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Ontario Greenhouse Vegetable Growers

LumiGrow

Optimizing light spectral composition and vertical distribution to improve yield and quality in greenhouse tomato and sweet pepper production

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Introduction

- Both light intensity and quality (spectrum) affect the productivity of greenhouse vegetables.
- Different spectra of light triggers different plant growth processes and the optimum light spectrum for various plant growth processes such as leaf and fruit growth may be different.
- Greenhouse tomato (*Solanum lycopersicum* L.) and sweet pepper (*Capsicum annuum L.*) are of tall crops, with most of the leaf growth occurring in the top and middle canopy while fruit growth occurs in the middle and bottom canopy.
- Optimized seasonal and vertical spectral distribution regimes could be developed for improving both vegetative and fruit growth.
- Light emitting diodes (LEDs) have low surface temperature and narrow wavelength band, which can be used both as overhead and intra-canopy lighting (interlighting) in greenhouse tomato and sweet pepper production to improve seasonal and vertical light spectral distribution.

The objective of this study was to evaluate the effects of overhead LED spectra (placed above crop canopy) and different spectra of intra-canopy LEDs (interlighting, placed inside the canopy near the developing cluster of fruit) on the fruit yield of greenhouse tomato and sweet pepper.

Materials & Methods

Experiment location: Harrow Research and Development Centre, Harrow, Ontario, Canada. One glass greenhouse (200 m^2 growing area) was divided into 4 main plots by white curtains, each having 50 m^2 growing area for each overhead lighting treatment (2 replications). There were 4 subplots for interlighting treatments nested with each of the main plots (Pictures A-J).

Tomato Trial (Oct. 2015 to Mar. 2016, 3.2 plants m^{-2})

Overhead LED treatments

1) **Constant light spectra**: red:blue:white = 76:16:8.
2) **Varying light spectra**: 100% red (Oct to Dec, 2015), red:blue:white = 67:22:11 (Dec, 2015 to Feb, 2016), and 100% red after Feb. 2016.

The 2 overhead treatments have same light intensity (140µmol m^{-2} s^{-1}).

Four intra-canopy LED treatments

Red (455nm), Blue (660nm), and White at the same 20µmol m^{-2} s^{-1} light intensity, and UV-A(11µmol m^{-2} s^{-1}, 365nm), started in late Nov. 2015 (Pictures A, B, C, E & F).

Sweet Pepper Trial (Oct. 2016 to May 2017, 6 stems m^{-2})

Overhead LED treatments: 100% Red or Mixed (red:blue:white = 76:16:8), at the same 140µmol m^{-2} s^{-1} light intensity.

Four intra-canopy LED treatments

Control (no interlighting), Red (455nm), Blue (660nm) and White at the same 30µmol m^{-2} s^{-1} light intensity, started in late Nov. 2016 (Pictures D, G-J).

Acknowledgement

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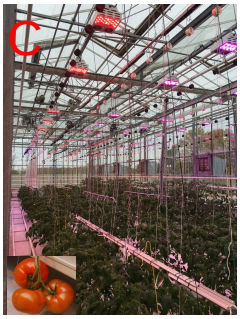

Results

Table 1. Effects of overhead and interlight LED lighting on cumulative fruit production of tomato cv. Foronti (December, 2015 to March, 2016)*

Overhead LED	Interlight LED	Weight (kg plant^{-1})	Fruit size (g fruit^{-1})
Constant	Red	5.36 ab	180 b
	Blue	5.59 a	192 a
	White	5.42 ab	193 a
	UV-A	5.12 b	179 b
Varying	Red	5.75 a	193 a
	Blue	5.64 a	191 a
	White	5.53 ab	183 b
	UV-A	5.28 b	185 ab

Table 2. Effects of overhead and interlight LED lighting on cumulative fruit production of sweet pepper cv. Redwing (January to May, 2017)*

Overhead LED	Interlight LED	Yield (kg m^{-2})	Fruit size (g)
100% RED	Control	15.53 b	236.2
	Red	15.03 b	222.7
	Blue	14.70 b	218.4
	White	17.77 a	231.1
Mixed (R:B:W - 76:16:8)	Control	15.85 b	227.8
	Red	16.31 b	225.8
	Blue	16.56 ab	239.6
	White	17.38 a	239.2

*. The means for inter-light LED treatments followed by different letters are significantly different ($p < 0.05$); all other effects are not significant ($p > 0.05$).

Results and Conclusion

1. Varying overhead LED spectrum over the season increased fruit yield by 3% on tomato but the increase was not statistically significant.
2. Mixed overhead LED light had 5% higher fruit yield than 100% red on sweet pepper but the difference was not statistically significant.
3. The red, blue and white LED interlighting had similar fruit yield while the yield with UV-A was lower on tomato.
4. The white LED was clearly better than red and blue LEDs as interlighting for sweet pepper production.
5. The optimum vertical light distribution regimes varied with crop species.

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