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SHORT REPORT

SPECTRAL COMPARISONS OF SUNLIGHT AND DIFFERENT LAMPS

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The following tables were compiled to characterize the spectra of available lamp types and provide comparison to the spectra of sunlight.

Table 1 reports the spectral distributions for various lamp sources and compares them to those measured for sunlight. All of the values are normalized to 100 μmol $m^{-2}s^{-1}$ of PAR (400-700 nm) in order to simplify calculations. To use this table, simply establish the level of PAR that is desired, or measured, under various lamp sources and multiply by a multiple of 100. For example, if 300 μmol $m^{-2}s^{-1}$ of PAR are desired and you are using Cool-White fluorescent lamps, multiply any spectral range listed for Cool-White lamps by 3. Thus, if you are interested in the amount of ultraviolet light (350-400 nm) present in 300 μmol $m^{-2}s^{-1}$ of Cool-White fluorescent light, simply multiply 1.11 by 3 which gives a total of 3.33 μmol $m^{-2}s^{-1}$ of ultraviolet light. The amount of red light (600-700 nm) available under these conditions would be 3 x 22.56 = 67.68 μmol $m^{-2}s^{-1}$, the amount of far-red light (700-750 nm) would be 1.40 x 3 = 4.2 μmol $m^{-2}s^{-1}$, etc. Note that the wavelength ranges do not correspond exactly to the defined regions for UV-B (280-320 nm), UV-A (320-400 nm) and Far-red (700-800 nm). This was done arbitrarily to facilitate comparison of the active wavebands for different plant responses. The percentages relate the relative number of photons in various sources to sunlight. Thus, only Xenon has a solar spectral distribution in all of the visible wavelength regions, but it has about twice the relative amount of short wave UV-B. It also has much more infra-red radiation that does not appear in this table, which limits its usefulness. Other sources should be chosen for the relative importance of different wavelength regions since they all vary significantly from sunlight.

Table 2 provides the amount of energy in Wm^{-2} relative to the number of photons of PAR (400-700 nm) for each light source. This calculation can be further simplified by simply multiplying the PAR value in μmol $m^{-2}s^{-1}$ by 0.2 to obtain the energy content of this region since none of the sources tested vary by more than 0.02 Wm^{-2}. In addition, Table 2 allows an accurate determination of the number of photons of PAR, even if a photometric instrument (lux or foot-candle meter) is used to measure this value. Simply multiply the number of lux or the number of foot-candles given in the table by the number of photons of PAR desired for each lamp source and set the corresponding photometric value accordingly. Thus, if 300 μmol $m^{-2}s^{-1}$ of Cool-White fluorescent light is desired multiply 79 lux or 7.3 foot-candles by 300 and set the meter to read 23,700 lux or 2,190 foot candles. For Vita-Lite fluorescent the same amount of PAR would be obtained by setting 18,900 lux or 1,770 ft-c; for metal halide 22,350 lux or 2,070 ft-c, but low pressure sodium would require 31,800 lux or 2,955 ft-c. Note that only the wide spectrum Gro-Lux and Xenon are equivalent to sunlight for this calculation.

TABLE 1. Spectroradiometer measured photons in various wave bands for sunlight and different lamp types normalized to 100 μmol m-2 s-1 of PAR (400-700 nm). Percentages are the amounts of photons relative to sunlight.*

Light Source	Barrier	ULTRAVIOLET 250-350	ULTRAVIOLET 350-400	BLUE 400-500	GREEN 500-600	RED 600-700	FAR-RED 700-750
Sunlight	**None**	**2.88**	**6.21**	**29.16**	**35.20**	**35.64**	**17.00**
Incandescent (100W)	1/8 in. Plexiglas	0.00 0%	0.47 7%	7.52 26%	28.49 81%	63.98 180%	47.00 276%
Cool White Plexiglas	1/8 in.	0.03 1%	1.11 18%	24.85 85%	52.59 149%	22.56 63%	1.40 8%
Vita-Lite	None	0.54 19%	2.32 37%	26.31 90%	40.69 116%	33.00 93%	7.00 41%
Gro-Lux Original	None	0.16 6%	3.72 13%	29.36 101%	20.22 57%	50.42 141%	1.01 6%
Gro-Lux Wide Spectrum	1/8 in. Plexiglas	0.00 0%	0.83 13%	19.78 68%	32.52 92%	47.70 134%	10.00 59%
High Pressure Sodium	None	0.17 6%	0.53 9%	6.52 22%	56.57 161%	36.91 104%	4.00 24%
Low Pressure Sodium	None	0.03 1%	0.15 2%	0.12 0%	99.33 282%	0.54 2%	0.04 0%
Metal Halide	None	0.66 23%	6.71 108%	20.38 70%	55.52 158%	24.10 68%	4.00 24%
Xenon	None	5.81 202%	7.66 123%	26.88 92%	34.17 97%	38.94 109%	19.00 112%
Microwave	1/4 in. Plexiglas	0.00 0%	0.68 11%	23.99 82%	45.00 128%	31.00 87%	10.00 59%
Cool White plus Incandescent (100W) In a 3:1 ratio	1/8 in. Plexiglas	0.02 1%	1.03 17%	22.63 78%	49.22 140%	28.15 79%	8.00 47%
LED 660	None	0.00 0%	0.00 0%	0.00 0%	0.06 0%	99.94 280%	0.31 2%
LED 735	None	(0.07) -2%	0.00 0%	(0.03) 0%	(0.03) 0%	0.00 0%	100.00** ---

* Measurements by Gerald Deitzer, University of Maryland.

** Normalized to 100 μmol $m^{-2}s^{-1}$ of photons in 700-750 nm waveband.

Table 2. Calculated conversion values for spectroradiometric data of Table 1.*

Light Source	Barrier	PAR $W\ m^{-2}$ per $\mu mol\ m^{-2}s^{-1}$	Photometric	
			Lux per PAR ($\mu mol\ m^{-2}s^{-1}$)	Ft-c per PAR ($\mu mol\ m^{-2}s^{-1}$)
Sunlight	None	0.22	55.18	5.13
Incandescent	1/8 in. Plexiglas	0.20	49.00	4.56
Cool White (100 W)	1/8 in. Plexiglas	0.22	78.75	7.32
Vita-Lite	None	0.22	62.78	5.84
Gro-Lux Original	None		37.02	3.44
Gro-Lux Wide Spectrum	1/8 in. Plexiglas	0.21	55.09	5.12
High Pressure Sodium	None	0.20	83.28	7.74
Low Pressure Sodium	None	0.20	106.12	9.87
Metal Halide	None	0.22	74.50	6.93
Xenon	None	0.22	54.16	5.04
Microwave	1/4 in. Plexiglas	0.22	67.43	6.27
CoolWhite + Incandescent (100 W) In 3:1 W ratio	1/8 in. Plexiglas	0.21	74.53	6.93
LED 660	None	0.18	11.75	1.09
LED 735	None	----	----	----

* Calculations by Gerald Deitzer, University of Maryland.