

# Comparison of Light Emitting Diode and High Pressure Sodium Light Treatment for Hydroponics Growth of Boston Lettuce

Summary Report

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Recent developments in light emitting diode (LED) technology have brought the required irradiance to a suitable level to be considered a replacement to traditional high pressure sodium (HPS) lamps in hydroponics growth environments. LED lamps are destined to replace HPS lamps in most applications due to their reduced electricity consumption, improved quality of light and the possibility for customization of the light spectrum for increased yields. While equipment costs are still high, as is the case with most new technologies, growers across the world stand to substantially decrease their energy use which directly translates into reduced costs and carbon emissions from the energy providers. We have compared the effects of LED lamps made by LED Innovation Design against HPS lamps used at HydroSerre Mirabel for the growth of Boston lettuce. The light treatments were applied two hours before and for eight and a half hours after sunset to extend the photoperiod to eighteen hours. During the course of the experiment, plant and root samples were taken every week and weighed.

We found that optimum HPS light treatment produced similar masses compared to optimum LED light treatment even though the LED lamps provided roughly half the intensity of light energy compared to the HPS lamps at the last harvest time (average total light irradiance of 71.3 moles/m<sup>2</sup> for HPS and 35.8 moles/m<sup>2</sup> for LED over the four weeks of each run).

S-1 Intensity Measurement per Plot				
	Feb 17, 2010	Mar 25, 2010	Apr 19, 2010	Moyenne
Units	$\mu\text{mol}/\text{m}^2/\text{sec}$	$\mu\text{mol}/\text{m}^2/\text{sec}$	$\mu\text{mol}/\text{m}^2/\text{sec}$	$\mu\text{mol}/\text{m}^2/\text{sec}$
Plot 1, Optimal HPS Near	64,8	84,9	82,2	77,3
Plot 2, Optimal LED Near	37,6	40,4	38,9	39,0
Plot 3, Regular HPS	8,6	8,1	13,3	10,0
Plot 4, Optimal LED Far	39,2	42,3	40	40,5
Plot 5, Optimal HPS Far	79,4	86,8	83,1	83,1
Plot 6, Control	0,3	0,5	0	0,3

The values were taken out of **Table 1** from the final report. Between run 1 and 2 HPS regular and control plots were exchanged. For comparison needs, in this table, all the HPS regular data are in plot 3 and control data in plot 6. The average light intensity for Optimal HPS treatment was 80,2  $\mu\text{mol}/\text{m}^2/\text{sec}$  and 39,7  $\mu\text{mol}/\text{m}^2/\text{sec}$  for the Optimal LED treatment.

LED light treatments showed improved homogeneity of plant mass across the entire area while HPS light treatment showed potential for slightly higher production in limited areas. Ratios of plant mass (in grams) by artificial irradiation (in moles per meter<sup>2</sup>) were 2.23 g/mol/m<sup>2</sup> and 0.98 g/mol/m<sup>2</sup> for both HPS experimental replication and of 4.19 g/mol/m<sup>2</sup> and 1.21 g/mol/m<sup>2</sup> for both LED experimental replication, respectively. After normalizing to remove the impact of sunlight, the ratios are then 0.471g/mol/m<sup>2</sup> and 0.204g/mol/m<sup>2</sup> for HPS light treatment

replications and 0.452g/mol/m<sup>2</sup> and 0.142g/mol/m<sup>2</sup> for LED light treatment replications, respectively.

S-2 Dry matter produced by mole of light					
	<i>Dry matter (D.M)</i>	<i>D.M. par mètre carré</i>	<i>D.M. produced by Artificial lighting</i>	<i>D.M. per mole of Artificial lighting</i>	<i>Total D.M. per total moles</i>
<i>Units</i>	<i>(g)</i>	<i>(g/m<sup>2</sup>)</i>	<i>(g/m<sup>2</sup>)</i>	<i>(g/mole/m<sup>2</sup>)</i>	<i>(g/mole/m<sup>2</sup>)</i>
Plot 1, Optimal HPS Near	7,1	172,0	38,19	0,57	0,57
Plot 2, Optimal LED Near	5,8	140,5	15,81	0,45	0,45
Plot 3, Regular HPS	5,7	138,1	6,22	0,49	0,48
Plot 4, Optimal LED Far	5,9	143,0	16,23	0,45	0,45
Plot 5, Optimal HPS Far	5,4	130,8	25,97	0,34	0,34
Plot 6, Control	4,8	116,3	0,81	0,32	0,38

Data in this table has not been normalised and may differ from data in the texte. Between run 1 and 2 HPS regular and control plots were exchanged. For comparison needs, in this table, all the HPS regular data are in plot 3 and control data in plot 6. DM are the averages extract from **Table A4** (1<sup>st</sup> run) and **A8** (run 2) mean. DM/m<sup>2</sup> is the DM multiplied by the number of plant per plot divided by the surface. DM produced by artificial lighting is the D.M. per m<sup>2</sup> by % of artificial light in both runs, data extracted from **Table B1** and **B7** for HPS and **B2** and **B8** for LED lights.

Table S-2 indicates that the actual effect on plant mass production was statistically identical between both light treatments. Table S-3 is of the ratios for each light treatment replications and shows the similarity between dry ratios for both experimental replications. Plant dry ratios are typically more stable than wet ratios and provide a better understanding of the effect of light on plant growth. Table S-4 summarises the weather and irradiance data for the entire experiment.

S-3 Normalized Ratio of Plant Mass versus Artificial Light per plant			
	<i>Wet ratio per percent</i>	<i>Dry ratio percent</i>	<i>Supplement light / total light</i>
<i>Units</i>	<i>(g/moles/plant)</i>	<i>g/moles/plant</i>	<i>%</i>
HPS average - run 1	11,41	0,54	21,10%
HPS average - run 2	4,95	0,35	20,90%
LED average - run 1	10,96	0,59	10,80%
LED average - run 2	3,45	0,26	11,80%
Regular - run 1	11,56	0,65	4,80%
Regular - run 2	6,13	0,34	4,20%
Control - run 1	8,74	0,45	0,30%
Control - run 2	3,04	0,23	1,10%

Wet and dry plant mass in grams versus artificial light in moles per plant; normalized by percentage of supplemental light versus total light. All the data for this table has been extracted from Table 3 of the final report.

S-4 Summary of Weather Data and Irradiance Levels for Both Experimental Replication					
	Surface Temperature	Std dev	Total Light	Supplemental Light	Sun Light
Units	°C		(mole/m <sup>2</sup> )	(mole/m <sup>2</sup> )	(mole/m <sup>2</sup> )
<b>A - Run 1</b>					
HPS	11,78	5,00	344,62	72,65	271,99
LED	11,44	4,93	284,68	30,78	253,90
Regular	12,95	4,88	267,65	12,68	255,13
Control	11,47	5,05	310,99	0,98	310,01
<b>B- Run 2</b>					
HPS	12,95	5,64	344,93	69,87	275,06
LED	14,18	5,48	346,85	40,73	306,12
Regular	12,81	4,62	307,57	12,91	294,66
Control	12,75	5,54	300,13	4,08	296,05

Data has been extracted from Table B-1 to B-12 of the final report

In designing the experimental setup, the lighting plan with the LED lamps has been developed to provide a minimum of 10% of artificial lighting as evenly as possible across the plots. Holding accurate data on light dispersion, it was determined that an amount of 24 LED lamps were required. While according to data available for HPS lamps it was determined that 18 lights were needed. Table S-5 summarizes the average energy consumption for each lamp, total consumption per plot and the consumption per square meter. Whereas production of both treatments were statistically identical, and according to the experimental setup completed, the LED lamps provide energy savings of at least 33.8%. Table S-6 shows that one watt of LED light produced 0.019 g/m<sup>2</sup> of dry matter whereas one watt of HPS light produced 0.013 g/m<sup>2</sup> of dry matter.

S-5 Power Consumption					
	Power consumption by unit	Number of lamp per plot	Power consumption per plot	Power consumption per meter <sup>2</sup>	Power saving compare to HPS
Units	W	ch	W	W/m <sup>2</sup>	%
Optimal LED	319	24	7656	81,8	33,8%
Optimal HPS	642	18	11556	123,5	0,0%
Regular HPS	642	4	2568	27,4	22,2%
Control	0	0	0	0,0	N/A

S-6 D.M. versus power consumption			
<i>Units</i>	<i>Dépenses énergétique</i> <i>W/m<sup>2</sup></i>	<i>Moyenne des poids sec</i> <i>g/m<sup>2</sup></i>	<i>Moyenne des poids sec par watt consommé</i> <i>g/W/m<sup>2</sup></i>
Optimal LED	81,8	141,8	0,019
Optimal HPS	123,5	151,4	0,013
Regular HPS	27,4	138,1	0,054
Control	0,0	116,3	N/A

### Conclusion

According to the experimental setup, the LED lamps produce statistically the same amount of dry matter as the HPS lamps (600W) while consuming 33% less electricity. These are encouraging results for the LED technology because the reduced electricity costs do not impact the final crop yields.