Rofianda
Light Solutions

PAR, µmol/J, colours.

What does a plant really need?

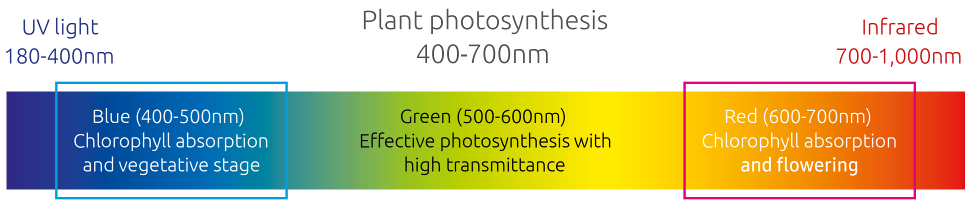
The switch from HPS to led brings a high insecurity about what is right and needed for the plant. The development of led brings endless possibilities in case of crop science and control, however the numerous possibilities causes confusion.

HPS, even though it was the best of the worst, was easy to use despite its limitations. This situation remained for a long time, until 10 years ago led was introduced and set a new standard for assimilation lighting. Red and blue light were introduced as the only wavelength that mattered to the plant.
This perception was based on the plant having green leafs and therefore it wouldn't adsorb green light.

Now 10 years later the confusion about the right wavelengths and colours has only increased; projects are still fitted with HPS and growers get more sceptical about led.

The rising question is: "what does a plant really need/use?"
To give a proper answer to that question we need to look further than only a specific wavelength.

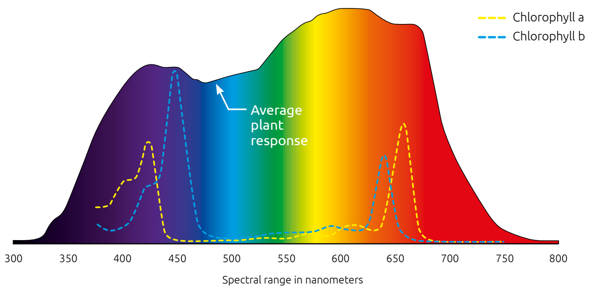
WAVELENGTH EFFECTS ON PLANT GROW



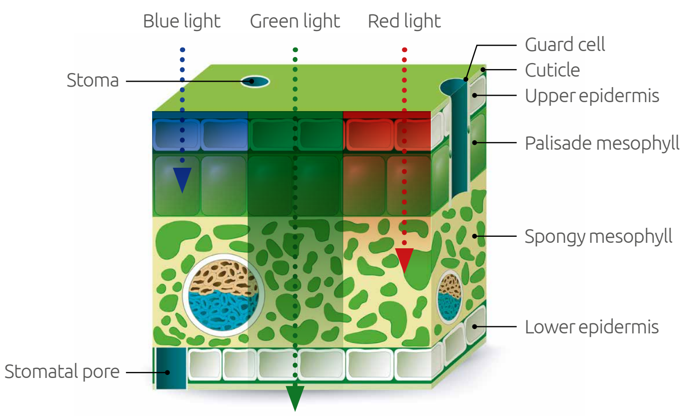
EFFECTIVENESS OR EFFICIENCY?

The efficiency of a fixture is measured in Watt/ m2. In general a plant is not that sensitive to the energy levels supplied. A plant is much more sensitive to the photons that the light contains. The number of photons is measured in PPE (photosynthetic photon efficacy) and shows the effectiveness of a fixture in the visible light range (350-800nm). PPE is the PAR photon divided by the power of the fixture needed to produce this level. This level, which is rated by µmol/W or µmol/J, shows the efficiency for the grower.

Several studies with different crops show that this effectiveness must have a more extensive description.



CHLOROPHYLL ABSORPTION AND PHOTOSYNTHETIC RESPONSE IN ADSORBED PHOTONS AT DIFFERENT WAVELENGTHS



Crops do not grow with only red- (600-700nm) or blue- (400-500nm) light or a combination of these colours.
For an optimal growth and development, the full range of the visible spectrum is crucial and so is a part of UV and NIR.

These wavelengths do have a lower PAR contribution and therefore might have a negative influence on effectiveness.

SCHEMATIC FIGURE ON ADSORPTION OF MONOCHROMATIC LIGHT IN COLOURS BLUE, GREEN, RED

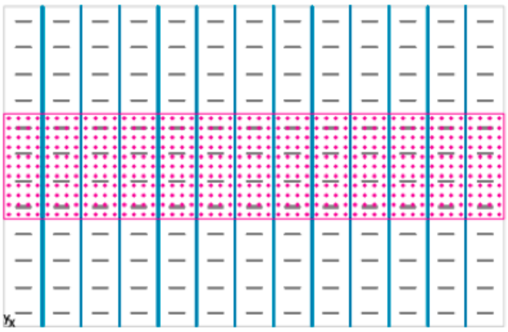
UNIFORMITY

Led has a limited beam angle of about 120°, therefore it is important to question the uniformity needed and how to create this. Placing lenses over the led's makes the beam angle smaller and reduces the scattering of the light. A smaller beam angle brings higher energy savings, however, a reduced uniformity might be a risk.
With HPS we had a wide and deep beam angle reflection which creates an uniformity of 70-80%.

One on one replacement with led lowers this uniformity till 40%, or even lower. It is important to be aware of this factor and the influences on the crop. It could be possible that an extra 1 or 2 light lines are needed to create the right uniformity.

By setting the right light scheme with the right measurements, lighting for every specific situation can be calculated.

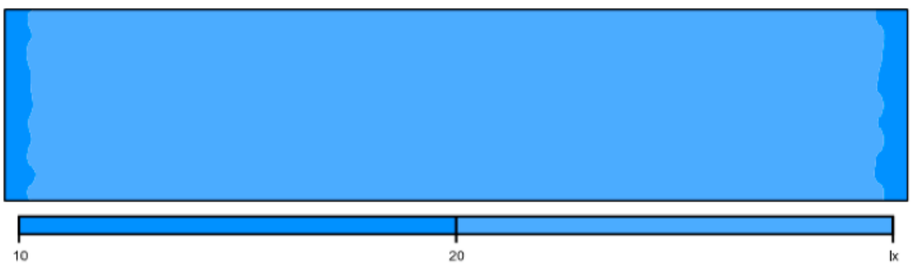
Greenhouse, measuring height 1,2m, 4,3m below fixtures / Perpendicular illuminance



Greenhouse, measuring height 1.2m, 4.3m below fixtures / Perpendicular illuminance (Grid)
Light scene: Light scene 1
Average: 24.4 lx, Min: 15.1 lx, Max 29,7 lx, Min/average: 0,62, Min/max: 0.51
Height 1.200m

Isolines (lx)
Scale: 1:327

False colours (lx)

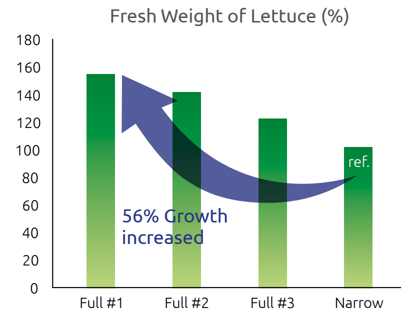


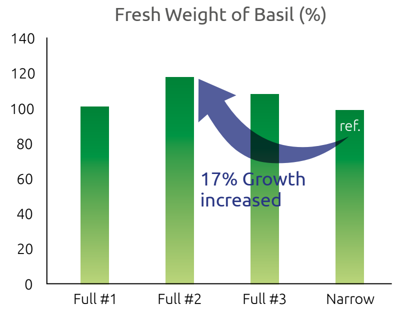
UNIFORMITY SHOWED IN A LIGHTING SCHEME BY DIALUX

MORE LIGHT (OR PAR) ALWAYS BETTER?

As written above it is very important to know what light a crop needs and how much it needs. Which spectral combination, which ratio and which amount of light.

Too much light and especially wrong lighting negatively influences growth and results. Several studies show that less lighting with a lower efficiency, but with a higher effectiveness has better results than just adding more light.



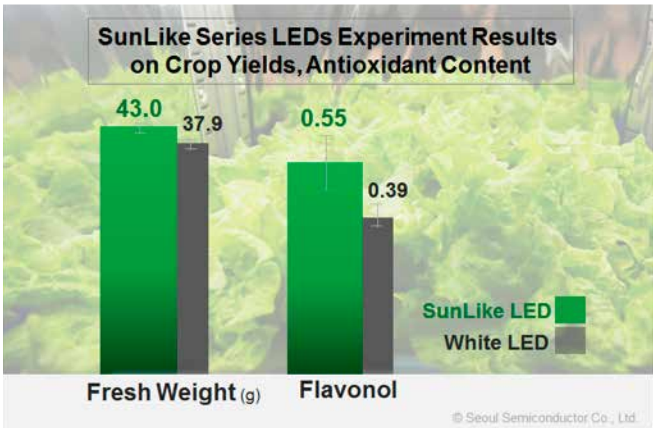


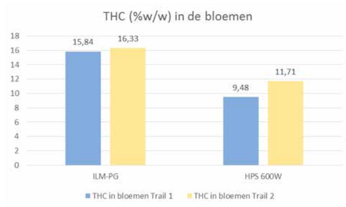
BAND LED (BLUE, DEEPBLUE, RED, FARRED)

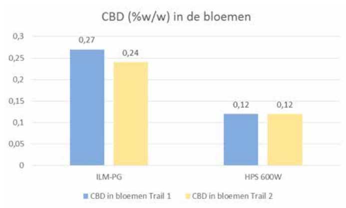
Growth chambers under 4 light conditions

	Blue	Green	Red
Full spectrum #1	1	4	4
Full spectrum #2	1	2	2
Full spectrum #3	1	2	12
Narrow spectrum	1	0	4

PPFD RATIO OF DIFFERENT LIGHT RECIPES







GROWTH RESULTS OF HIGH EFFECTIVENESS WITH LOW EFFICIENCY LIGHTING (LE) COMPARED WITH HIGH EFFICIENCY AND LOW EFFECTIVENESS (HE)

The ratio of 1:2:2 (blue:green:red) in artificial light is similar to sunlight and optimal for crop growth (seed to fruit).

A 10% share of far-red (700-800nm) and about 0,5% of UV-A (380nm) is necessary to have a crop with approximately 25% higher leaf surface and a stronger stem. This allows an easier flow of growth substances from the roots upwards.

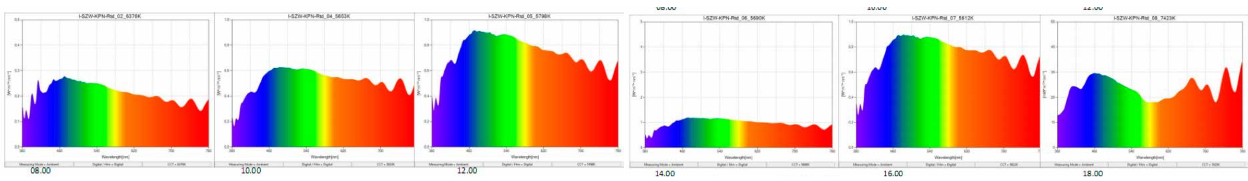
A combination of these factors results in a faster and better growth with higher yields.

SPECTRAL CHANGES DURING THE DAY OR PER LOCATION

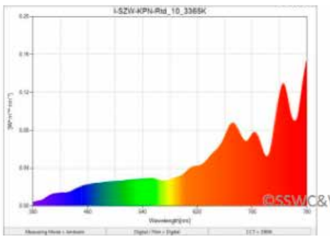
In this paper we claim that the composition of an artificial light source should be similar to sunlight. Another discussion which is often heard is, if that the spectral composition changes during the day and that is depends on the location.

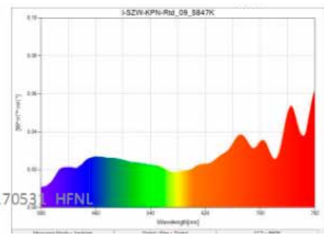
Measurements show that the spectrum only has minimum changes; most of them are during sunrise (more red) and sunset (more blue). The changes do not influence crop growth because of their short time period.

The light levels on the other hand, do change rapidly and can even rise up to 100.000 lux on sunny days. This fact confirms that sunlight is optimal for plant growth, for every type of crop. The only reason to work with coloured leds is to redirect the crop to a certain way if needed.



SUNRISE





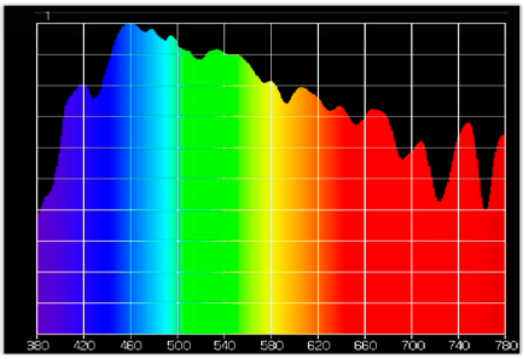
SUNSET

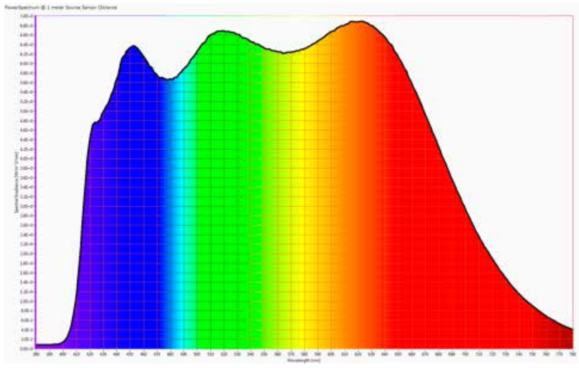
SPECTRAL COMPOSITION OF SUNLIGHT DURING THE DAY

CONCLUSION

Based on all the information mentioned above we can say that nature does quite a good job. 2 out of 4 seasons, spring and autumn, generate the right light for optimal crop growth. The climate is then stable enough to harvest a proper yield in combination with a good energy balance. Only during summer (too much light) and winter (too low light), light is not optimal. During summer we apply different techniques to keep the sun out and during winter we use artificial lighting.

All information combined; you must conclude that sunlight is optimal for crop growth.





Our assimilation lighting with the Sunlike V2 chip generates almost sunlight, with a ratio of 1,3:2:2 (blue:green:red), 0,4% UV-A and 7% NIR. We do this by only using 1 led chip for this spectral composition. Therefore we have the only fixture in the world which can be compared with true sunlight.

Spectrum Data

0,4 %	24 %	35 %	34 %	7 %	93 %
Ultraviolet	Blue	Green	Red	Far-red	PAR
< 400 nm	400-500 nm	500-600 nm	600-700 nm	700-800 nm	400-700 nm

CCT	CRI *	B:G Ratio	R:FR Ratio
5240	98	0.6	4.4

* highest in the industry.
CRI (color rendering index = the degree to which objects' colors render naturally under a light source)

RATIO OF ROFIANDA SUNLIKE V2 ASSIMILATION FIXTURES

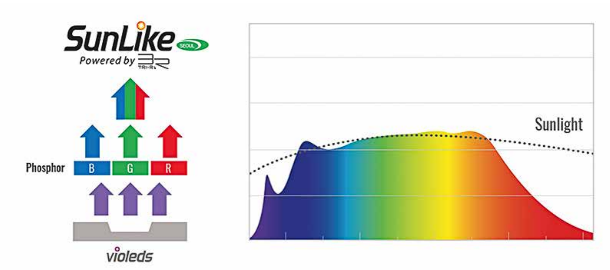
Rofianda
Light Solutions

Rofianda, in name of her founder Ronald Gronsveld, has well over 25 years of experience with development of lighting for plant growth. During 10 years this experience was gained from different international projects with companies like; Syngenta, Novartis, Bayer Crop Sciences and Monsanto.

Besides commercial companies, a lot of knowledge is gained by working with research institutes like the Universities of Utrecht, Leiden and Groningen (NL), but also institutes like e.g.:

- Max Planck (G)
- University of Basel (CH)
- Hudson Institute (Dundee, Scotland)
- University of Leeds (UK)
- University of Uppsala (S)
- John Innes Centre (UK)

Since 2004 Rofianda is co-developing lighting systems for agricultural and industrial use. During the past 4 years Rofianda has set up a co-operation with Seoul Semiconductor (South-Korea) and developed the Sunlike V2 led chip. This chip generates near sunlight. By using her knowledge and experience of Rofianda this unique fixture is available since December 2018.



ROFIANDA B.V.
Herastraat 43-07
5047 TX Tilburg
The Netherlands

Tel: +31-(0)13 - 85 00 964
Mail: info@rofianda.nl
www.rofianda.com