B2: LEDs and Plant Growth – Science, Energy & Cost Benefits: Dr. Matthew Davey & Martin Howes, University of Cambridge
LEDs and Plant Growth

Science, Energy and Cost Benefits

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Outline

- Background
- LEDs in Plant Growth Rooms
- LEDs in Algal Growth Incubators
- Energy Savings
- Financial Case & Other Incentives
- Conclusion
Background

- Plant Sciences grows a lot of plants and algae (surprise, surprise)

- Facilities range from individual pots and algal incubation shakers to growth cabinets, walk-in growth rooms and greenhouses

- Significant portion of departmental electricity costs are due to plant growth lighting and climate control
Background - Incentive

- The Plant Growth Facility is the most energy intensive building of the University’s estate

- PGF ~£25,000/mo  PlantSci ~ £14,000/mo
Background - Light, Climate, Energy

- Plant research is dependent on high quality lighting
- Critical to provide the right light intensity of the right wavelengths to the plants at the right height and evenly across shelf area
- Most of the energy output from lights is heat.
- In a controlled environment this must be exhausted and significant chilling costs are incurred
LEDs in Plant Growth Rooms

- Typical ‘day load’ is 8kW per room, not-including chilling provision
- 16 rooms ~128kW

- Trials began in 2012 with funding from the Energy & Carbon Reduction Project
- Plant growth, traits need to be the SAME under LED and Fluorescent lighting in order to compare experiments
Background - 1973...

GROW ELECTRIC
HANDBOOK 2

Lighting in greenhouses
LEDs in Plant Growth Rooms
Isophote maps show intensity of Photosynthetically Active Radiation 5cm above the surface of the growth tray.
### LEDs - Light Spectrum

<table>
<thead>
<tr>
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<th>Fluorescent Room 6</th>
<th>LED Room 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Intensity Set Point</td>
<td>200 µmol m² s⁻¹</td>
<td>200 µmol m² s⁻¹</td>
</tr>
<tr>
<td>Light Intensity at plant height</td>
<td>177 µmol m² s⁻¹</td>
<td>180 µmol m² s⁻¹</td>
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<tr>
<td>Plant height distance from light canopy</td>
<td>54cm</td>
<td>53cm</td>
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**Fluorescent and LED rooms full spectrum comparison**

![Graph showing light intensity comparison between Fluorescent Room 6 and LED Room 7 across different wavelengths.](image-url)
LEDs - Trials

- Studied Arabidopsis, wheat, tobacco, Cleome, Setaria and tomato
- CO$_2$ Uptake (Net, A/Ci and A/Q curves)
- Chlorophyll Fluorescence and content
- Growth Rate
- Flowering Time
- Biomass
- Seed Set
- Fungal Infection Rates
- Recombination Rates
- Effect of Red/Far-Red Ratio
- Research Group Specific Plant Traits
LEDs - Net photosynthesis

Wheat

![Wheat bar chart]

Tobacco

![Tobacco bar chart]

Tomato

![Tomato bar chart]
LEDs - A/Q curves photosynthesis

Light Curve

Wheat

Setaria

Tomato

Tobacco

Fluro
LED_1
LED_3
LED_4
LEDs - A/Ci curves Photosynthesis
LEDs - Trials

- Confident that plant growth traits are similar between light sources
- Two whole rooms have been converted to LEDs
- Continue monitoring and tested plants between LED and fluorescent light rooms
Infors Incubator Shakers are fully climate-controlled chambers for cultivating algae.

Each unit costs around £6000 per year to run in electricity and tube replacement costs.
LEDs - Algae
LEDs - Algal Growth

- Studied *Chlamydomonas, Chlorella, Phaeodactylum*
No significant differences have been found in algal growth and other traits when grown under LEDs and fluorescent lighting.
Energy Savings - Plant Growth Rooms

- Unconverted and converted rooms have been metered and logged throughout trials.

- 60% reduction in electrical demand from lighting. A ~4kW reduction replicated across all rooms will save £60,000 per year.

- Removal of heat exhaust fans reduces room baseload by 15% (twenty-four hours).

- A proxy for chilling demand suggests >15% reduction. This could boost savings to £100,000 per year across all rooms.
Payback on light electricity savings alone is ~ 12 years.

This doesn’t take reduction in chiller demand and wear, light replacement costs or maintenance time into account.

Lights themselves have longer lifespans with less ‘fall-off’ in light quality with age.
LEDs are:

- Over twice as efficient.
- Capable of producing nearly double the light intensity.
Financial Case - Algal Growth Incubators

► Payback on LED retro-fit: ~8 years
► Unit capability is improved.
► LEDs emit less heat which reduces chilling demand. A further ~55W is saved under normal operating conditions.
► Expected lifespan of the LEDs is 10x better than the tubes (10-20 years instead of 1-2 years).
Conclusion

- LED technology is maturing quickly. It is efficient, powerful and flexible.
- Energy savings are significant.
- There are significant other benefits for procurement and maintenance.
- Research grade plant and algae growth under LED is a reality.
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Thank You

Questions?

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