LED Lighting Systems

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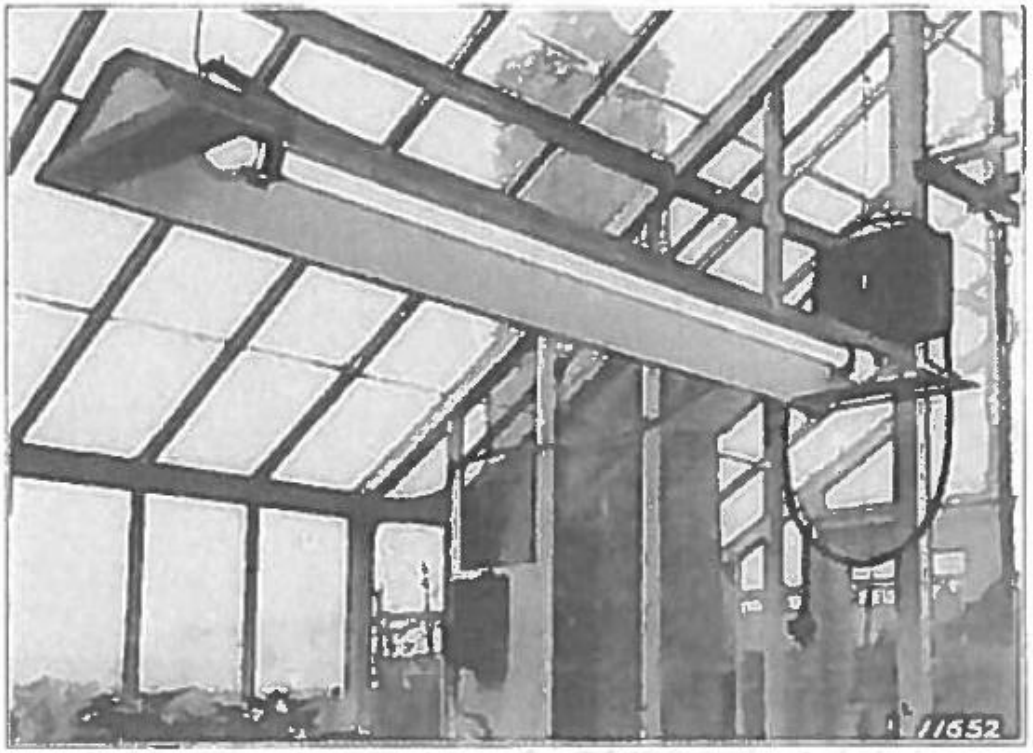
Background

- Three primary drivers
  - Photosynthesis
  - Photoperiodism
  - Photomorphogenesis



High Pressure Sodium supplementary lighting at 48 Wm^2 increases yields by

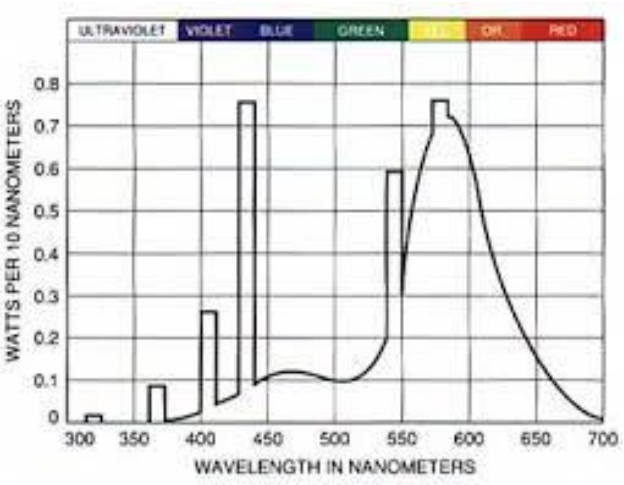
- Tomato: 18 to 25%
- Cucumber: 8 to 18%

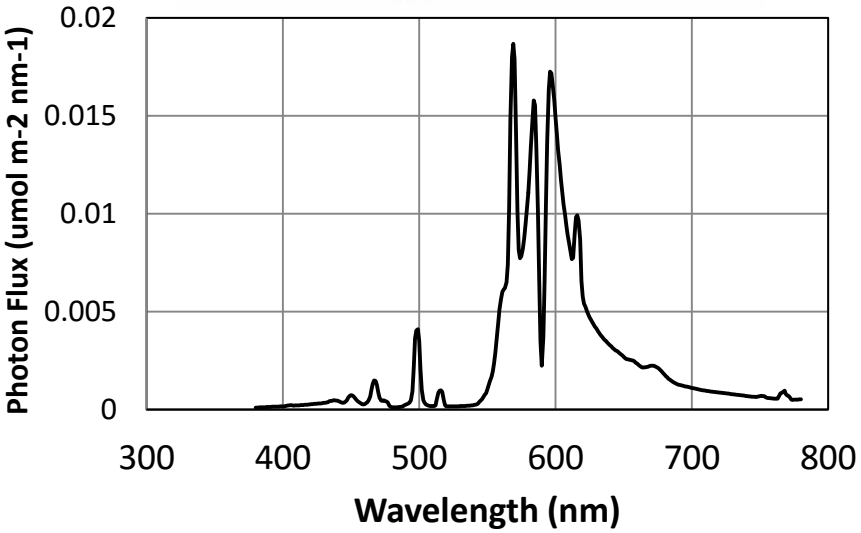
Blom and Ingratta, 1980

Artificial Light

•7% of the entire electrical load generated in the NL is used for crop lights

Standard Equipment





LED’s

A very large array of new systems are available

LEDs

- High energy efficiency…..+30%
- Haitz Law: Cost per lumen reducing by a factor of 10 every 10 years
- Controlled spectral output
- Defined luminaire distribution
- Long life

Though

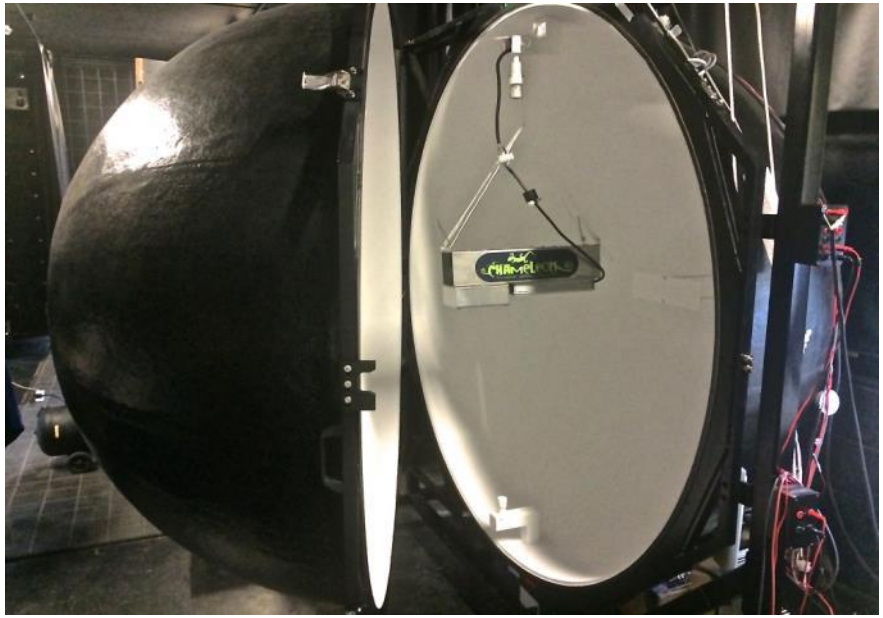
- Reduced total radiation output
- Which spectra for different crops….?

AHDB

Commercial Review of Lighting Systems for UK Horticulture.

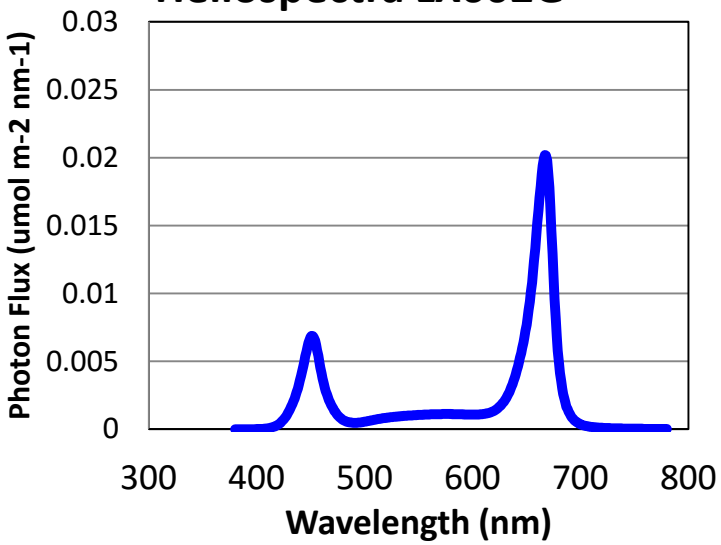
Objectives

- Test a number of commercial lighting systems.
  - Spectral output
  - uMol / W efficiency
  - Luminaire light distribution
- In an independent test lab.
- Very grateful to Phytolux, Chameleon, Heliospectra, Philips, Fionia for supply of lamps.

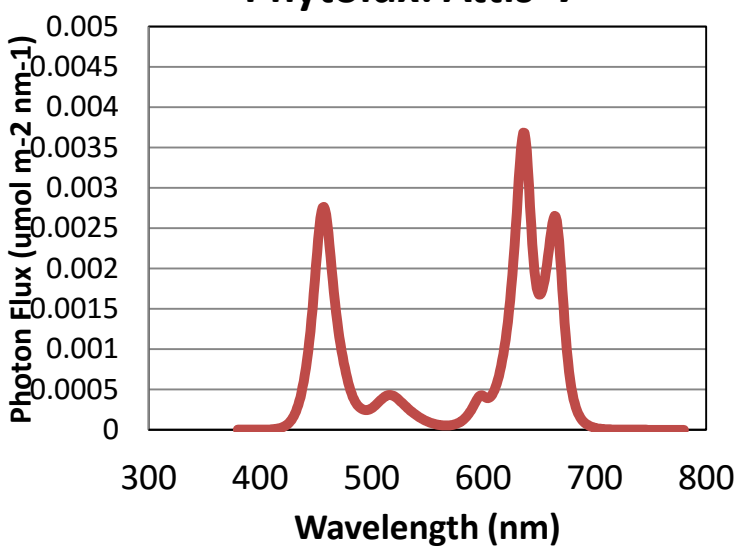


Integrating sphere at the LIA

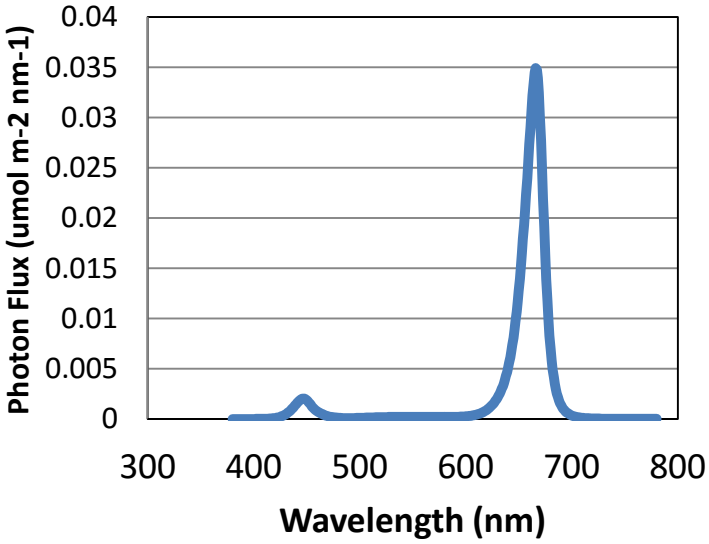
Heliospectra LX602G



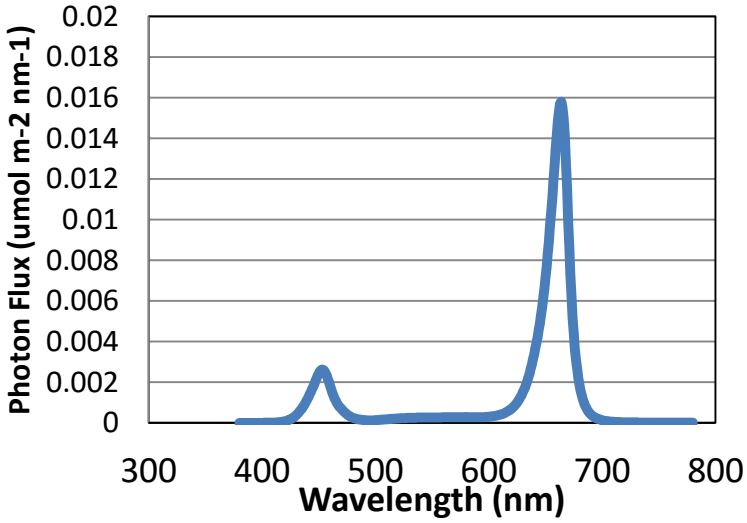
Phytolux: Attis 7

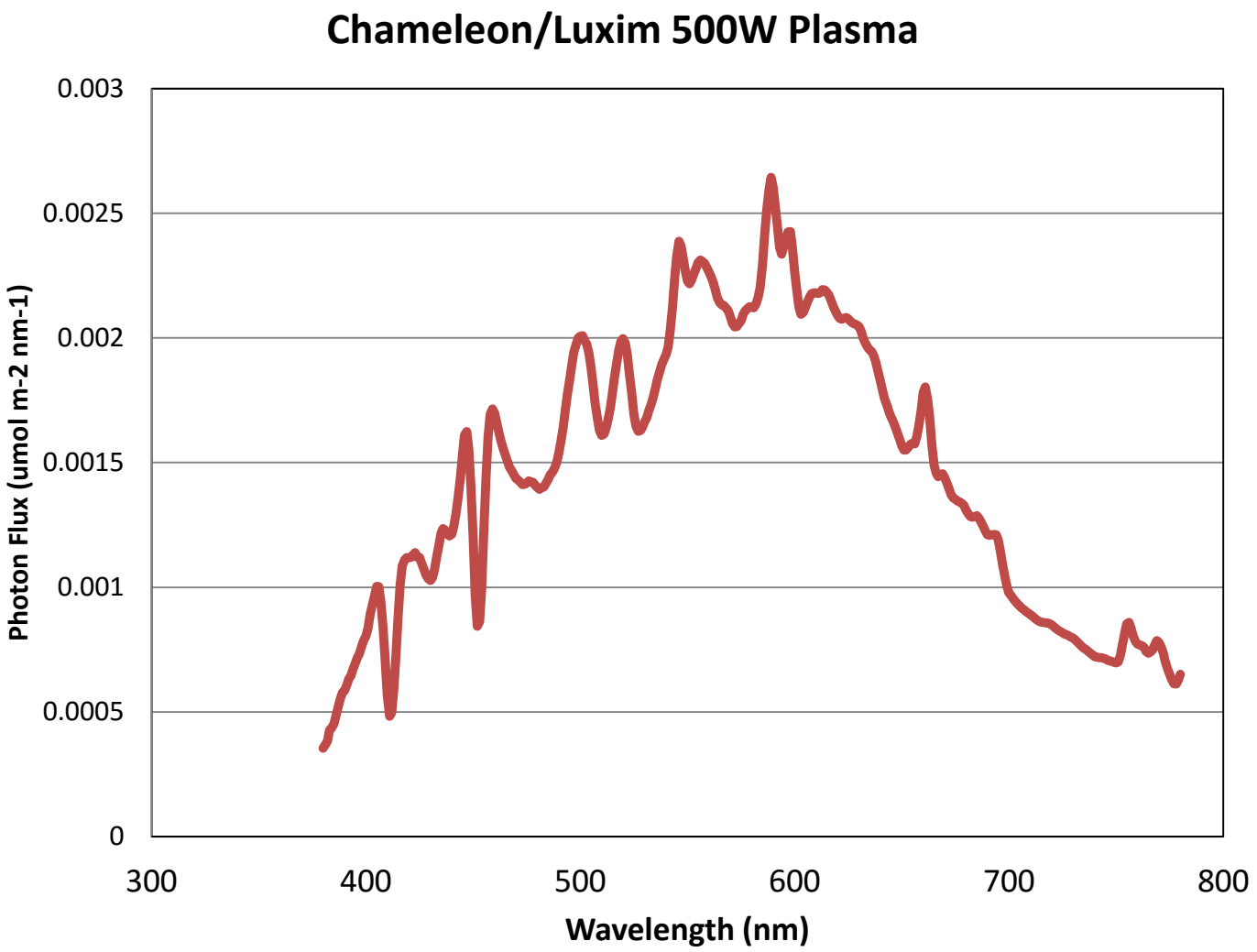


Fionia 490301



Philips DR W MB




Chameleon/Luxim 500W Plasma
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
Photon Flux (umol m-2 nm-1)
300
400
500
600
700
800
Wavelength (nm)

Summary

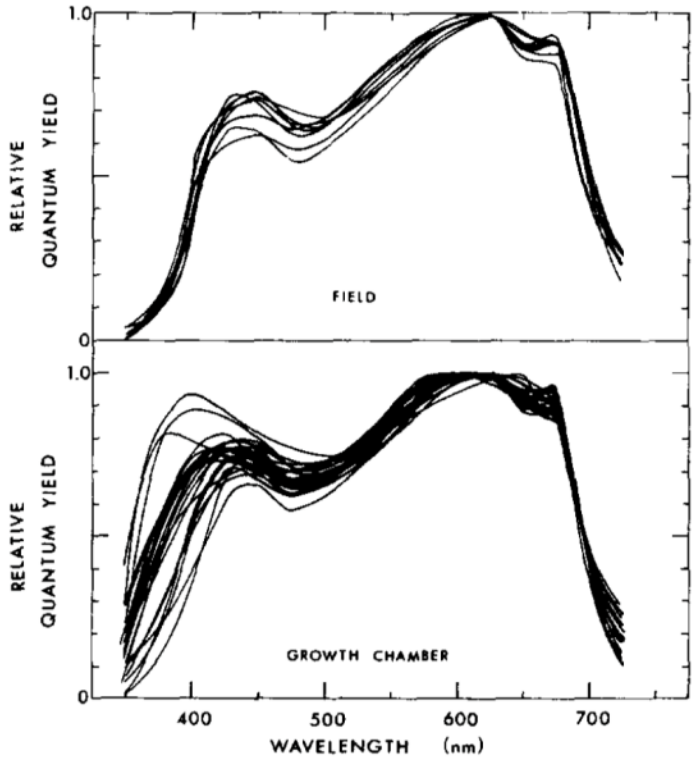
	LED Units					Plasma	SONT
Test Condition	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7
Voltage	200.4	240.3	220.4	411.4	422.7	240.0	400
Current mA	3262	946	1885	452	476	2119	1988
Power (W)	628.4	208	403.2	184.3	198.4	497.9	646.8
Power factor	0.96	0.92	0.97	0.99	0.98	0.98	0.81
Radiant power (380 to 780nm W)	177.2	51.6	177.4	92.2	97.1	124.2	203.4
Efficiency (µmol / J)	1.44	1.27	2.43	2.71	2.56	1.16	1.92
Unit weight (kg)	8.8	9.6	12.3	3.5	3.5	11.3	6.5
Radiant power per unit weight (W/kg)	20.1	5.3	14.4	26.3	27.7	5.5	31.3

Very diverse performance ……..but...

What is the optimal spectral quality?

The pink greenhouse…..

Contribution of McCree



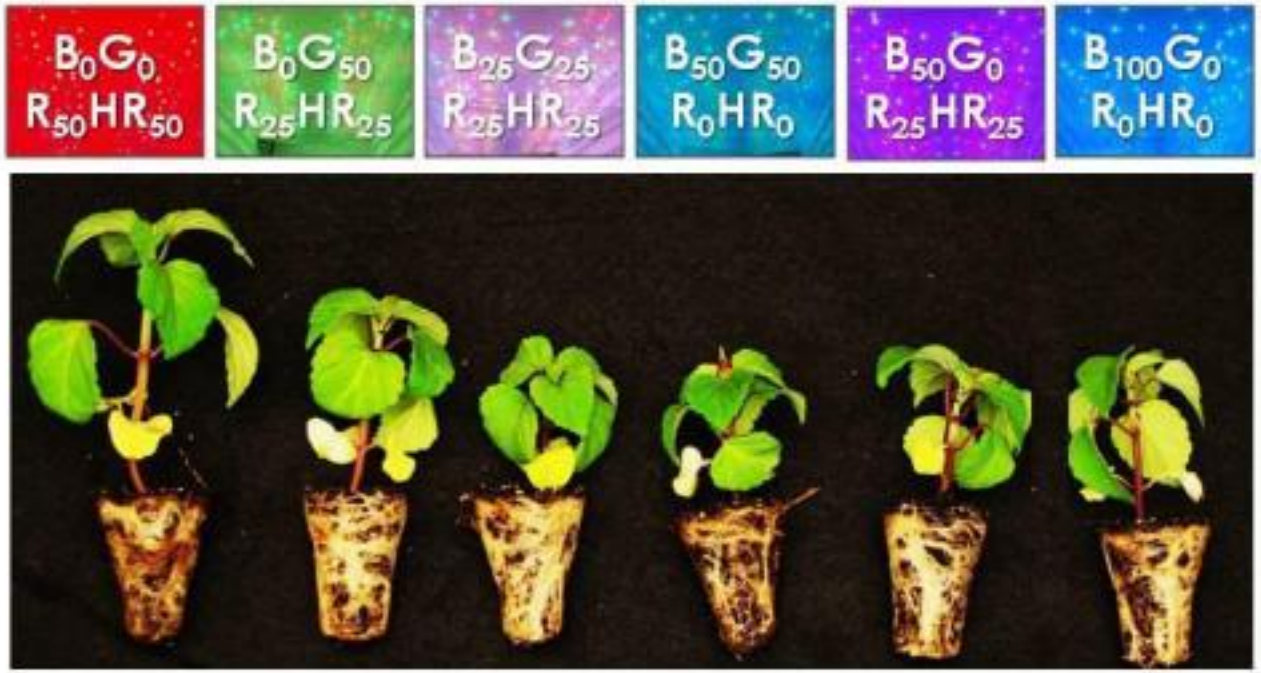
Quantum Yield of 22 Crop Species, McCree, 1972

A 44 year old classic!

If only it was easy…..

Salvia splendens 'Vista Red'

Seedlings grown at 68 °F for 4 weeks under LEDs
for 18 hours/day at PAR=160 µmol·m^{-2}·s^{-1} consisting of (%):

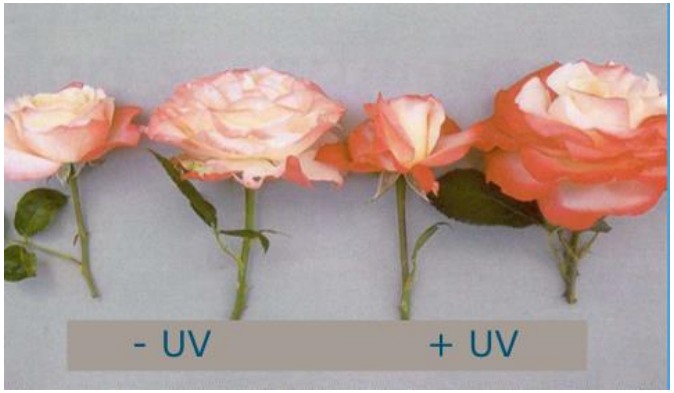


B=blue, 446 nm; G=green, 516 nm; R=red, 634 nm; HR=hyper red, 664 nm

Data from MSU

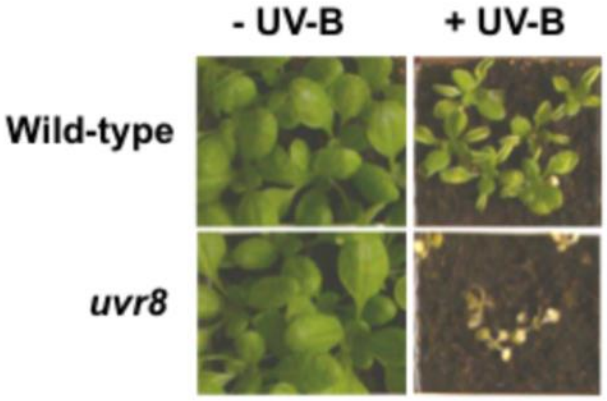
Ultra violet is missing

Ultra violet
- Insect activity
- Bees
- Fungal sproulation
- Crop flavour, esp Herbs
- Flower colour
- Photoinbition



Hemming et al, 2006

UVR8
- Mechanisms now well established
- Brown and Jenkins (2005)



We need a broad spectrum but attend to UV

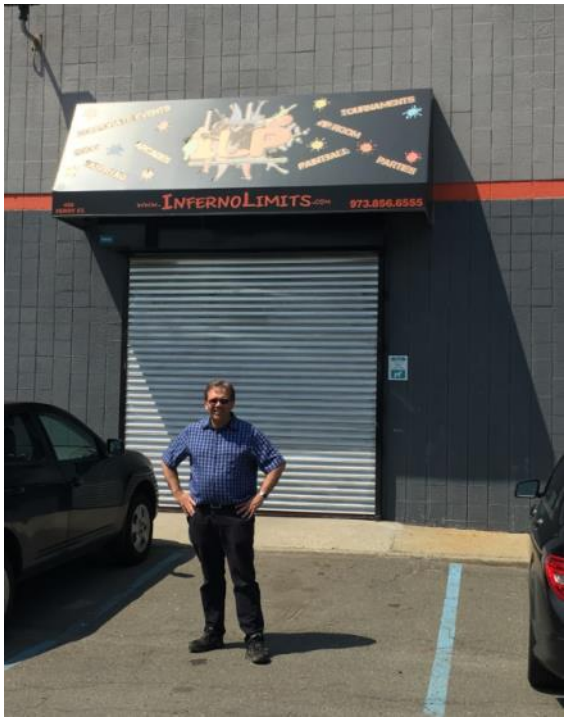
New ways to use light….urban farms

Will LED driven urban farms feed the future…?

Urban Farms can have a very positive social impact

Outside the Aerofarms, Newark test facility!

Group which has developed the World's largest urban farm!



Some numbers…..urban farm productivity

Pearson's Hydroponics Ltd	LUE g per MJ	Water content	Harvest index	MJ light per Kg dry mass	MJ light per Kg wet mass	MJ electric energy 20% eff	Energy Cost £ per Kg	Energy Cost per 200g	Tesco price
Lettuce	1.4	96%	100%	714	29	143	£3.17	£0.63	£0.49
Potato	1.2	79%	75%	1111	233	1167	£25.93	£5.19	£0.20
Wheat	2.2	13%	34%	1337	1163	5816	£129.23	£25.85	£0.20

Likely to improve

Meanwhile in Japan……

Certain produce lines may have application

23 ha of 5 layer stack hydroponic lettuce would supply 100% of UK
700,000 Lettuce per day

Some novel approaches

Chil-LED’s

Ceravision Plasma

Remote Phosphor LED

Double Phosphor LED’s

Energy

The Elephant in the Greenhouse and Urban Farm!

We need to think through;

Off- Grid solutions (renewables)
Buying Green Power
AD plant generation