Supplementary Files

Increasing the energy savings and yield of *Lactuca sativa*, L. in glass greenhouses through illumination spectral filtering

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Received: date; Accepted: date; Published: date

Calibration of the Heliospectra LED source

The Heliospectra LED light source was calibrated using the hand-held laser power meter LaserCheck (Coherent, Oregon, USA) by setting it to the specific wavelength to be measured, then turning the Heliospectra on at intervals of 100 'intensity' readings and using the LaserCheck meter to measure the power density (Wm^{-2}) at 0.2m height intervals from directly under the LED source down to pot height. This was conducted to determine the power output required from the Heliospectra LED light source at plant height, in order to attempt to emulate the Heliospectra output to the output power from the sun, across an 18 hour day/6 hour night, time interval, as discussed in literature to be an optimum daylight time interval for lettuce [1, 2], within the constraints of the Heliospectra system.

The calibration utilized the following data constraints, not to scale.

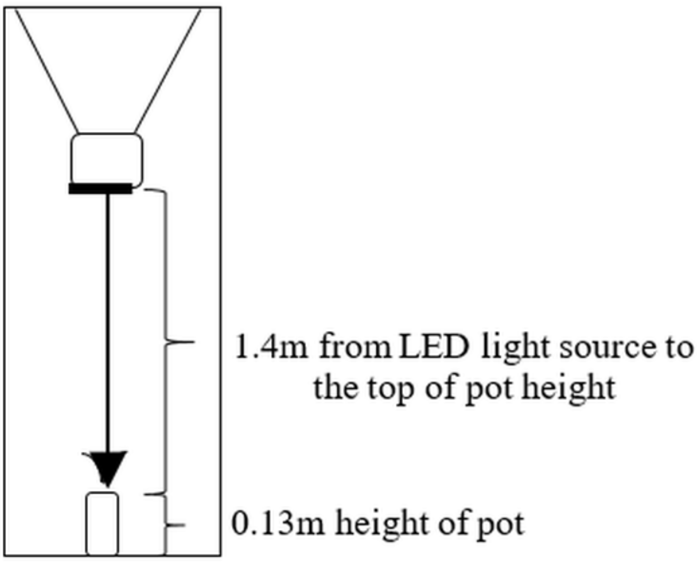
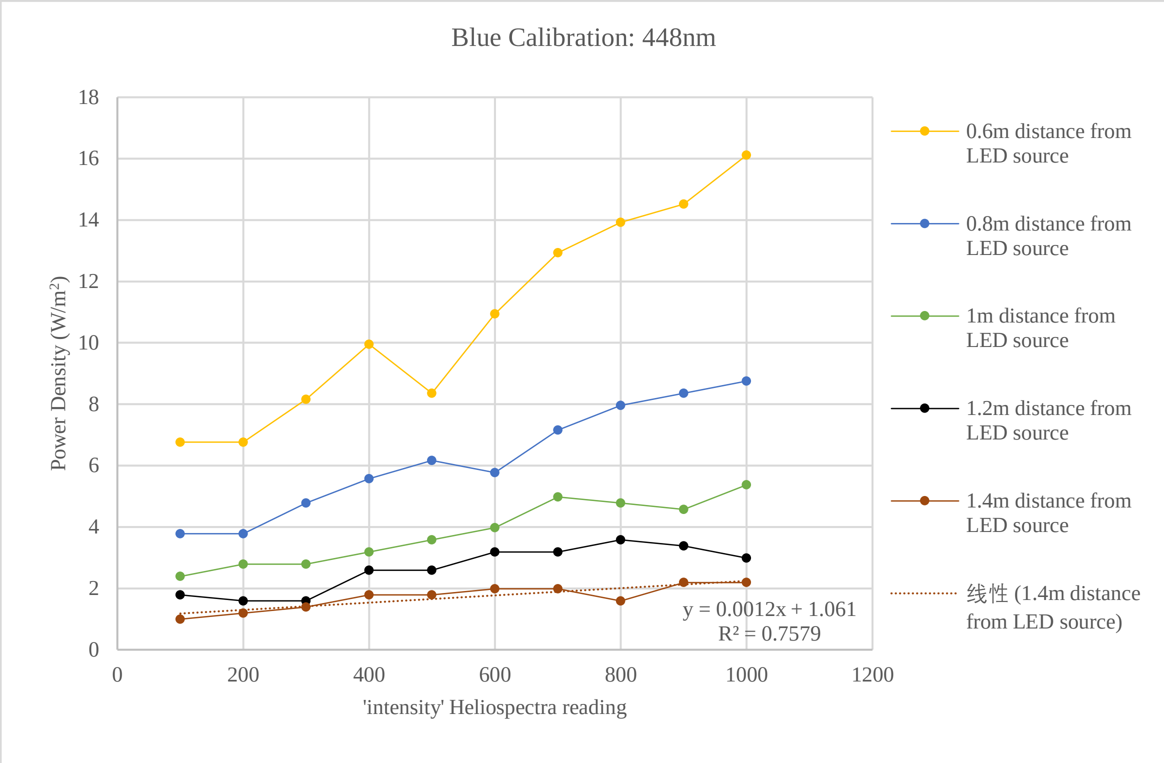


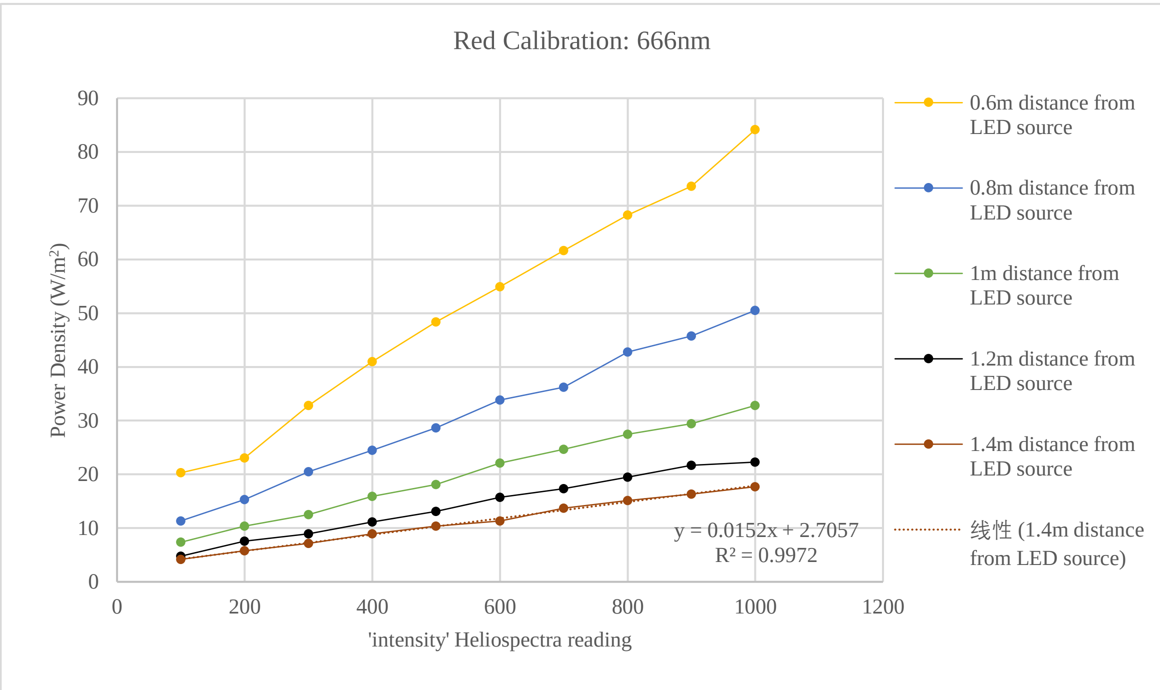
Figure S1. Schematic diagram of the Heliospectra LED source calibration setup.

The calibration graphs were obtained for the range 1.4m – 0.6m from LED (where the plants grew between 1.4m and 1.2m from the LED source in height, growing closer to the source, i.e. closer to

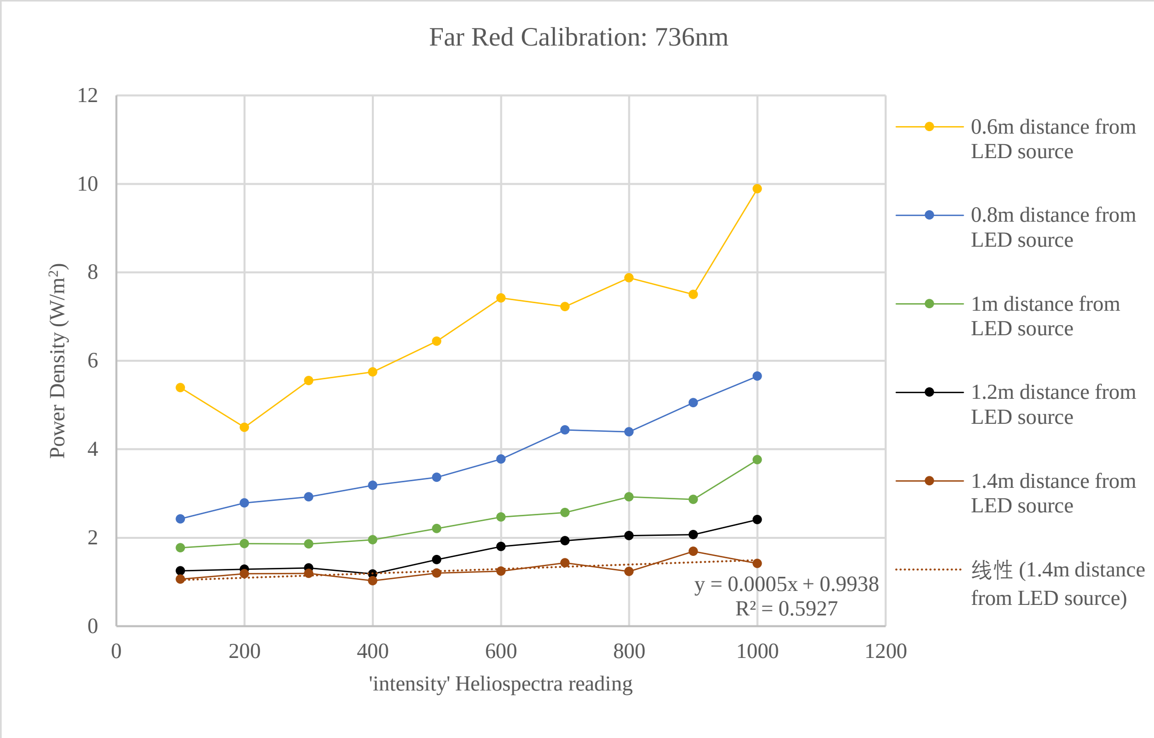
1.2m as growing). A linear regression line was fitted to the 1.4m from LED source data, which is approximately at pot height (the pot top being ~13cm from ground).



(a)



(b)



(c)

Figure S2. The power density calibration plots of the Heliospectra LED source.

Photon flux density (PFD) calibration to the Heliospectra 'intensity' reading

The photon flux density (PFD) is the number of photons in the wavelength regions under consideration (μmolm^{-2}s^{-1}) [3]. The wavelength regions of interest are selected due to their relevance to either the photosynthetic response, and/or the plant production yield. Using the power density (W/m^2), and the formula to convert the power density to PFD as shown below [4].

1 Js^{-1} = 1W

Photon Irradiance (mol.m^{-2}.s^{-1}) or Photon Flux Density (PFD) = $\frac{E}{\left(\frac{c.h}{\lambda}\right).N}$

Where:

E = Energy (J)

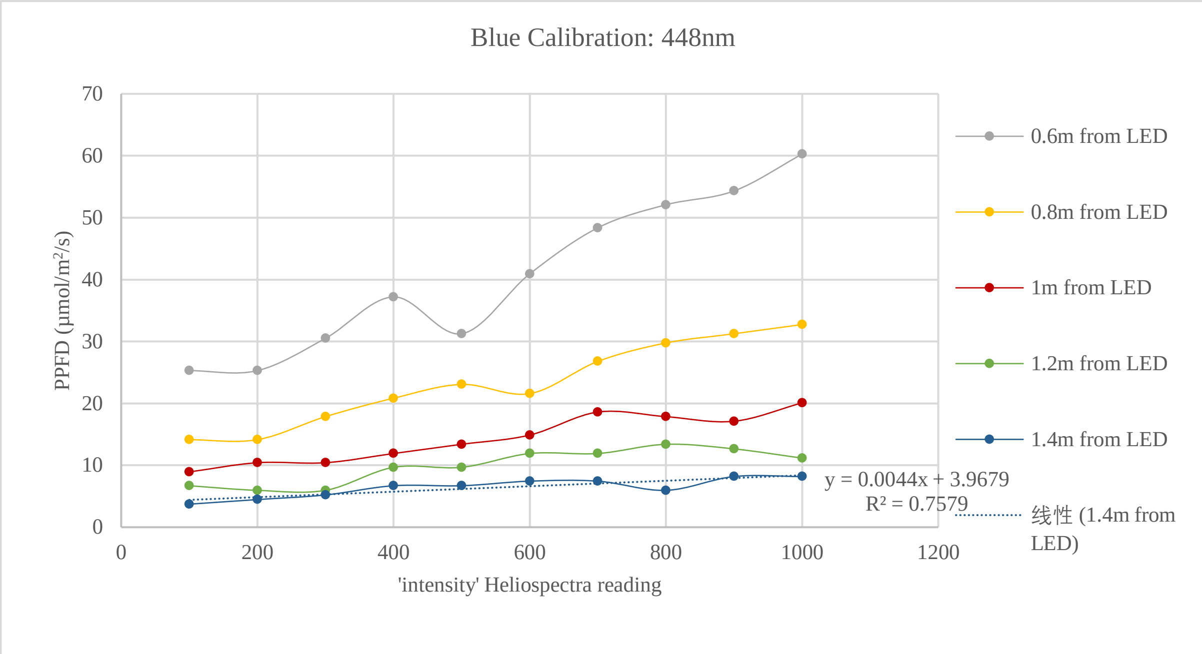
c = Speed of light = 3.0 x 10^{8}ms^{-1}

h = Planck's constant = 6.63 x 10^{-34}Js

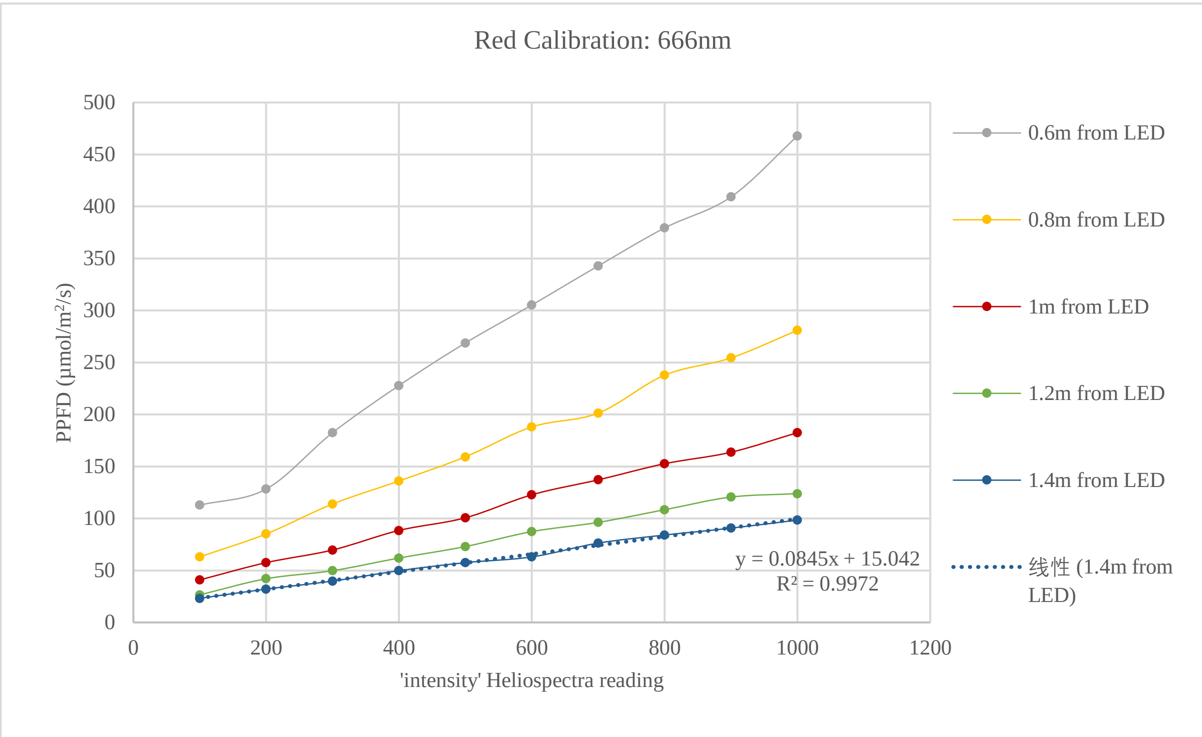
N = Avogadro's number = 6.023 x 10^{23} quanta mol^{-1}

λ = wavelength (m)

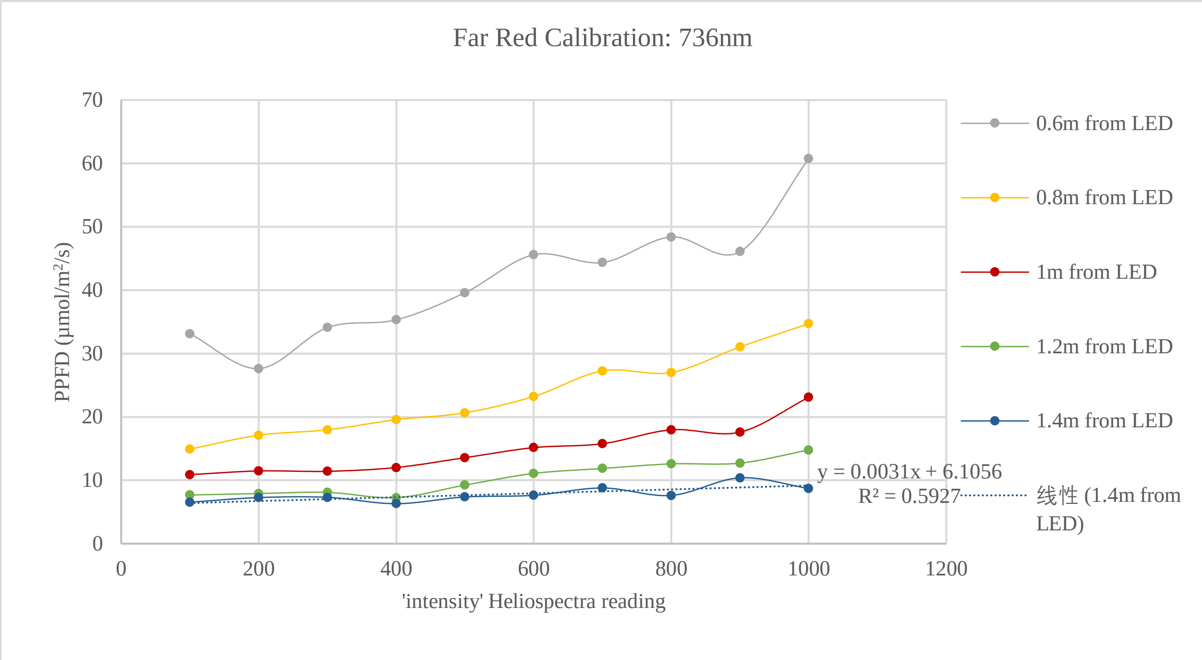
A linear regression was then applied to the 1.4m results (measured from the LED down to the top of the pot).


Blue Calibration: 448nm
PPFD (μmol/m²/s)
'intensity' Heliospectra reading
0.6m from LED
0.8m from LED
1m from LED
1.2m from LED
1.4m from LED
线性 (1.4m from LED)
y = 0.0044x + 3.9679
R² = 0.7579

(a)


Red Calibration: 666nm
PPFD (μmol/m²/s)
'intensity' Heliospectra reading
0.6m from LED
0.8m from LED
1m from LED
1.2m from LED
1.4m from LED
线性 (1.4m from LED)
y = 0.0845x + 15.042
R² = 0.9972

(b)



(c)

Figure S3. The photon flux density calibration plots of the Heliospectra LED source.

The PFD values determined were:

Tent 1 – White at 1000 'intensity': ~101µmolm^{-2}s^{-1} (3 s.f.)
Tent 2 – Blue at 1000 'intensity', Red at 458 'intensity': ~ 61.9µmolm^{-2}s^{-1} (3 s.f.)
Tent 3 – Blue at 1000 'intensity', Red at 458 'intensity', Far Red at 1000 'intensity': ~70.6µmolm^{-2}s^{-1} (3 s.f.)

Wavelength calibration of Ocean Optics fibre spectrometer

Periodically, tests of the wavelength calibration accuracy of the fibre spectrometer instrument were made, using a range of diode-pumped solid-state, semiconductor, and gas (red He-Ne) laser sources of known wavelength.

The technical essence of the procedure is checking that a light source of a particular central wavelength, FWHM bandwidth, and spectral emission line shape, is measured with the spectrometer as a spectral distribution fitting these specifications, to an acceptable degree of error (usually being about ± 1nm for most optical source measurements not requiring mode distrubution analysis, or the characterisation of longitudinal coherence properties).

It is necessary to check the wavelength calibration stability and accuracy across the entire spectrum range of the measurements required, therefore, three solid-state laser sources were commonly used, eg a 473 nm blue laser, 532 nm green diode-pumped solid state (DPSS) laser (featuring frequency doubling of a stable 1064 nm radiation line from a Nd:YAG crystal pumped by a 808 nm semiconductor laser), a 635 nm red DPSS laser, and eg a 670 nm semiconductor laser. These sources covered the entire spectral range of interest where the broadest (white LED) Heliospectra source had any significant optical output. The maximum spectral drifts noted so far in the spectrometer wavelength calibration never exceeded about ± 1nm, gauged from the spectral positions of the measured emission peaks with respect to the known wavelengths.

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