'Growing for a sustainable future'

'LED Technology in Horticulture'

Tim Haworth, General Manager
CambridgeHOK.

21st October 2014.

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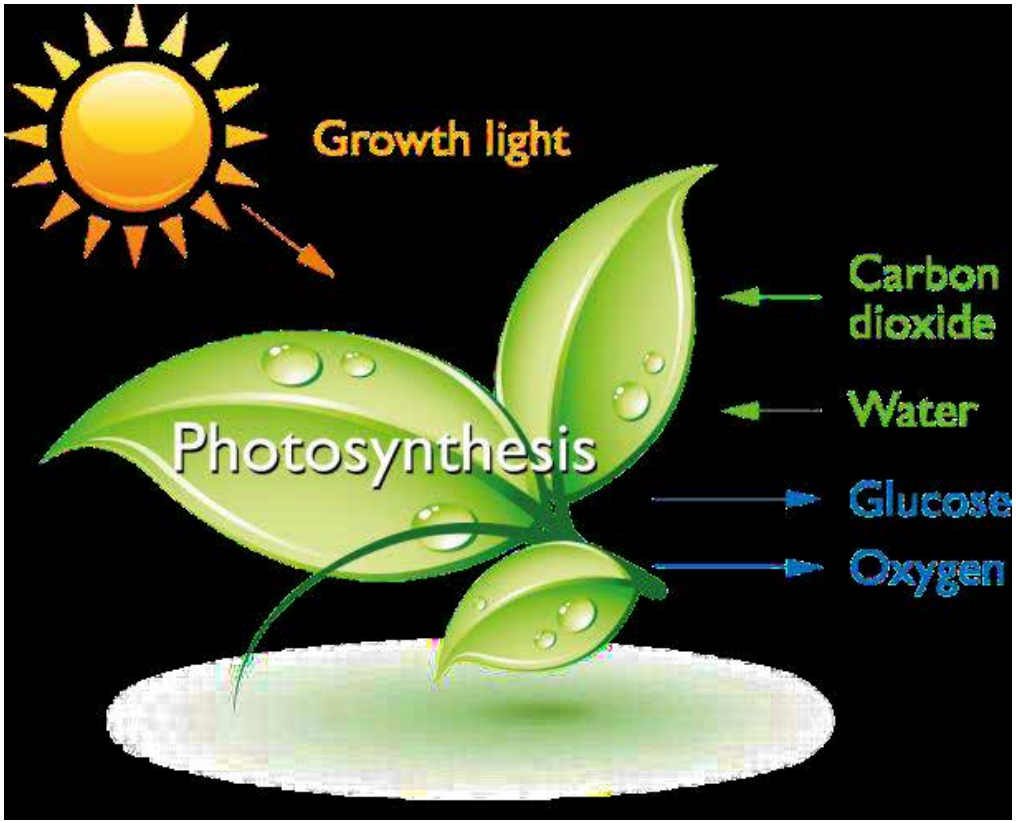
A plant needs light to grow: photosynthesis



Light photons are absorbed by pigments in the plant (e.g. chlorophyll). The energy of the photons is captured in glucose by fixing carbon dioxide and water, whilst releasing oxygen.

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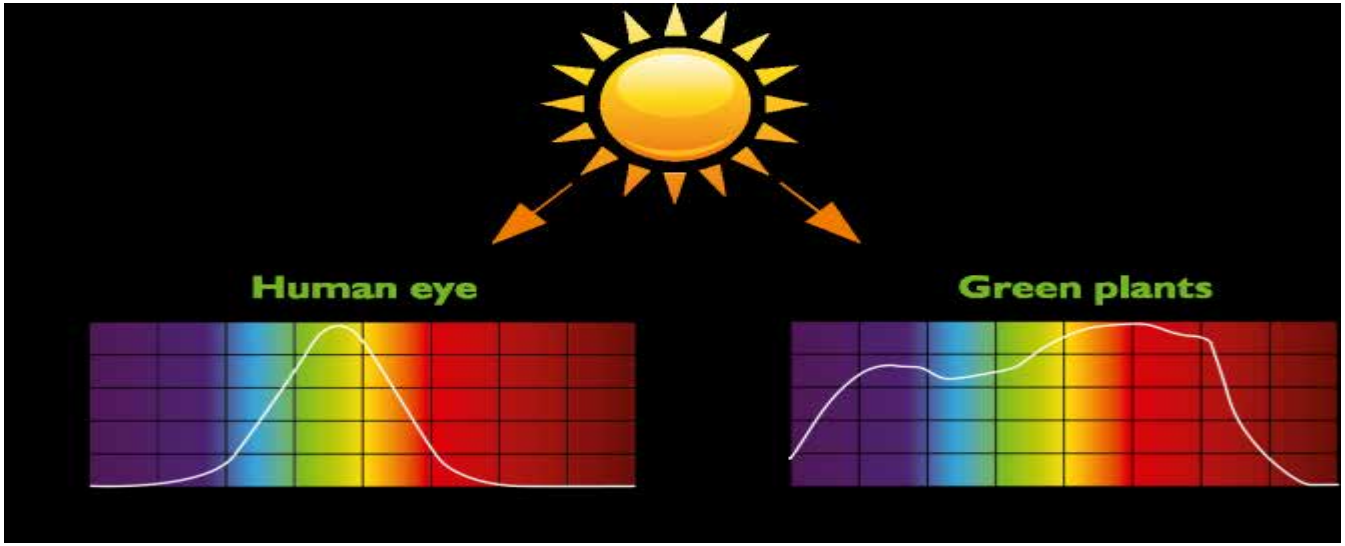
Plants see light differently than we do

Plants have a different sensitivity for light than, for example, humans.
We are most sensitive to green light, plants have a broader sensitivity for photosynthesis
with a preference for blue and red light.



Growth light is one of the most important factors driving photosynthesis.
It is the **number of photons per second** in between 400-700nm, called PAR* area, indicated in **micromol/s** (µmol/s).
* Photosynthetic Active Radiation

- **Lux/lumen** is the unit for light used for humans, this is corrected for the human eye sensitivity curve.
- **Micromol/s or micromol/m2/s** is the unit for light for plants, corrected for the 400-700 nm area

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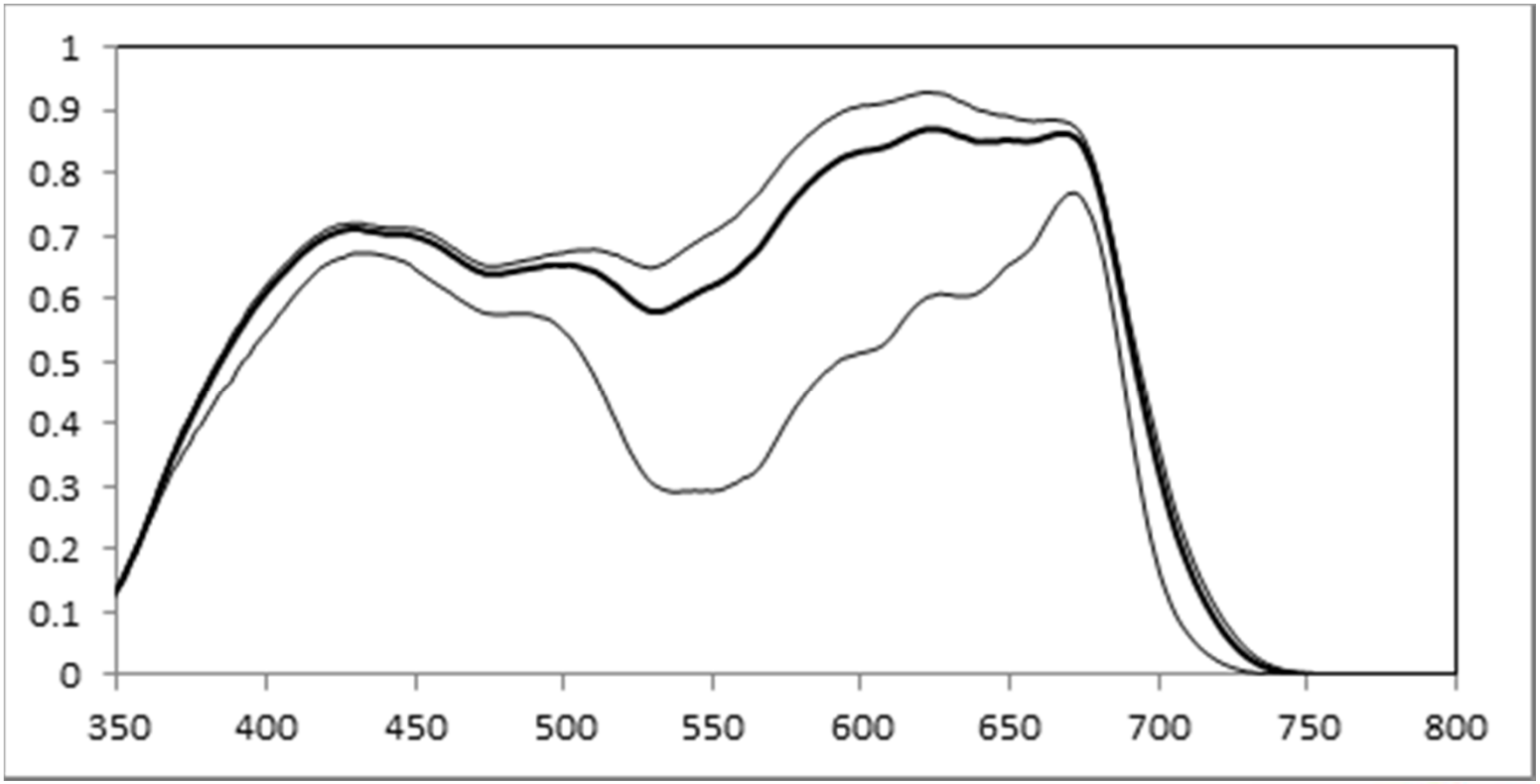
The relative photosynthetic action spectra.

These lines are calculated for leaves with different light absorptances. The bold line is the average of 25 different plant species.



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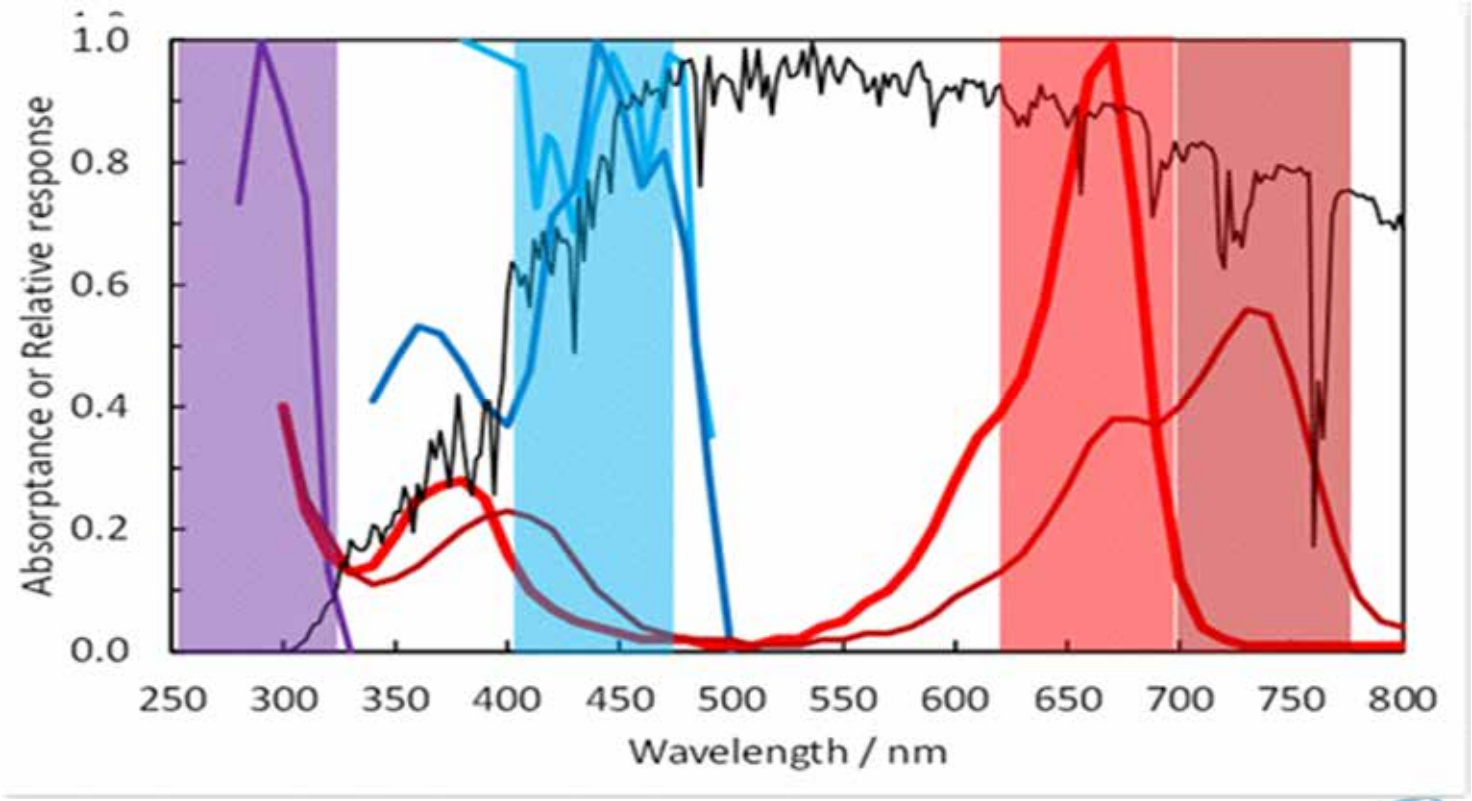
Photoreceptor action spectra.

Red and dark red are the different states of phytochrome. The two blue lines are the for two different types of blue light photoreceptor (cryptochrome and phototropin) The purple line is the UVB photoreceptor.



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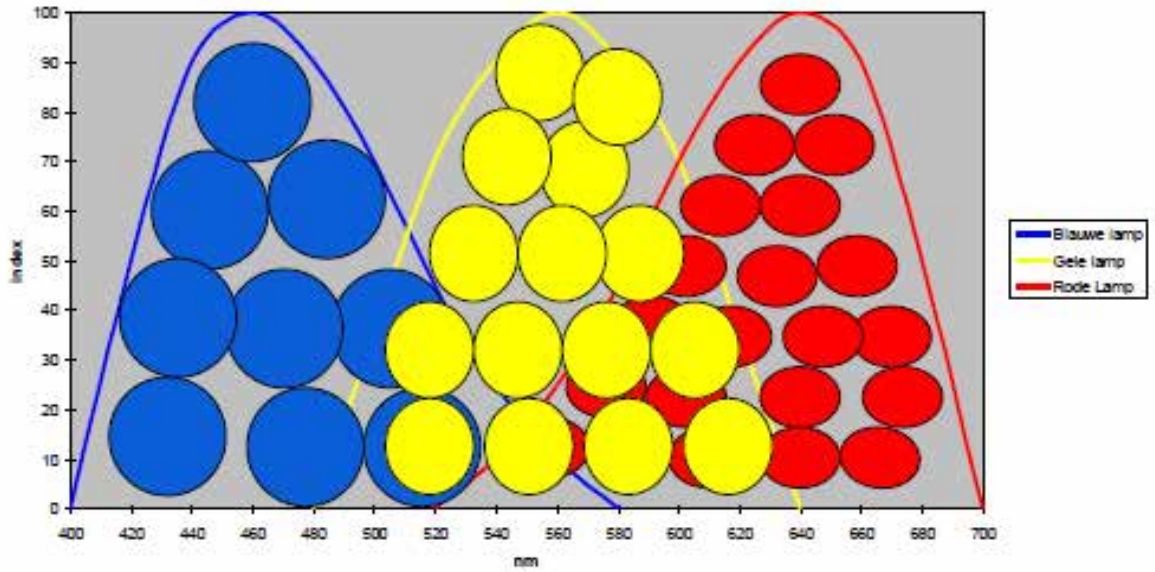
What colour light create per Watt energy the most photons for growthlight?



There is more energy necessary to create a blue photon than for a red photon.

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LED Top lighting and Interlighting solution for tomatoes

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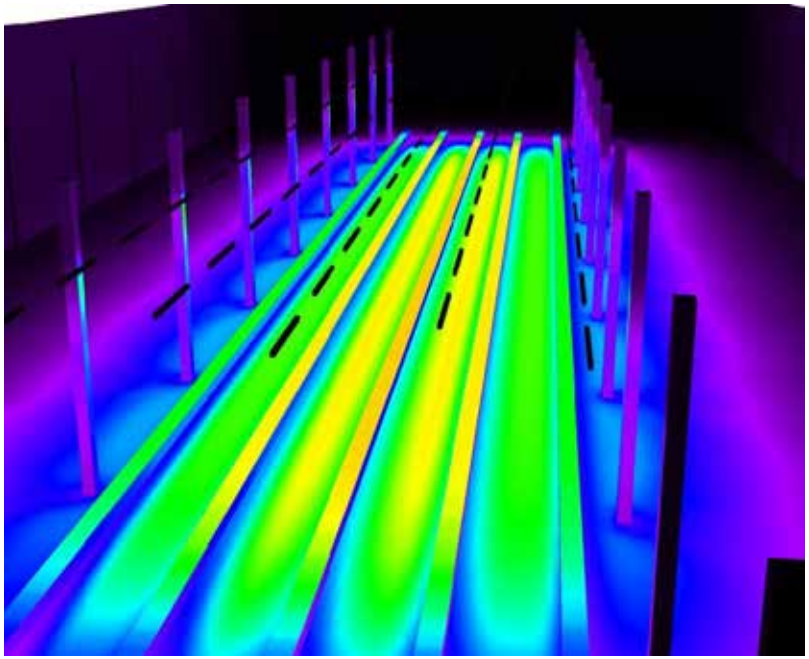
Trial set-up and goals

Target: Learning to growing tasty tomatoes with supplemental LED lighting in UK.
Cultivar: Sweet Rosso
Treatments:

- 100% LED: 110 umol LED top + 110 umol LED IL
- Control no light
  - Commercial control
  - Control same plant age as LED

Lighting, climate, and plant density strategy adapted to get most learnings out of a normal planting date in a further non lit greenhouse



Trial set up and goals

Our targets for productions!

Assuming using lighting ~1200 hours

	kg/m2	extra kilo vs control	% production vs control
control last year (first year)	21,8		
control	25		
Andy Liggat	28	3	112%
Erik	29	4	116%
Esther	30	5	120%
Andy Roe	31	6	124%
Tim Haworth	32	7	128%

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Strategy for the Winter phase

110µmol Top lighting & 110 µmol Interlighting

- Variety Sweet Rosso was agreed to be the variety on a 320m2 growing area.
- Agreed flowering speed of 1 truss per week based on a predicted 19C 24hr average.
- Due to planting date 16th December we needed to create a light demand so:-
  - Received from the propagator a plant just breaking flower.
  - Planted at 3.6/m2
  - Control planted 2.4/m2 breaking flower on 16th December but with no lights
  - Commercial crop planted 23rd December with 'normal' plant at 1.8/m2
- It was expected that water uptake would be greater with lights so a new valve zone was made to allow watering relative to the lit plants needs.
- Installed 2nd aspirated screen to monitor localised climate.
- Grow pipe was placed under the gutters to add basal heat supply.
- We were off and running …….

	LED	Control	Comm control
Sowing date	20th Oct	20th Oct	4th Nov
Plant date	16th Dec	16th Dec	20th Dec
Plant density strategy	WK 51 3,6 WK 2 5,4 WK 12 4,2 WK 37 0	WK 51 2,4 WK 8 3,6 WK 37 0	WK 51 1,8 WK 8 3,6 WK 37 0

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Key Milestones (5)

- 17th March
  - Commercial crop

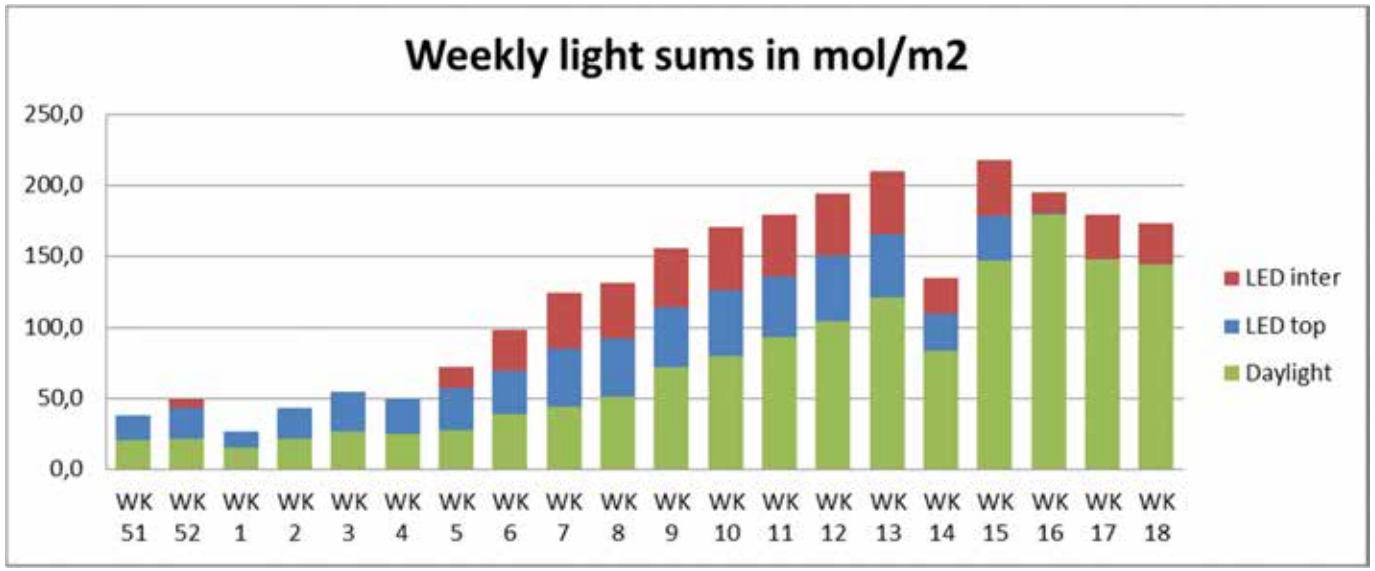
Control

LED

Results

Realized lighting

- Total lighting hours: As expected until end of April.
  - LED top 1308
  - LED inter 1225



* 1,5 mol/m2 ~100 J/cm2 outside measured global radiation
* 1 hour of lighting with whole installation ~0,8 mol/m2 = ~53 J/cm2 (excl. X-factor effects LED)

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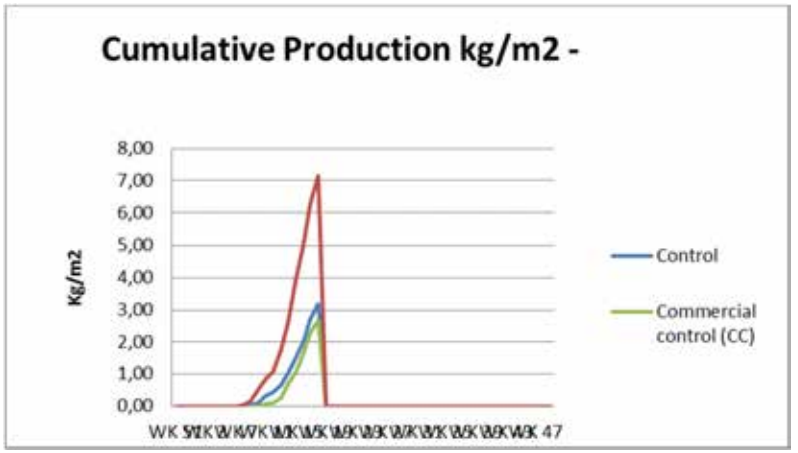
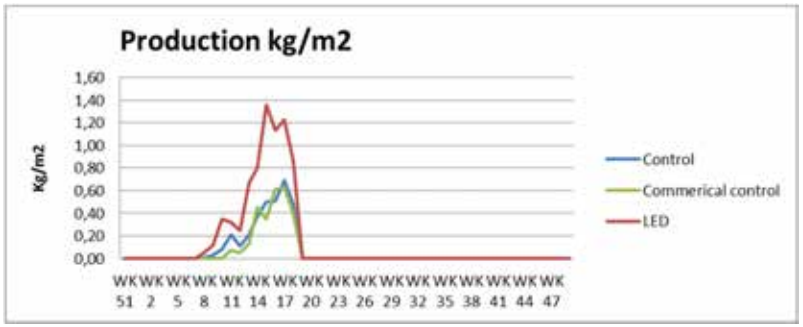
Results

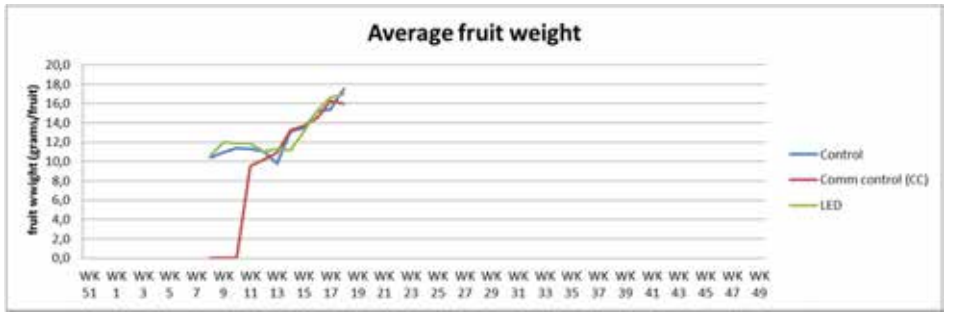
Production

- LED 3 weeks earlier than commercial control (started with slightly older plant)
- LED was 1 truss ahead of “control” after 3 weeks and 2 trusses after 8 weeks production
- Production difference after 10 weeks production (wk 8-18) **4-4.5kg/m2**
- Fruit weight increasing in time for all treatments





LED (g/fruit)	Control (g/fruit)	Commercial control (g/fruit)
12,9	12,7	13,1



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Summer Strategy

- Maintained density at 4.2/m2 until week 31.
- Week 31 reduced density to 3.6/m2
- Commercial control was reduced to 3/m2 from its summer density of 3.6/m2

- Net effect was that we managed an additional density of 0.6/m2 through the summer and autumn representing a potential additional 16% production.

- Increased interlighting from week 33 to 38 as day length was shortening and significant deficit being calculated for weeks 36 to 40 so provided additional light to the calculated weekly requirement to ensure sufficient total light was received for fruits to be harvested between 36 and 40.

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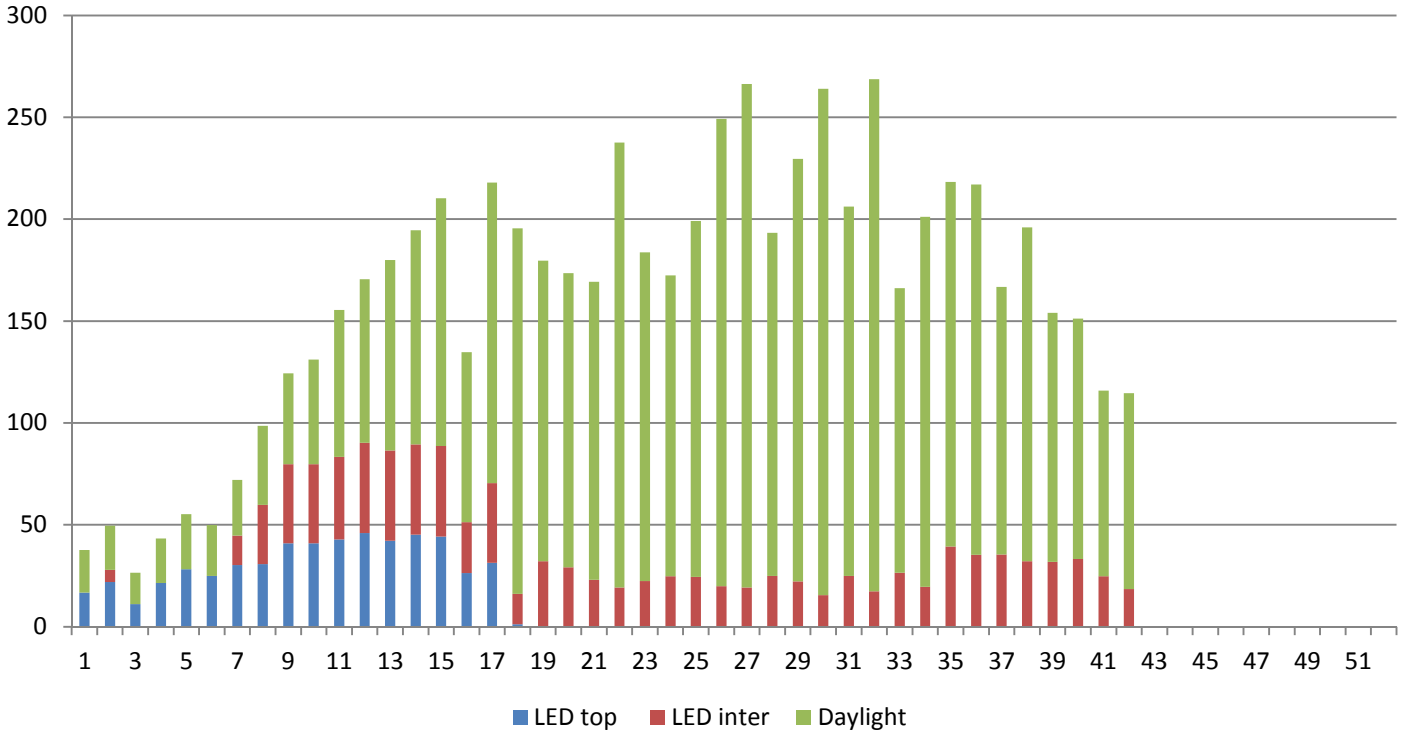
Results

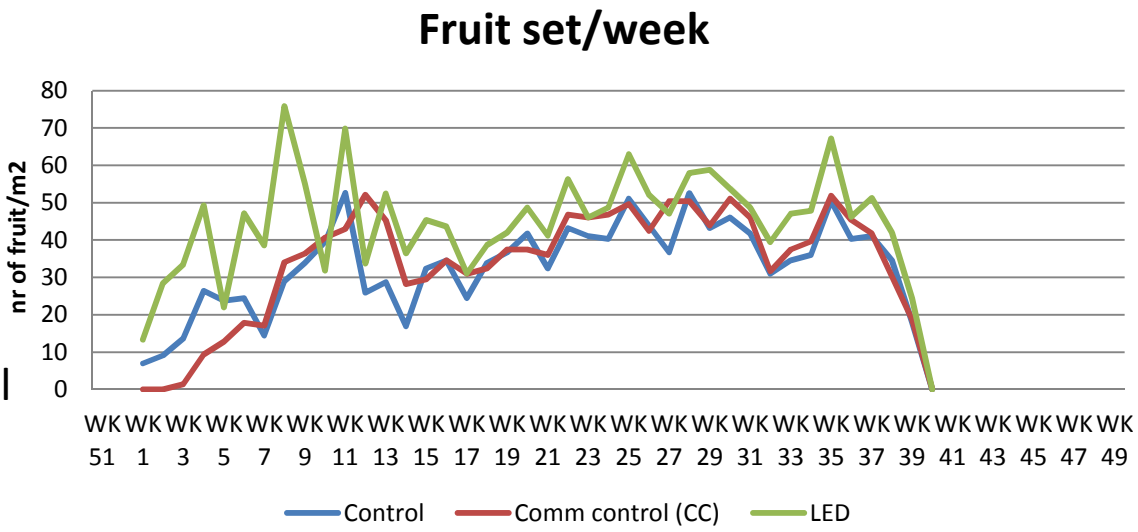
Interlighting used from sunrise

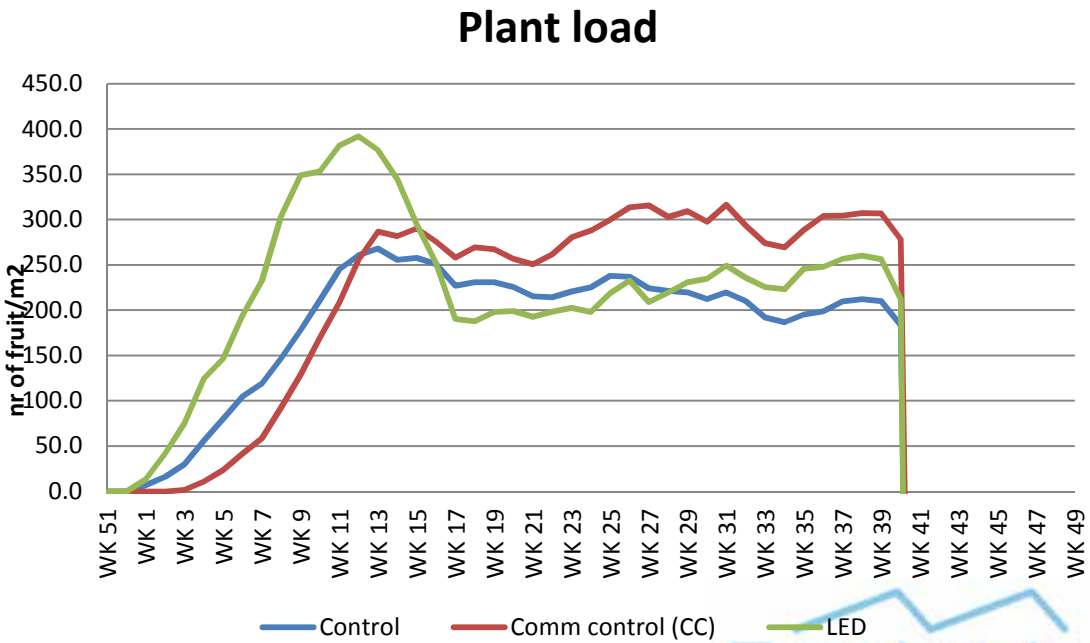


WK 18	0	73.5
WK 19	0	58
WK 20	0	48.5
WK 21	0	56.5
WK 22	0	62.5
WK 23	0	61.5
WK 24	0	50
WK 25	0	48.5
WK 26	0	63
WK 27	0	56
WK 28	0	39
WK 29	0	63
WK 30	0	44
WK 31	0	67
WK 32	0	49.5
WK 33	0	99.5
WK 34	0	89
WK 35	0	89.5
WK 36	0	81
WK 37	0	80.5
WK 38	0	84
WK 39	0	62.5
WK 40	0	46.5
WK 41	0	0
WK 42	0	0
WK 43	0	0
WK 44	0	0
WK 45	0	0
WK 46	0	0
WK 47	0	0
WK 48	0	0
WK 49	0	0

Results

- Fruit set 20% more than control despite only 16% more density.
- Fruit load lower likely due to less changes to plant temperature with use of interlighting.
- Potential with lower plant load to increase further growing temperature.





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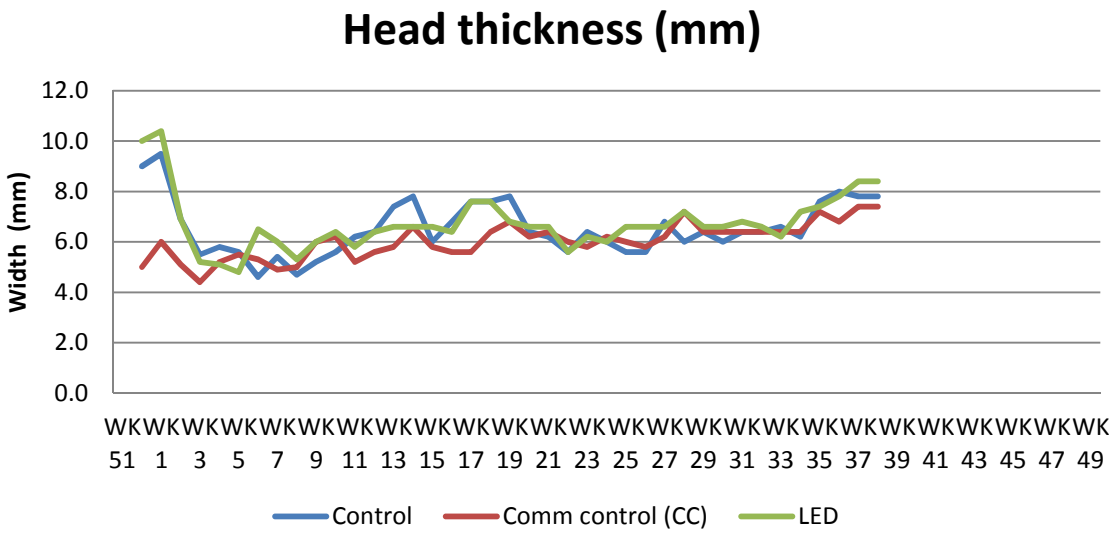
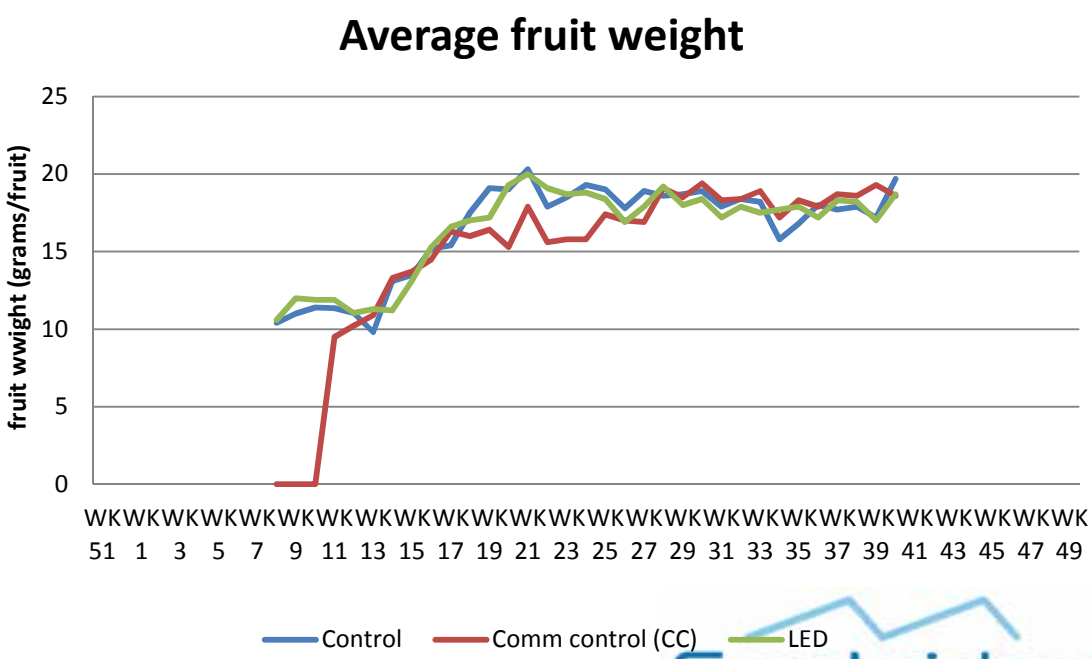
Results

- Head thickness strongest through the summer likely due to lower plant load so again supporting potential for increased growing temperature.

- No reduction in fruit size was realised supporting the correct balance between additional light and increased density.





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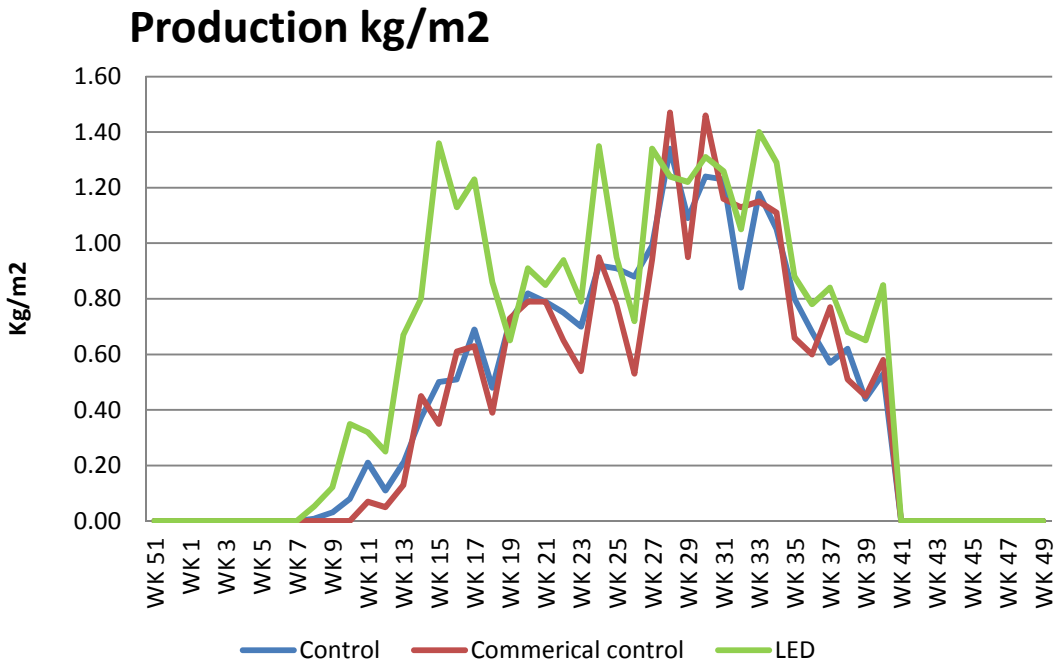
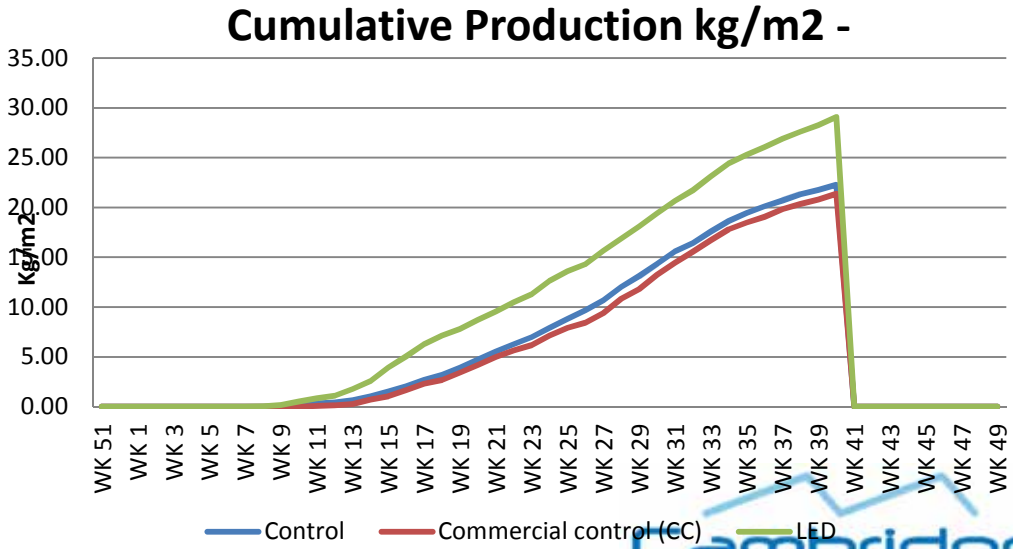
Results

- Weekly production from week 19 to 41 on average 24% more production compared to the commercial trial with only 16% more density.
- As a result cumulative yield has increased.





Results

	LED	Control	Comm Control
Production until WK 41 model	29.09 kg	22.29 kg	21.38kg
%age Increase over Control	36%	4%	n/a

Predicted End of season	LED	Control	Comm Control
Production until WK 41 model	29.09 kg	22.29 kg	21.38kg
Remaining fruits/m2	212	183	278
Current fruit weight	18.7	19.7	18.8
Projected yield	33.05Kg	25.89Kg	26.6Kg

control	25
Andy Liggat	28
Erik	29
Esther	30
Andy Roe	31
Tim Haworth	32

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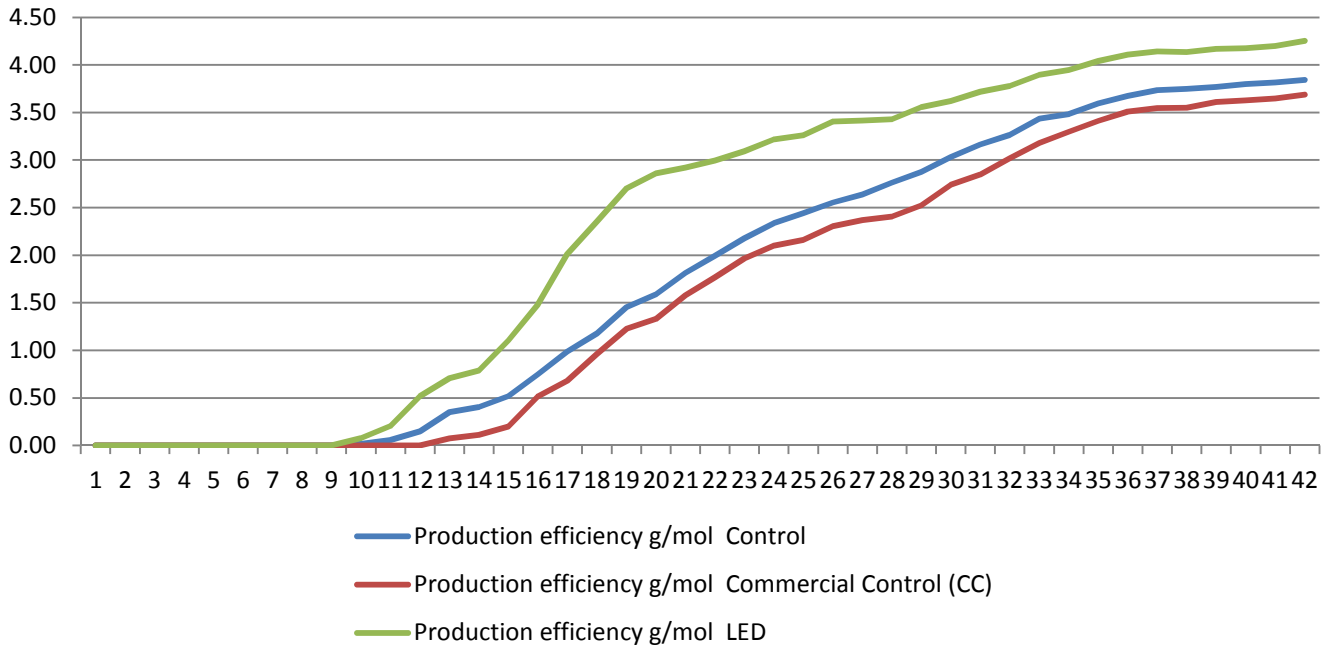
Results



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Strawberry flowering lamp

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Activities for LED recipes for strawberries

Esther Hogeveen –van Echtelt
Global Plant specialist
Philips Horticulture LED Solutions
10th of June 2014

PHILIPS

Strawberry

From recipe development to commercial scale operation

Target:

- Control early production of strawberry by stretching first leaves and flower stems by not using incandescent lamps (lamps used in February; production April-May)

	Flowering %	Leaf length after 35 days (cm)	Truss length until last fruit (cm)	Early Production
LED – Farred	62.5%	7.5	18.4	-
INC	65%	10.8	21.3	+-
LED + farred	72.5%	12.1	21.8	+
LED 2xfarred	80%	14.7	24.1	++

Recipe partners

- Botany (NL), Research Centre Hoogstraten (B)
- + growers

Commercial scale examples

- Alain Lutz (B), Jan Janse (B), Van Gennip (NL)

Brookberries (NL)

Benefits light recipes based on GP LED Flowering lamp:

- Energy savings (up to 85%)
- Better stretch (type with FR), early production
- Easy installation, less heavy electrical installation

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Strawberry

Winter production – GreenPowerLED toplighting

Diverse projects together with recipe partners 2014-2015 :

- Wageningen UR → Effect of positioning of light on taste
- Proefcentrum Hoogstraten (Belgium) → several years focus on various light recipe for production in Febr-March defining best light level, spectrum
- GreenQ Improvement Centre/DLV → Focus on production Dec-Jan with good quality
- Diverse grower initiatives/trials → UK

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Thankyou

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