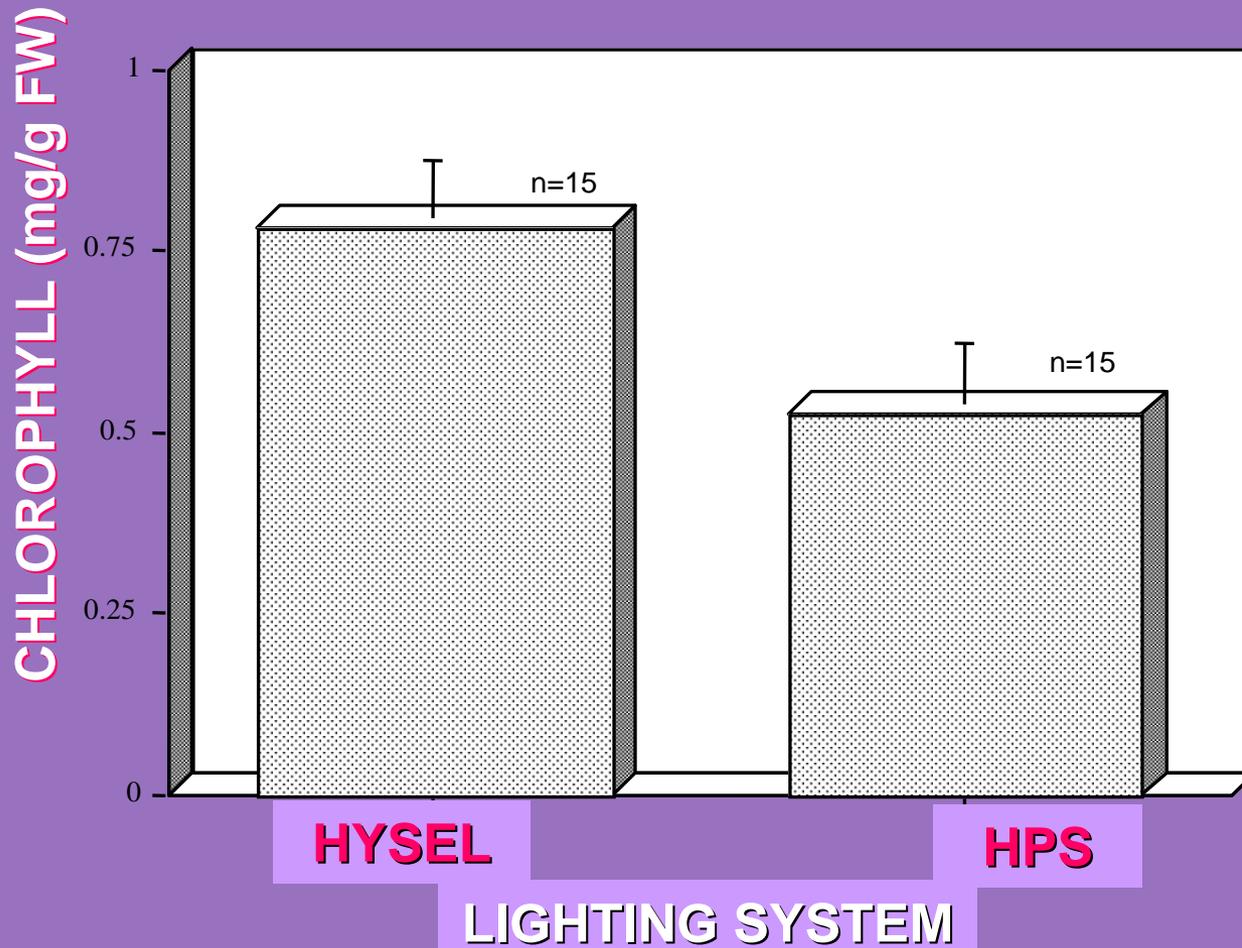
Lighting Profiles



Light Compensation Point



Chlorophyll Content



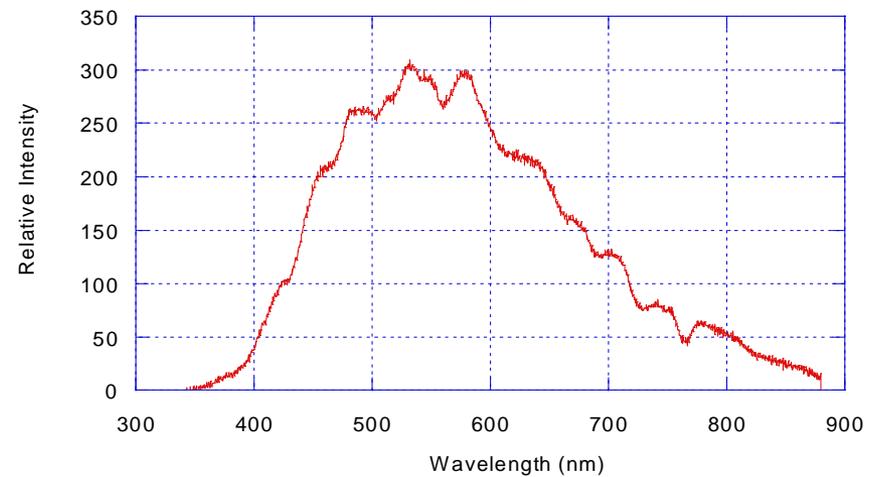
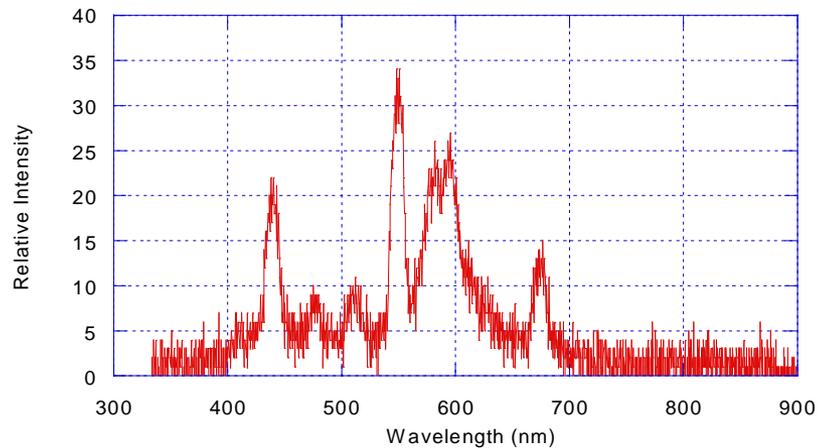
HYSEL VS. HPS

	HYSAL	HPS
DARK PERIOD (hr)	0	14.5/day (or 435 total)
LCP ($\mu\text{mol m}^{-2} \text{s}^{-1}$)	55.3	169.1
PPFave ($\mu\text{mol m}^{-2} \text{s}^{-1}$)	83	194

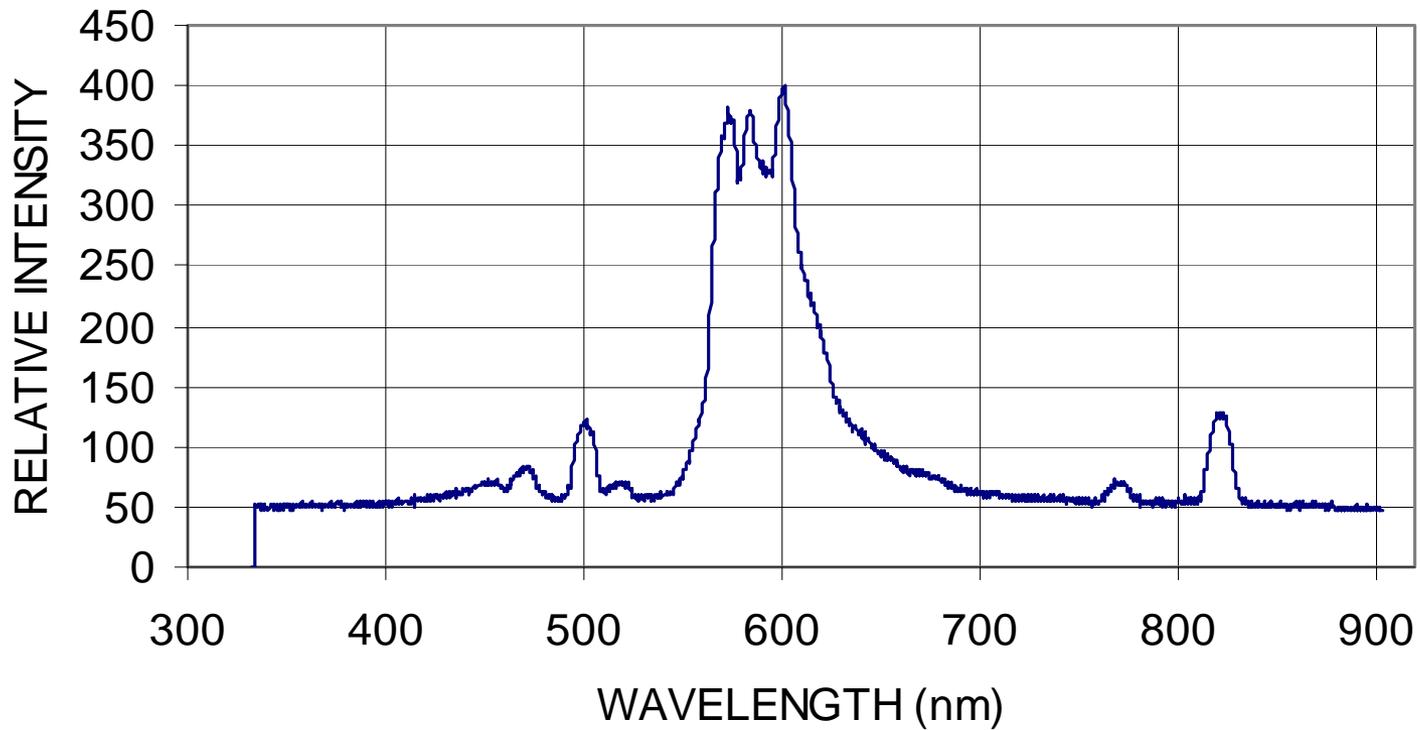


HYSEL System's Spectral Output

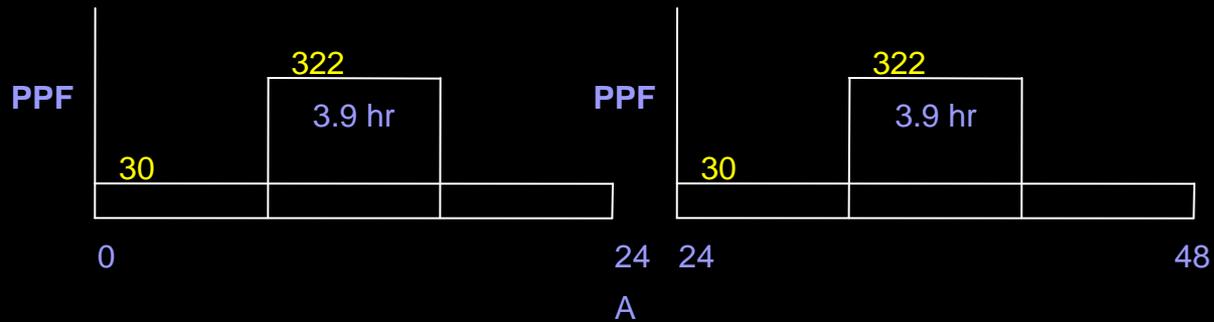
HYSEL - XMH



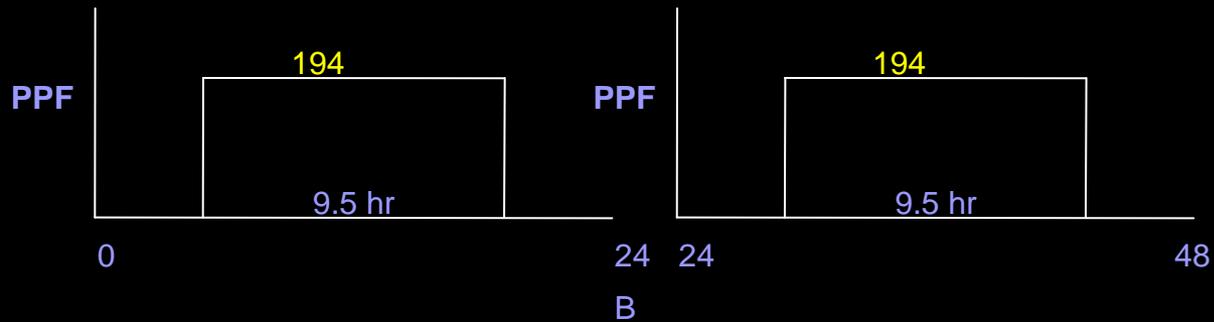
HPS Spectral Output



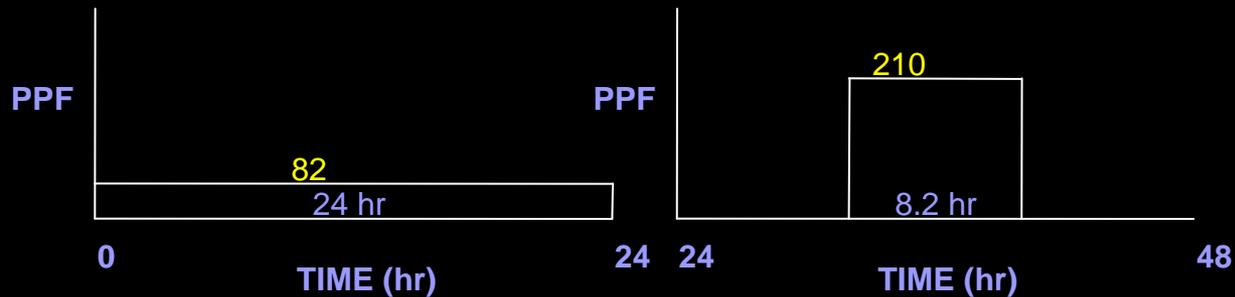
Lighting Profiles



HYSEL

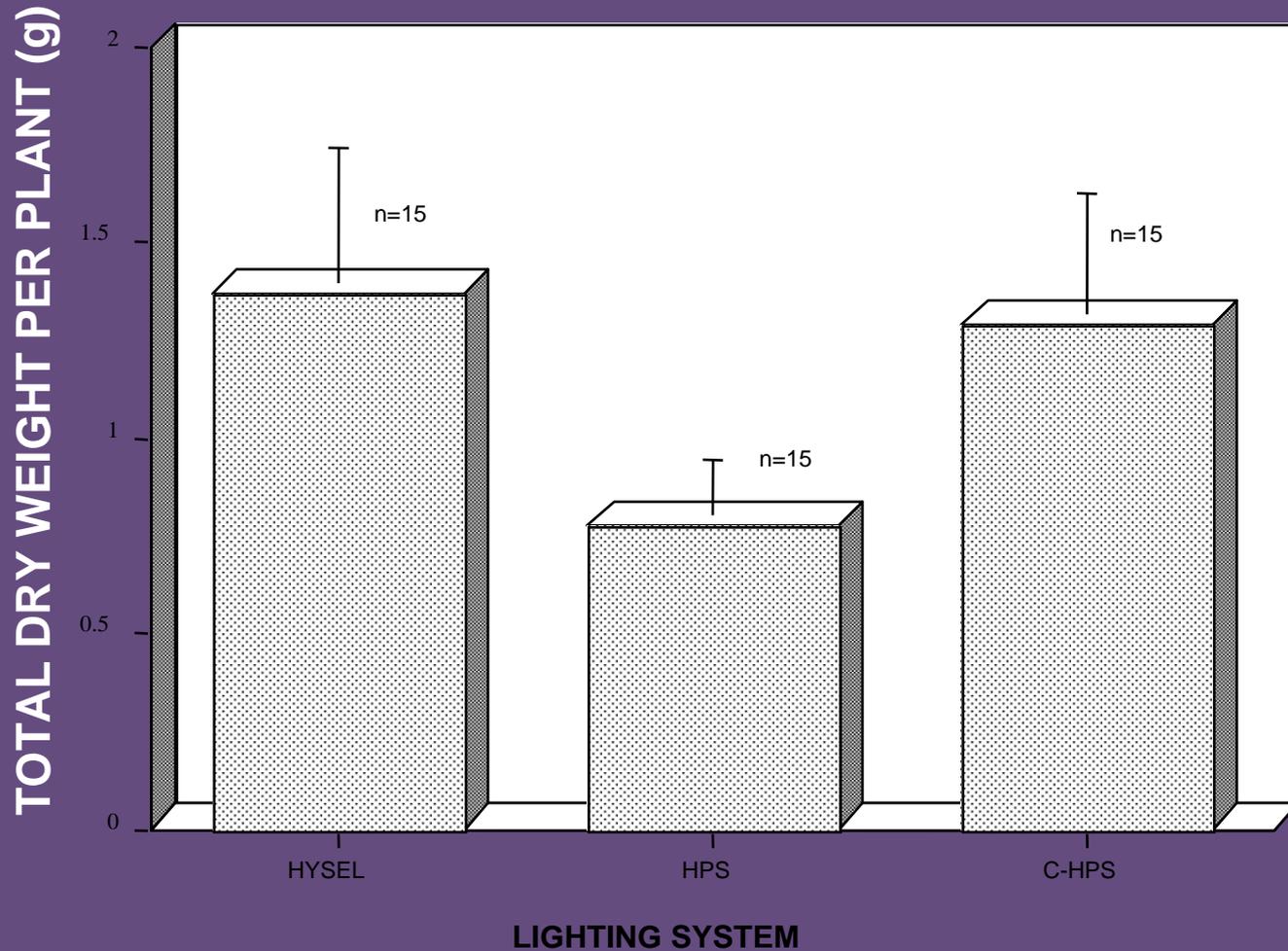


HPS



C-HPS

Dry weight



CONCLUSIONS



- The average total dry weight per plant for the **HYSEL** treatment exceeded significantly by **76%** that for the **HPS** control, despite the two treatments receiving equal moles of photons on a daily basis and for the entire growth period;



CONCLUSIONS



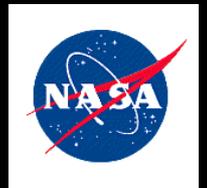
- This significant discrepancy in accumulated biomass could be explained physiologically by:
 - **HYSEL** having no dark period at all, while the **HPS** had 14.5 hrs of dark period each day or a total of 435 hrs (18.1 days)
 - **HYSEL** had a **LCP** that was significantly lower than that for the **HPS**;



CONCLUSIONS



- The average total dry weight per plant for the **C-HPS** was statistically indistinguishable from that for the **HYSEL**, but **significantly greater by 65%** when compared with that of the **HPS**;

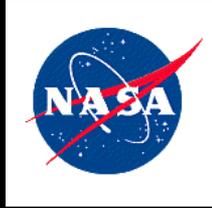


CONCLUSIONS



- The composite lighting profile of HYSEL, not the light-quality factor, was confirmed to constitute the physical (or environmental) causal factor that effected the biomass discrepancy.





National Aeronautics and Space Administration (NASA)

Grant No. NAG10-0255

	Nutrition	Light Cycle
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Control

Photoautotrophic
With 5% CO₂ provided

12 hours: 200 μ mol m⁻² s⁻¹
12 hours: Dark

Composite Lighting

Photoautotrophic
With 5% CO₂ provided

12 hours: 175 μ mol m⁻² s⁻¹
12 hours: 25 μ mol m⁻² s⁻¹



	Nutrition	Light Cycle
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Control

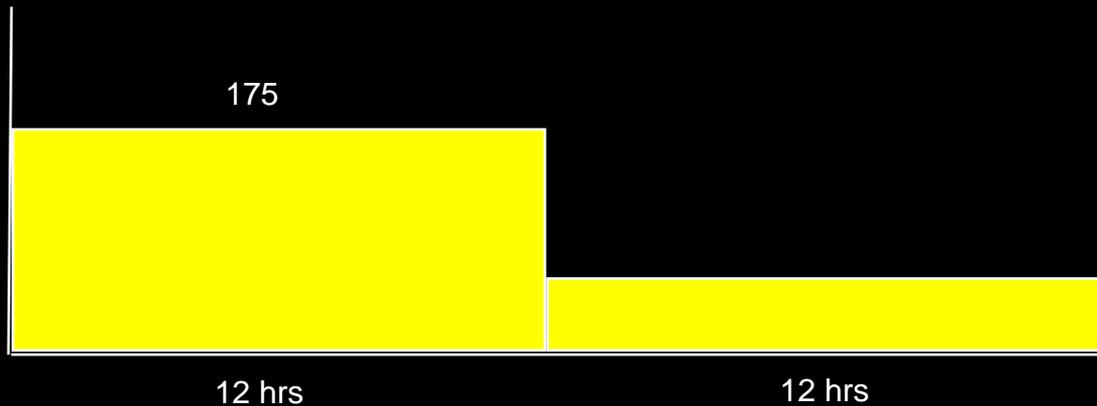
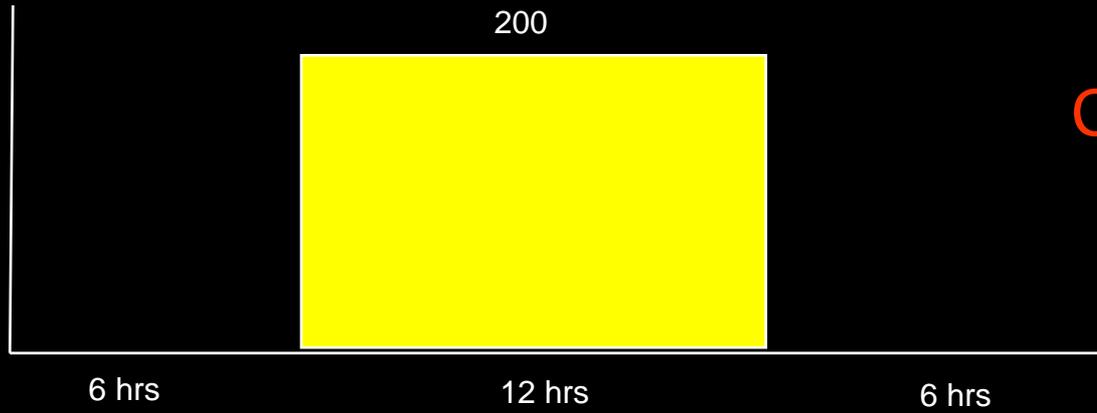
Photoautotrophic
With 5% CO₂ provided

12 hours: 200 μ mol m⁻² s⁻¹
12 hours: Dark

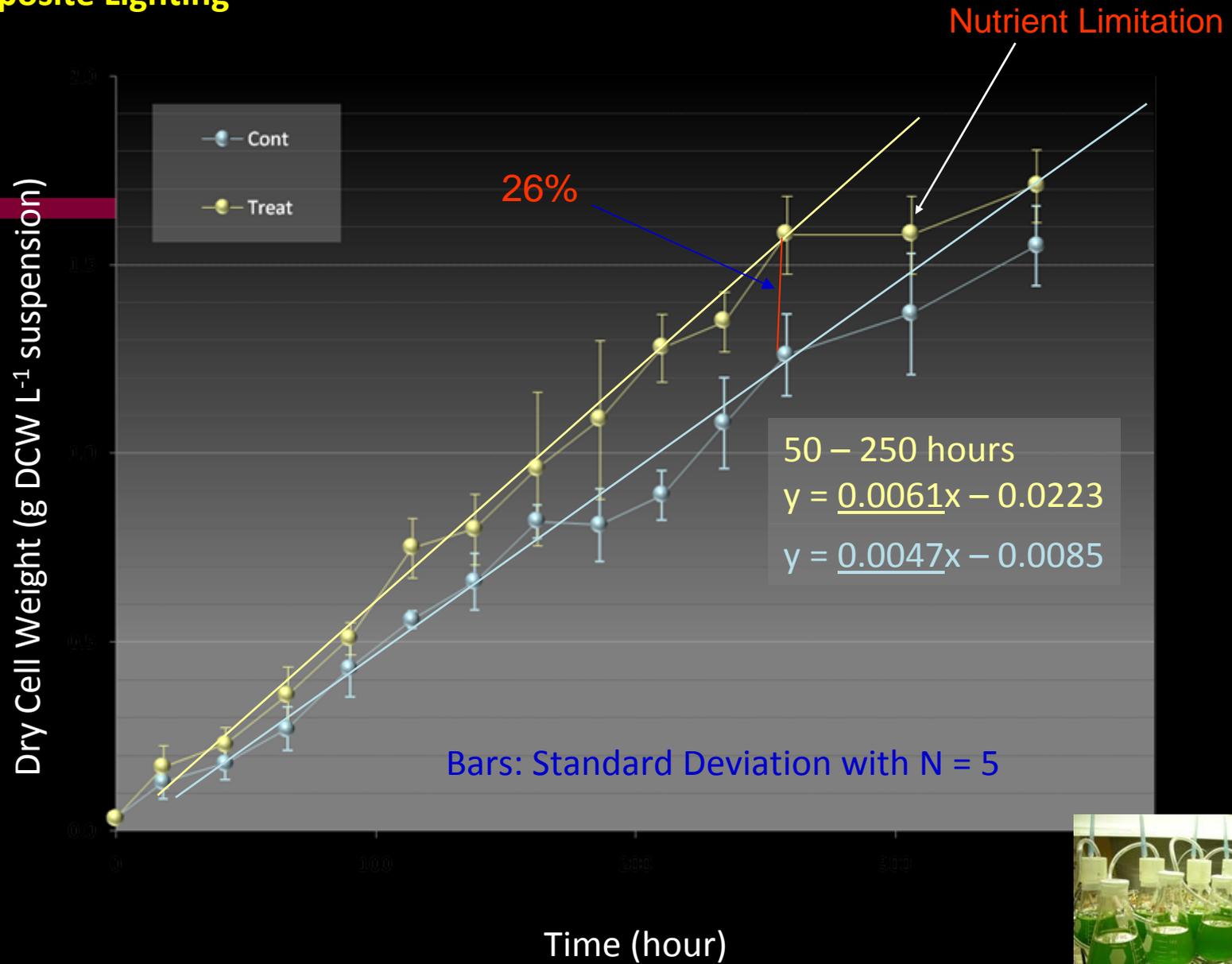
Composite Lighting

Photoautotrophic
With 5% CO₂ provided

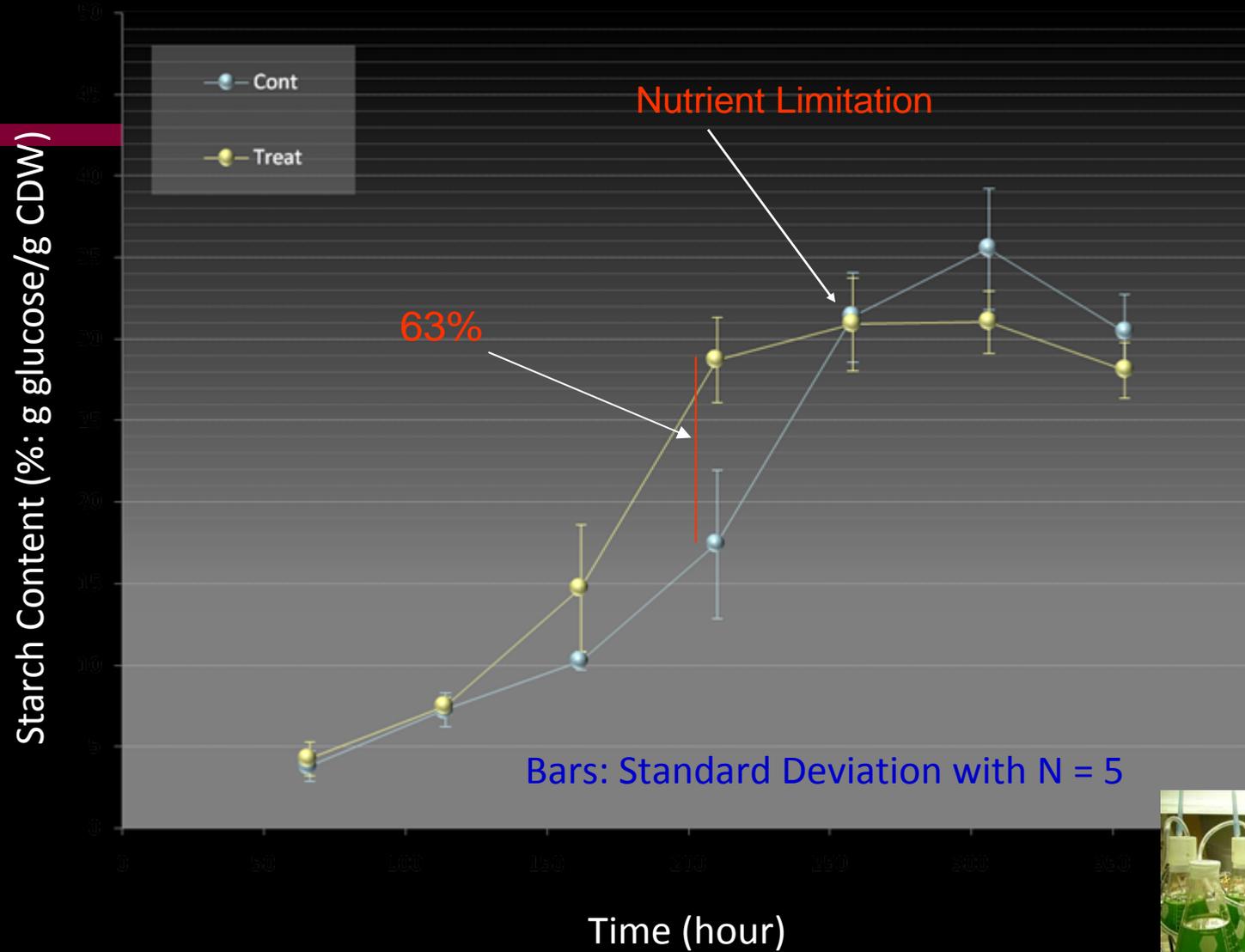
12 hours: 175 μ mol m⁻² s⁻¹
12 hours: 25 μ mol m⁻² s⁻¹



Composite Lighting



Composite Lighting



Conclusions



Equal moles of photons do not necessarily result in equal growth (or CO₂ assimilation) in algae

Composite Lighting design significantly increases growth (and CO₂ assimilation and retention) in algae for a given light level

Composite Lighting design significantly increases algae biofuel productivity for a given light level

