



Horticultural lighting

LEDiL
From Light to Lighting

Horticultural lighting

- Specific terms and units
- Lighting for plants – design approaches
- Optics for horticultural lighting
- Reference design with Cree LEDs

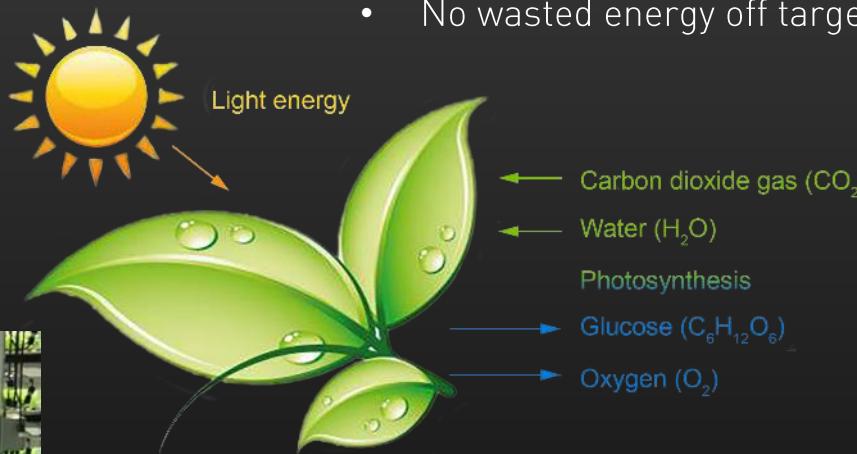


Why LED?

Horticultural lighting

Control of spectral content

- Better match of spectra to plant's needs
- By species / growth stage



Lower radiated heat

- Lights closer to plants → more dense farms
- Lower water consumption



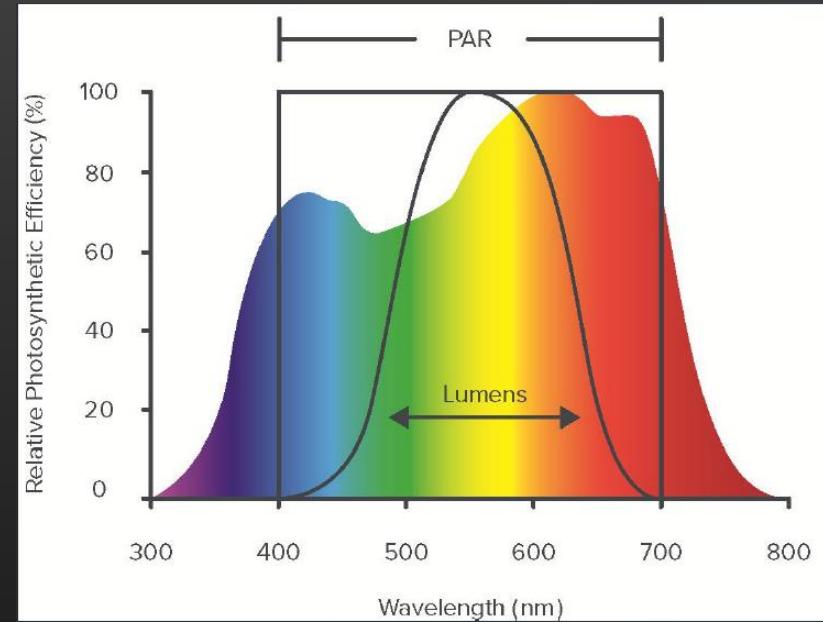
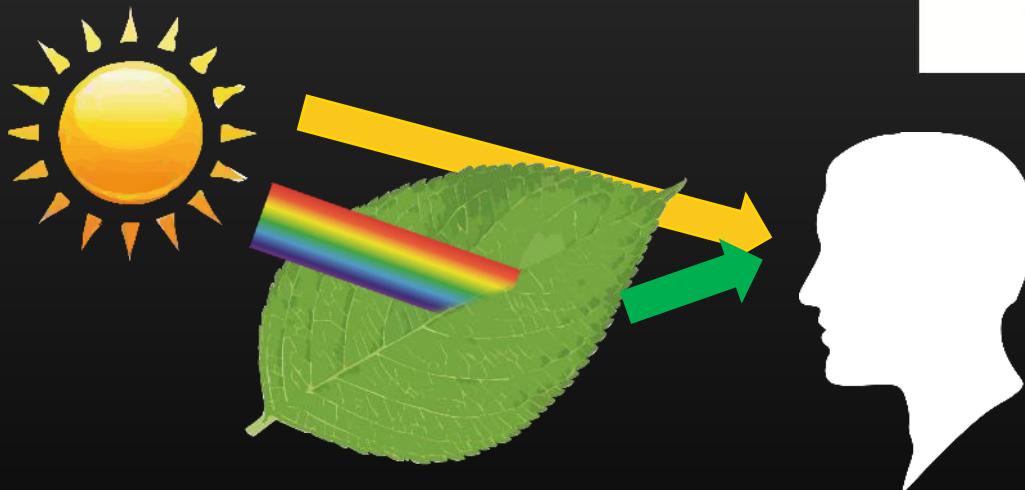
Sustainability

- Long lifetime of luminaires
- Lower maintenance costs

Lumens are for humans – Plants see photons

Horticultural lighting

- Plants have completely different sensitivity to light colors than humans
- Uniformity and constant quality of light spectrum is very important for production
- Plant growth strongly determined by PPF

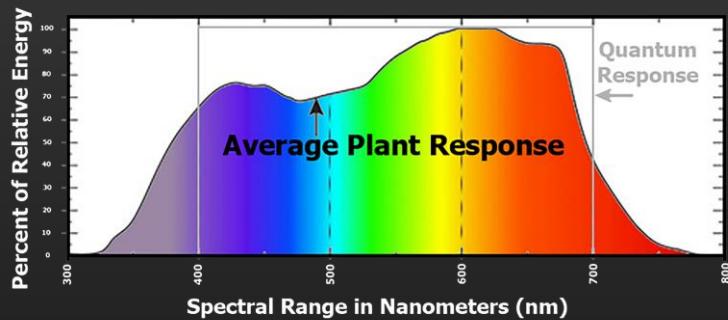


Specific terms and units

Horticultural lighting

- PAR (Photosynthetically active Radiation)
 - Spectral range between 400-700 nm

The McCree Curve



- PPF (Photosynthetic Photon Flux)
 - PPF is the total amount of PAR photons generated by luminaire
 - Measured in micromol / second
 - Similar to **lux**

- PPFD (Photosynthetic Flux Density)
 - PPFD is the total amount of PAR photons falling on target area
 - **ONLY PHOTONS THAT HIT THE TARGET COUNT**
 - Similar to **lux**

- DLI (Daylight integral)
 - DLI requirements vary by plant species
- PPF/W (Photosynthetic efficiency)
 - PPF/W is the luminaire's efficiency at converting electricity into PAR photons
 - Measured in micromol / Joule
 - Similar to **luxens/W**

Key questions

Lighting for plants – Design approach

Component

- LEDs
- Driver

Affecting

PPF &
Spectral Power

- Generating enough photons?
- Correct ratio of photons?

- Optics

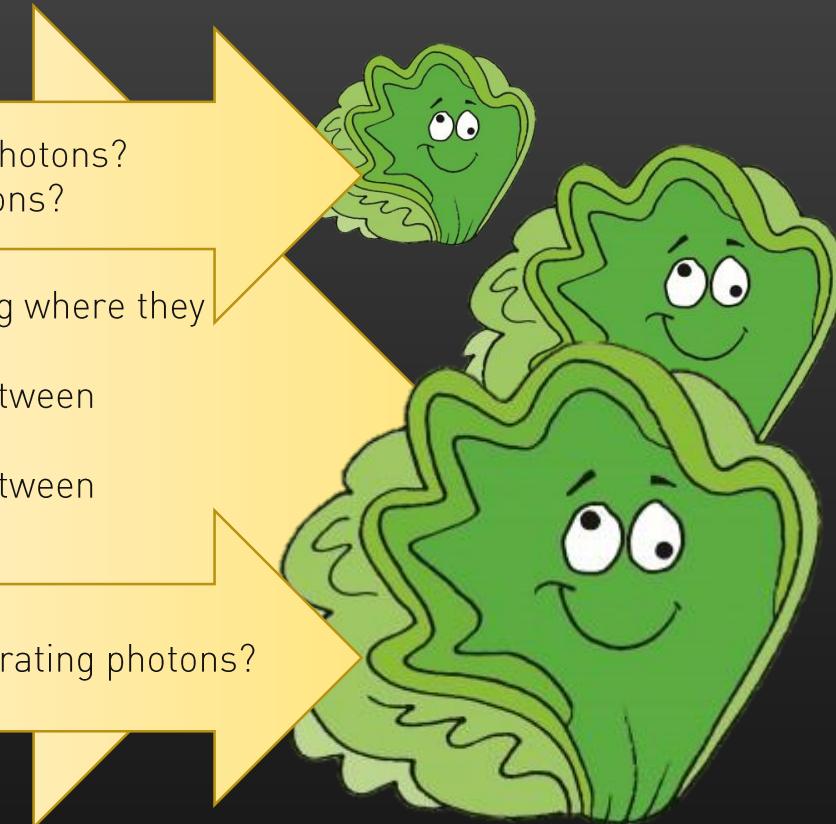
PPFD
(min, max,
uniformity)

- Are the photons going where they are needed?
- Distance required between luminaires
- Distance required between luminaire & plants?

- All

PPF/W
(efficacy)

- How efficient at generating photons?



Successful growlight fixture is the sum of it's components!

LEDiL

www.ledil.com

Maximize your usable efficacy

Horticultural lighting

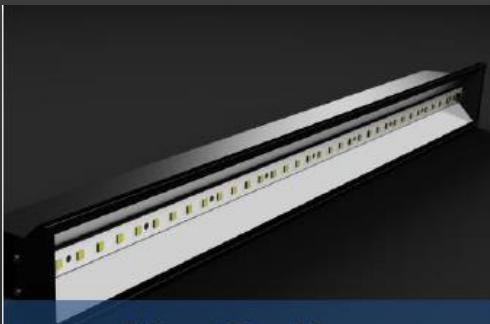
- Focus light energy into where it's needed
→ Greater yield with a greater PPFD and less electrical power
- Uniform intensity and spectral distribution
→ Healthier and more productive plants
- Optics help focusing the light into plants, allowing either greater crop yield and shorter grow cycles or reduced BOM costs of luminaire



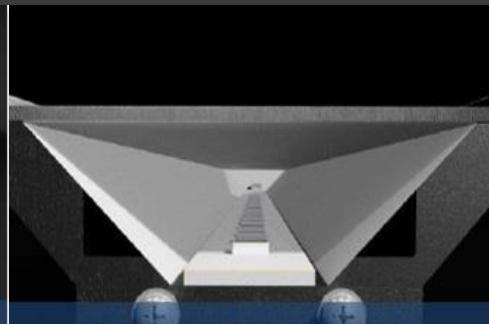
www.ledil.com

Optics for horticultural lighting

Horticultural lighting



No Optics



Simple Optics



Individual Optics



High Bay

Not Recommended

- Optics will greatly increase PPFD and are worth the cost

Lowest Cost

- Reflector/film improves PPFD and uniformity
- Enables wider range of mounting heights

High Performance

- Good uniformity
- Improved mixing for multi-color systems

Optics:

- Focus light into plants
- Increase both spectral and PPFD uniformity



Different ways to light

Different types of Top lighting and Intra-canopy lighting

➤ Top lighting - greenhouses

- General hall/greenhouse lighting from the roof
- Retrofitting old HPS or modifying spectral content
- **Challenges:** light concentration on plants, uniformity and constant quality of light spectrum, high amount of power needed



➤ Top lighting – vertical farming

- Emerging trend – illumination from top at a close distance
- **Challenges:** uniform intensity and spectral distribution, plants shading each other, photosynthetic efficiency (PPF/W), heat



➤ Intra-canopy lighting

- Illumination on the side or inside the plants
- Possible with LEDs (HPS too hot)
- **Challenges:** uniform PPFD, good color uniformity (if continuous/wide spectrum), spectrum fit to the rest of lighting



Different ways to light

LEDiL optics for different types of Top lighting and Intra-canopy lighting

➤ Top lighting - greenhouses

Optics: 60-90deg low/mid bay (beam depends on installation height) with a slight batwing for uniform illuminance

Beam examples

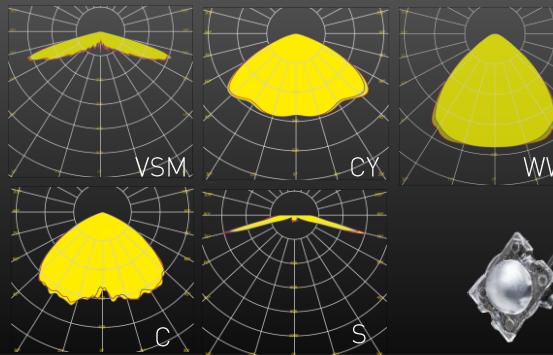


Optic examples



➤ Top lighting – vertical farming

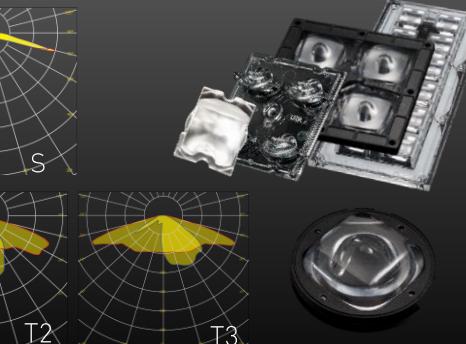
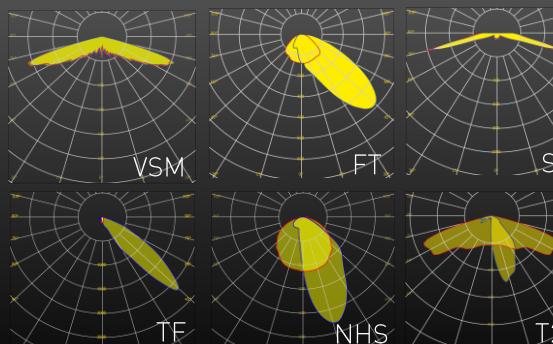
Optics: -VSM, -CY, -WWW, STRADA-C, STRADA-S or other >90deg optics, FLORENCE-3R with LED clusters for plants requiring a high DLI



➤ Intra-canopy lighting

Optics: -VSM, STRADA-S, STRADA-FT and other forward throw beams (TF, NHS, T2, T3)

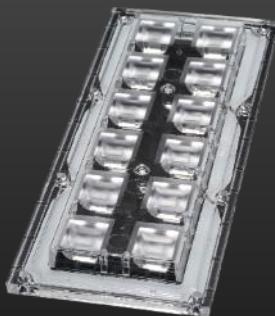
Potential: ZT25/ZT45 or WAS beams as an additional light installed in corridors for illumination of bottom parts of plants



IP High Bay & Linear lenses

Easier and cheaper solutions with up to IP67 for horticultural lighting

HB-IP-2X6

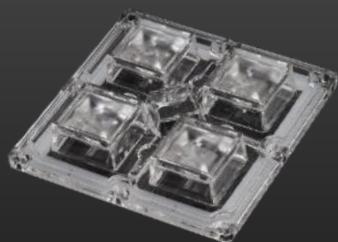


HB-IP-2X6-RS
HB-IP-2X6-M
HB-IP-2X6-W
HB-IP-2X6-WW
HB-IP-2X6-O

Up to 5050 size

HP

HB-2X2MX



HB-2X2MX-M
HB-2X2MX-W
HB-2X2MX-WWW

Up to 7070 size

Ultra HP

HB-2X2MXS



HB-2X2MXS-M
HB-2X2MXS-WW
HB-2X2MXS-WWW

Coming 1H2017

Up to 7070 size

Ultra HP

STELLA



STELLA-HB
STELLA-HB-WWW

Up to 30mm LES

COB

FLORENCE-3R-IP



FLORENCE-3R-IP-Z90
FLORENCE-3R-IP-Z60
FLORENCE-3R-IP-O

PMMA upon request

3x11 mid power modules

MP
HP



www.ledil.com

Horticultural lighting & chemicals

PC vs PMMA materials

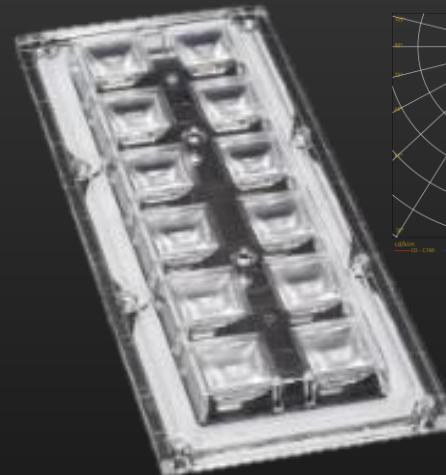
- In general PMMA is more resistant than PC to chemicals like ammonia that is a widely used fertilizer in horticulture
- General chemical behavior of PC:
 - » The chemical resistance of Makrolon® depends on the concentration of the substance, the temperature, the contact time and the internal tension level of the polycarbonate sheet due to fabrication etc.
- Check chemicals resistance from [LEDiL Installation Guide](#)
- We strongly recommend that every customer fully tests and takes the necessary measures to ensure a complete compatibility of the chemical used with one's particular product, LEDs and other components.



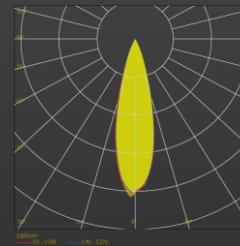
HB-IP-2X6

Ingress protected and efficient

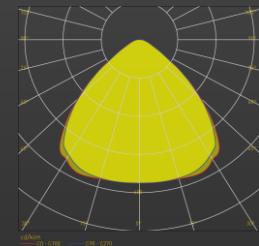
- Range of standard 2X6 modules compatible with high power LEDs
- Easy to achieve IP67 rated luminaire
- Full range of beam angles always optimizes your PPFD for different installation heights



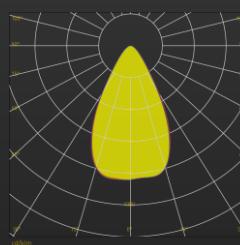
HB-IP-2X6-M



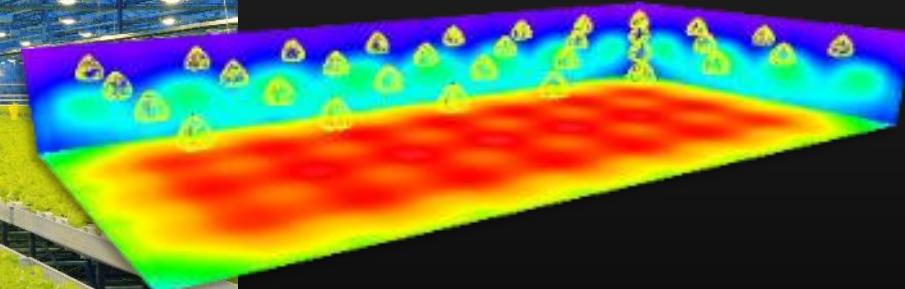
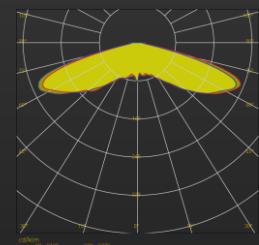
HB-IP-2X6-WWW



HB-IP-2X6-W



STRADA-IP-2X6-VSM



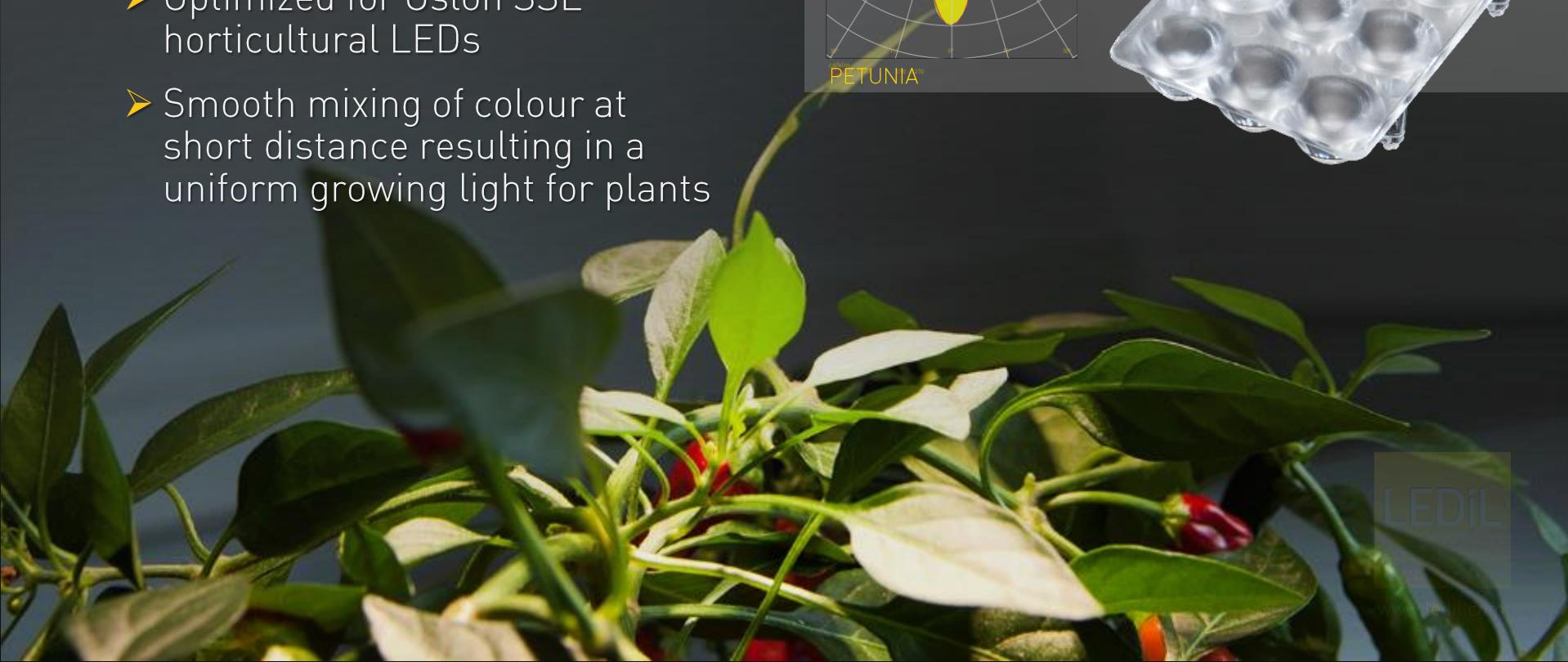
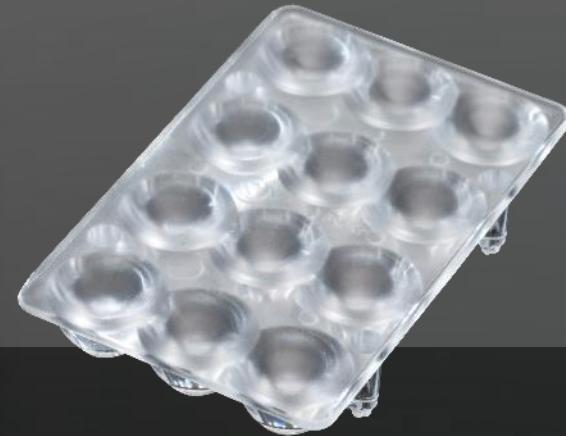
LEDiL

www.ledil.com

PETUNIA

Compact with good mixing

- Linear luminaires and consumer products
- Compact size (29.5 x 46.5 mm)
- Optimized for Oslon SSL horticultural LEDs
- Smooth mixing of colour at short distance resulting in a uniform growing light for plants



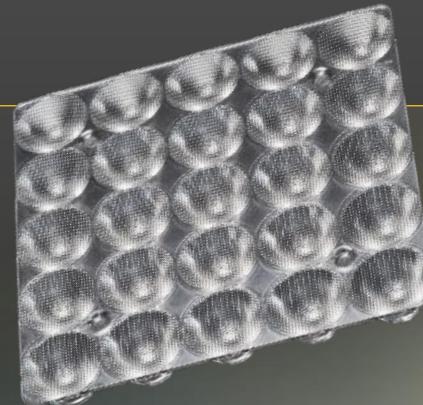
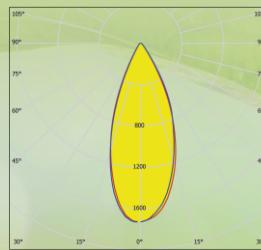
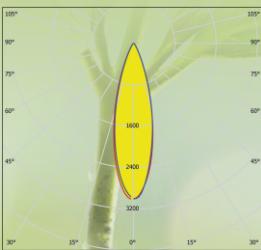
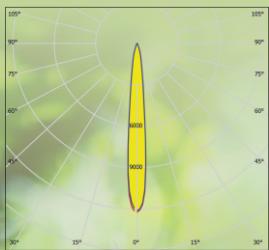
LEDiL

www.ledil.com

VIRPI

High density array

- 25 High-Power LEDs in a tight array
- High output module to maximize PPFD
- 3 different beam solutions to optimize installation height (S-14°, M-28° and W-42°)
- Dimensions: 74.9 x 74.9 x 9.4 mm



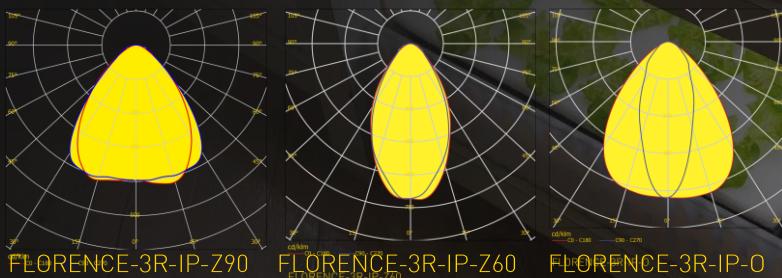
LEDiL

www.ledil.com

FLORENCE-3R-IP

33-up lens array for highly efficient mid-power LEDs

- Up to IP67 PC lens with an integrated silicone gasket
- LEDiL's proprietary color mixing surface helps to achieve uniform spectral and PPFD distribution
- 90°, 60° and oval beams
- Compatible with flat-package mid-power LEDs (primary) or High power LEDs such as Oslon SSL series. Can be used with single LEDs or clusters



PMMA variants soon available



Reference design

HPS top-light replacement with Cree LEDs and LEDiL's IP-2X6 family

- Modular design employing 4 engines
- Designed to match PPFD of 1 000 W DE HPS system at half power



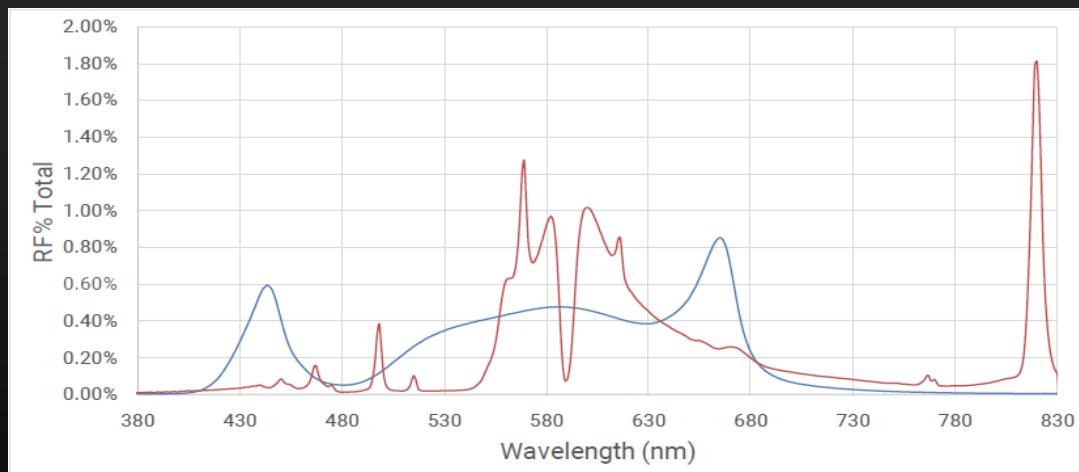
LEDs (Count)	144x XP-G3, 4 000 K, CRI 70 48x XP-E Photo Red
PPFD Average	320 $\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ @ 4.9 ft
PPF/W	1.82 $\mu\text{mol}\cdot\text{J}^{-1}$
Power	553 W
Dimensions (LWH)	63 x 38 x 8 cm
Weight	12.2 kg



Reference design

Simulated results at manufacturer recommended height

	Reference Design	Gavita 1000W HPS
Height (m)	1.5	1
PPFD Max	390	394
PPFD Min	182	184
PPFD Avg	320	303
PPFD Uniformity (min/max)	0.47	0.47
PPF / W	1.82	1.72
Power (W)	553	1064



Target was to match the HPS for relative amount of orange while increasing blue & green content

Reference design met the goals:

- Matching PPFD min/max
- Matching PPFD uniformity
- Reducing power consumption vs 1000W HPS
- No IR to heat up plants