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Spectral Power vs PFD:

How to interpret spectral power versus photon flux density in light spectra for plant growth.

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How to interpret spectral power versus photon flux density in light spectra for plant growth

Do y-axis units matter when interpreting my light spectrum? Yes!

Have you ever scratched your head looking at a light spectrum graph when selecting a light source or planning an experiment? If so, you are probably not alone. A web search for "LED light spectra" will return not only a wide range of spectra, but also several different y-axis units. It is challenging enough to understand how your light spectrum guides plant growth and may affect your experiment; the y-axis units should not be another barrier preventing you from reliably comparing light spectra. The two most common units for the y-axis of spectral graphs are **spectral power** and **photon flux density (PFD).** Most often these units are expressed as a percent (%) of the highest peak value, commonly titled *Normalized Spectral Power (%)* or *Relative Spectral Power (%)* for spectral power or *Normalized PFD (%)* or *Relative PFD (%)* for PFD. Do spectra change if expressed as either spectral power or PFD? Yes! Below 562nm (UV, blue, green) spectral power is greater than PFD, and above 562nm PFD is greater than spectral power (Figure 1). These differences are because shorter wavelengths have more energy per photon and longer wavelengths have less energy per photon.

The reason spectra are usually expressed as a percent (%) of the highest peak value is to easily compare two or more spectra. Comparing two or more spectra in their actual units (spectral power: W m^{-2} nm^{-1} or PFD: µmol photons m^{-2} s^{-1} nm^{-1}) can be difficult to compare if expressed on the same axis due to differences in intensity (Figure 2). Spectral power can be any multiple of watt (W), with milliwatt (mW) and watt (W) being most common. PFD can be expressed as any molar multiple of photons, however is almost exclusively expressed as micro mol (µmol) photons. For plant growth and development, PFD is the preferred unit to use and compare spectra, and is the standard unit for light intensity for plant growth (Photosynthetic PFD, PPFD, sum of photons from 400 to 700nm). Recently ePAR has been proposed to replace PPFD as the standard light intensity unit for plant growth (Figure 2A).[1-3] Most light quality research reports and uses PFD in calculating color percentages (eg. %Blue), color ratios (eg. Red:Far-red), and other light quality parameters such as the Phytochrome PhotoStationary State (PSS) and Far-red Fraction.[4-10]

If you have access to the spectral power data from a given spectrum, in any W multiple, you can convert this data into PFD by using this calculator from Apogee Instruments:
https://www.apogeeinstruments.com/content/PPFD-to-Illuminance-Calculator.xlsx

For more information on how your light spectrum affects plant growth, please read: *How does the spectrum of my light source affect the growth of my plants?*[11]

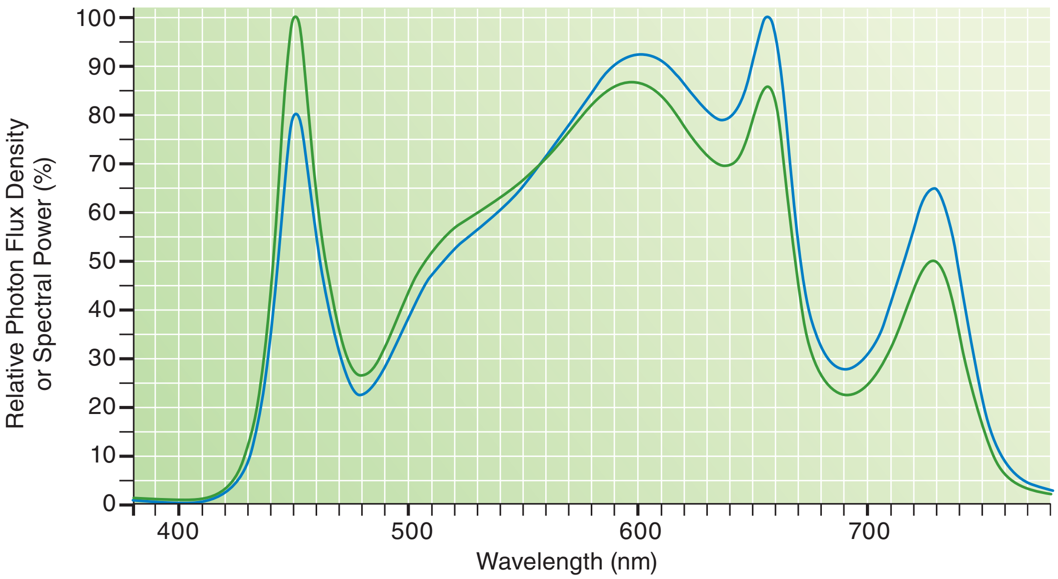

Figure 1:
Relative Photon Flux Density compared to Relative Spectral Power. Data is from the same measurements. Data are the average of 14 measurements taken in two BioChambers FXC-10s and two BioChambers FXC-19s in multi-tier modes, at shelf height (45 to 84cm from lights), center of the growth area, at 20°C. Fluence PhysioSpec Indoor and far-red (Pfr Spec) were both at 50% intensity.

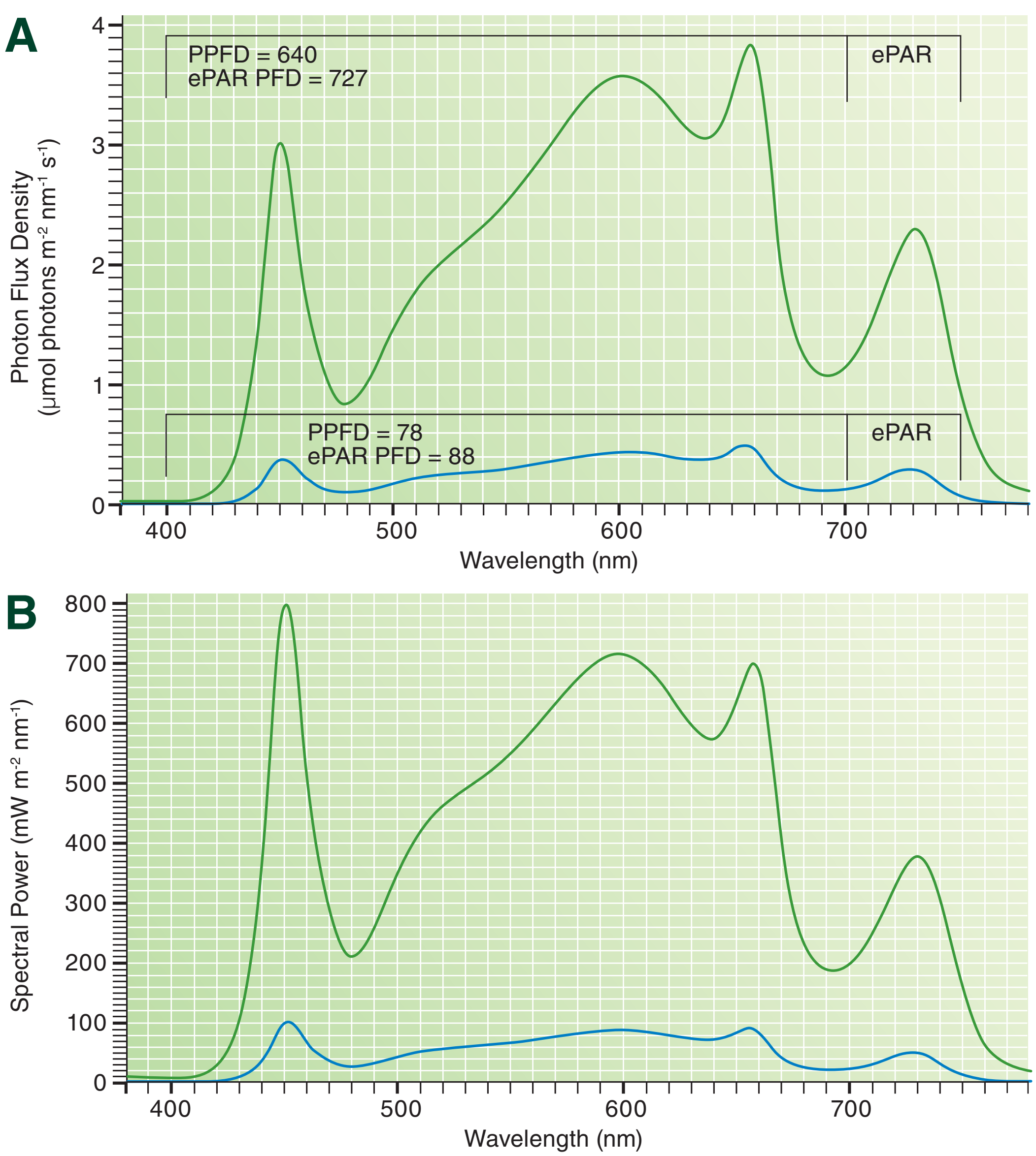

Figure 2:
A) Photon Flux Density and **B)** Spectral Power at 10% and 100% intensity of both Fluence PhysioSpec Indoor and far-red (Pfr Spec). In **A)** PPFD = Photosynthetic Photon Flux Density (sum from 400 to 700nm). ePAR PFD = Extended PAR, extended PPFD (sum from 400 to 750nm).[1-3] Data is from the same measurements taken on the top shelf of a BioChambers FXC-19 in two-tier mode, center of the growth area, 77.5cm from the lights, at 20°C.

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