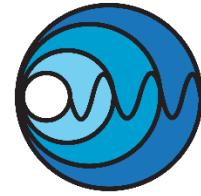


Photobiology



Nemalux[™]
INDUSTRIAL

Jode Himann | Nemalux Research | 12.01.2017

Photobiology is the study of light and its effect on living things. There has been a great deal of study on photobiology in the area of agriculture. This interest is growing because of the science becoming more refined and the marketplace developing. Some random notes and an initial Nemalux fixture spectra is shown.

McCree Curve: K. J. McCree (1970) studied and developed the action spectrum, absorption and quantum yield curves of photosynthesis in crop plants. The action spectrum is commonly known as the McCree Curve. McCree curve shows the wavelengths shows the relative photosynthesis response in the between 400-700 nm (commonly known as photosynthetically active region or PAR) for plants growth. This is also known as generalized PAR curve. McCree also showed the relative quantum yield and relative absorption for 400-700nm region. This work has been the basis of all of the researches that followed until now.



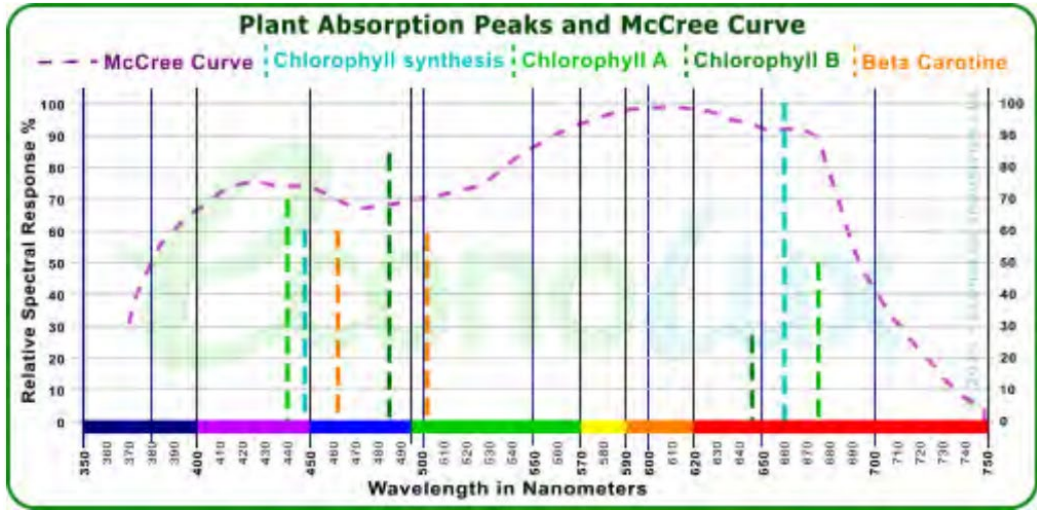


Image : Econolux

Action curve vs Absorption curve: Action curve shows the wavelengths that are most effective for photosynthesis. On the other hand Absorption curve shows the wavelengths that are absorbed by Chlorophylls (Chlorophyll A & B) and Carotenoids.

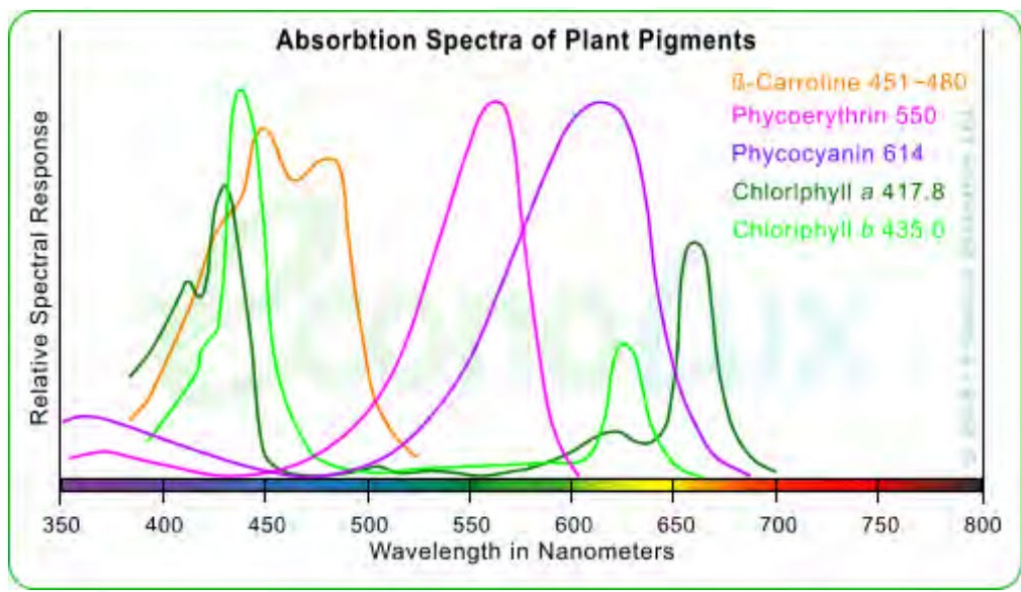


Image : Econolux

It is easily understood that most of the absorption happens in 400-500nm (blue) and 600-700nm (red) region. There's a very little absorbance in the 500-600nm (green) region. However, there are still 70% of the 550nm absorbance is present as the integrity of leaf increases.

Different studies shows that Chlorophylls responds to Blue (400 – 500nm) and Red (600-700nm) wavelengths. More specifically Chlorophyll A works with 400-450nm and 650-700nm, and Chlorophyll B

works 450-500 nm and 600-650 nm. Phycoerythrin requires 500-600nm and Phycocyanin requires 600-650nm.

Phytochromes shows activity mostly in red and far red wavelengths. Partial activity has been detected in green, blue, and near UV wavelengths.

Chrytochromes shows activity in blue and UV-A wavelengths.

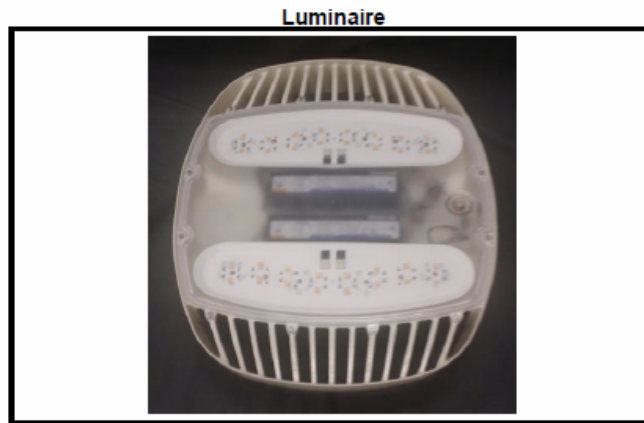
Vegetative cycle requires more blue and green wavelengths. Stem elongation requires blue, green, and red wavelengths.

Flowering and fruit cycle requires more red with other wavelengths from PAR spectra.

Radiant power in 400-700nm is measured in PAR (Photosynthetic Active Radiation). Illuminance on a surface is measured in PPF (Photosynthetic Photon Flux Density). Illuminance is measured in PPF (Photosynthetic Photon Flux) and the unit for this is $\mu\text{mol m}^{-2} \text{s}^{-1}$ (micromoles per sq. meter per second) Higher PPF levels increases the growth rate for the plants.

$1\mu\text{mol m}^{-2} \text{s}^{-1}$ PAR = 5 Fc (visible) sunlight. The $\mu\text{mol m}^{-2} \text{s}^{-1}$ to lux/fc varies for different light sources.

Regular grow light users uses 40% Red, 60% blue, 2-3% UV



Luminaire Characteristics

Luminous Length: 19.50 in.
Luminous Width: 16.50 in.

Summary of Results

Integrating Sphere

Luminous Flux: 20940 Lumens
Efficacy: 79.4 lm/w
CCT: 3344 K
CRI (Ra): 87.9

Distribution

Total Luminaire Output: 20380 Lumens
Luminaire Efficacy: 77.5 lm/w
Maximum Candela: 7510 Candela

Electrical Data at 120 VAC

Test Temperature: 25.3 °C
Voltage: 120.1 VAC
Current: 2.199 A
Power: 263.6 W
Power Factor: 0.998
Frequency: 60 Hz
Current THD: 4.73 %

Horticultural Lighting - Integrating Sphere

Integrating Sphere Test Conditions

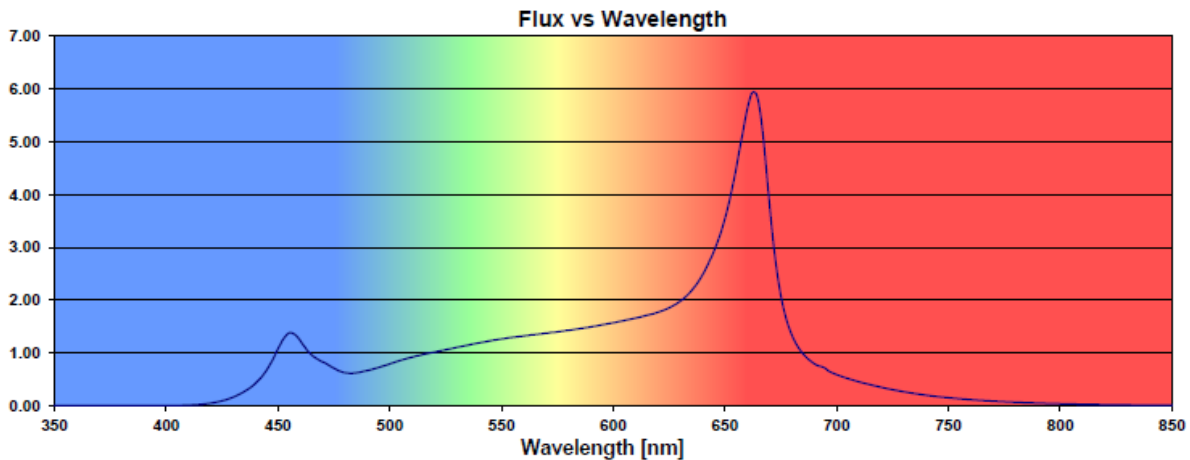
Temperature	Voltage	Current	Power	Power Factor	Frequency	Current THD
25.3 °C	120.1 VAC	2.199 A	263.6 W	0.998	60 Hz	4.73 %

Summary of Results

Radiant Flux	89.20 Watts	Radiant Efficiency:	33.8 %
Luminous Flux:	20940 Lumens	Luminous Efficacy:	79.44 lm/W
PPF (400-700nm):	420.67 µmol/sec	PPF Efficacy:	1.5959 µmol/sec/W
PAR Flux(350-800nm):	441.83 µmol/sec	PBAR Efficacy:	1.6761 µmol/sec/W
Lumens to µmol/sec conversion factor: 0.020089 µmol/sec/lm			

	Wavelength Range [nm]	Photon Flux [µmol/sec]
UVA	350 - 360	0.083817
	360 - 370	0.081946
	370 - 380	0.083188
	380 - 390	0.073920
	390 - 400	0.072483
Violet	400 - 410	0.098155
	410 - 420	0.300566
	420 - 430	1.013601
	430 - 440	2.824641
Blue	440 - 450	7.110570
	450 - 460	12.988720
	460 - 470	9.911376
Cyan	470 - 480	7.204308
	480 - 490	6.349977
	490 - 500	7.297483
Green	500 - 510	8.637560
	510 - 520	9.742671
	520 - 530	10.637426
Yellow	530 - 540	11.521483
	540 - 550	12.324904
	550 - 560	12.982361
Yellow	560 - 570	13.520462
	570 - 580	14.043768
	580 - 590	14.635400

	Wavelength Range [nm]	Photon Flux [µmol/sec]
Orange	590 - 600	15.357557
	600 - 610	16.187630
	610 - 620	17.159301
	620 - 630	18.645746
Red	630 - 640	21.978003
	640 - 650	29.537594
	650 - 660	45.308579
	660 - 670	53.663808
	670 - 680	22.587203
	680 - 690	10.127313
	690 - 700	6.975558
	700 - 710	5.209338
Infrared	710 - 720	4.033192
	720 - 730	3.092984
	730 - 740	2.350011
	740 - 750	1.781522
	750 - 760	1.366261
	760 - 770	1.047543
	770 - 780	0.799815
	780 - 790	0.611601
	790 - 800	0.466052



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NEMALUX LED LIGHTING

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