Advantages of Crop Production in a Controlled Environment With a LED Sole Source of Lighting

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INTRODUCTION

Successful space colonization requires sustainable crop production in a controlled environment (CE) depended on artificial sole source of lighting (SSL). The interest in CE technologies increases also in terrestrial conditions due to SSL potential benefits including high level of control, independence of outside conditions and economical use of water and space.

When the most or whole dietary needs are covered by SSL production, factors such as dietary values and taste become of high importance.

Here we present results from a small-scale experiment, being a part of a larger study primarily designed to test effects of different lighting strategies on aromatic compounds and antioxidant value of leafy crops.

CONCLUSIONS

- Plants develop faster In the stable conditions of GR
- GR conditions had positive effect on aromatic compounds quantity in basil and dill.
- Decreased stress in GR affects the amount of antioxidants in plants' leaves, yet the differences are not large and can be compensated by pre-harvest light treatments.

METHODS

Basil 'Aroma 2', dill 'Ella' and red-leaf lettuce 'Galiano' was cultivated in a greenhouse or in a controlled environment growth room (GR). Both greenhouse and GR grown plants received 18h of full spectrum LED light of 180 and 188 µmol photons/m^2/s from customized Heliospectra LX60 series fixtures, as supplemental or sole source lighting, respectively. Additionally greenhouse plants received 9 to 10 hours of late autumn daylight. Temperature was set to be maintained between 23 and 18°C in the greenhouse and 22/17 ± 1°C in the growth room. Plants were irrigated according their needs with water with fertilizer (Plant-Prod® 20-20-20). After four weeks of the light treatment plants were harvested and analysed. Main aromatic components were identified and analysed by olfactometric test and mass spectrometry. Vitamin C (Ascorbic acid, AA) was quantified by HPLC and total phenolic compounds (TPC) by Folin-Ciocalteu method.

APPLICATION

Commercial plant production with SSL in terrestrial conditions is not always best solution due to the high cost. Yet the variation in greenhouse light conditions can be attenuated with intelligent light control system. Integrating sensors with smart lighting ensures optimization of the amount and quality of light plants receive during the growth cycle.

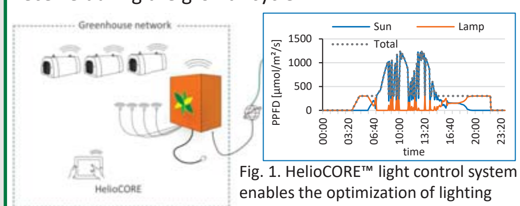


Fig. 1. HelioCORE™ light control system enables the optimization of lighting conditions in greenhouse production.

RESULTS

Plants in the growth room developed faster and had nearly twice as large biomass production when compared with plants grown in the greenhouse. The content of most identified aromatic compounds were significantly higher in basil (except borneol) and dill (except isopropyl phenol) grown under SSL. For the lettuce the differences in the amount of aromatic compounds were small, but they profile can suggest that greenhouse grown plants may have a milder taste. The content of vitamin C did not differ statistically but the concentration tended to be higher in dill grown in GR conditions but lower in basil and lettuce when compared to greenhouse grown plants. The opposite trend was observed for total phenolic compounds. Those traits can be modified by changes in lighting quality (spectrum) and/or pre-harvest treatments. The lack of sunlight enhances effectiveness of such treatments.

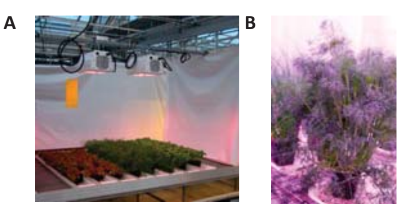
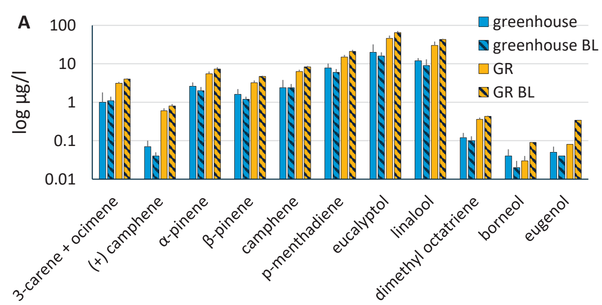


Figure 2. Leafy greens developed slower when grown in a greenhouse with supplemental LED lights (A) than in a stable conditions of GR with a sole source LED lighting (B) .

Table 1. Comparison of the fresh biomass, content of vitamin C (AA) in fresh leaf samples and total phenolic compounds (TPC) per dry weight of plants grown in a greenhouse and in a growth room. N= 5 and N=3 (for AA, TPC), SD is given in parenthesis.

	Basil		Dill		Lettuce 'Galiano'	
	Green house	GR	Green house	GR	Green house	GR
FW total relative %	53%	100%	56%	100%	-	-
FW leaves relative %	51%	100%	-	-	52%	100%
AA [mg/g]	0.17 (*0.03*)	0.13 (*0.01*)	0.56 (*0.09*)	0.65 (*0.01*)	0.16 (*0.02*)	0.10 (*0.01*)
TPC [mg/g]	24.0(*1.9*)	30.7(*0.7*)	9.3(*0.7*)	6.57(*0.5*)	17.1(*0.5*)	17.3(*0.0*)



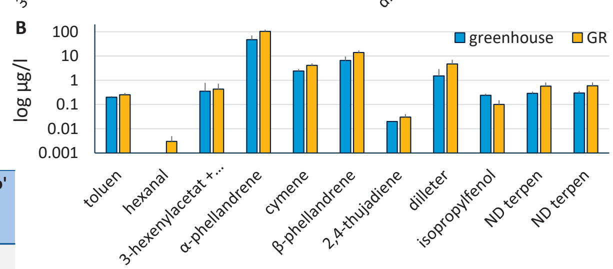


Figure 3. Quantification of selected aromatic compounds in basil (A) and dill (B) grown in a greenhouse and in a GR. The light treatment with increased blue light proportion (BL) had a positive effect on aromatic compound content in basil grown in the GR, but not in the greenhouse. The error bars represent SD, N= 3

REFERENCES

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