From Forest Nursery Notes, Summer 2013

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Gomez, C., Morrow, R. C., Bourget, C. M., Massa, G. D., and Mitchell, C. A.
HortTechnology 23(1):93-98. 2013.

Comparison of Intracanopy Light-emitting Diode Towers and Overhead High-pressure Sodium Lamps for Supplemental Lighting of Greenhouse-grown Tomatoes

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ADDITIONAL INDEX WORDS. **controlled environments, high-wire tomato, LED, *Solanum lycopersicum*, solid-state lighting, vertical lighting**

SUMMARY. **Electric supplemental lighting can account for a significant proportion of total greenhouse energy costs. Thus, the objectives of this study were to compare high-wire tomato (*Solanum lycopersicum*) production with and without supplemental lighting and to evaluate two different lighting positions + light sources [traditional high-pressure sodium (HPS) overhead lighting (OHL) lamps vs. light-emitting diode (LED) intracanopy lighting (ICL) towers] on several production and energy-consumption parameters for two commercial tomato cultivars. Results indicated that regardless of the lighting position + source, supplemental lighting induced early fruit production and increased node number, fruit number (FN), and total fruit fresh weight (FW) for both cultivars compared with unsupplemented controls for a winter-to-summer production period. Furthermore, no productivity differences were measured between the two supplemental lighting treatments. The energy-consumption metrics indicated that the electrical conversion efficiency for light-emitting intracanopy lighting (LED-ICL) into fruit biomass was 75% higher than that for HPS-OHL. Thus, the lighting cost per average fruit grown under the HPS-OHL lamps was 403% more than that of using LED-ICL towers. Although no increase in yield was measured using LED-ICL, significant energy savings for lighting occurred without compromising fruit yield.**

The U.S. greenhouse vegetable industry consists of many small, family-run operations and a few large facilities (Greer and Diver, 2000). Large greenhouse operations typically are located in the southwestern and western United States, where climate enables profitable production during winter, when vegetable prices are highest (Cook and Calvin, 2005). Nevertheless, several greenhouse facilities are also located in light-limited northern climates (low light intensities and short days), where optimal yield and quality of vegetables can be achieved only by using supplemental lighting (Dorais et al., 1991; McAvoy and Janes, 1984; Rodriguez and Lambeth, 1975; Tibbitts et al., 1987). However, the use of supplemental lighting represents an expense to greenhouse vegetable production. Currently, energy is second only to labor as the most expensive indirect cost of production (Frantz et al., 2010). Thus, the greenhouse industry is interested in cost-effective, energy-efficient sources of supplemental photosynthetic light to sustain steady supplies of high-quality produce during the off-season.

Most greenhouse growers who use supplemental lighting rely on overhead high-pressure sodium lamps because of their capability to deliver adequate photosynthetically active radiation (*PAR*). Furthermore, HPS lamps are ≈25% efficient, and the waste thermal energy can be used to increase ambient greenhouse and plant temperature. Brault et al. (1989) estimated that, in northern climates, the heat emitted from HPS lamps provided between 25% and 41% of the heating requirements for a greenhouse operation. Thus, heat generation is sometimes considered a useful by-product of HPS lamp operation. On the other hand, HPS lamps have a high life-cycle cost, an intense environmental impact, and an orange-biased, red-and-blue-deficient emission spectrum (Nelson, 2012). These lamps typically require reflectors to direct the light from the lamps onto crops, thereby providing satisfactory light distribution and efficiency, but also blocking sunlight from reaching the crops. Their significant thermal output often requires a glass barrier, cooling, and considerable separation distance between plants and lamps to avoid tissue scorching (Cathey and Campbell, 1977). Like most available light sources, HPS lamps were originally designed for human use. However, HPS lamps have been widely adapted for greenhouse supplemental lighting because they currently are the most economically viable mass-produced light source available that provides an adequate spectrum for plant growth.

LIGHT-EMITTING DIODES. Light-emitting diodes are a promising supplemental lighting technology for the greenhouse industry as they surpass in many aspects capabilities of commercially available lamps commonly used in horticulture (Morrow, 2008). As described by Bourget (2008), LEDs are robust, solid-state semiconductor devices that can emit narrow-spectrum light to maximize

The research was funded in part by NIFA SCRI grant 2010-51181-21369.

Assistance from Judy Santini, Chieri Kubota, Yiwei Jiang, Roberto Lopez, Mark Kroggel, Rob Eddy, Dan Hann, Eric Whitehead, Michael Dzakovich, Lucie Poulet, Cannon Cheng, and Jamie L. Ortman is gratefully acknowledged. Thanks also to MGS Horticulture for Biocontrol support, Syndicate Sales for growth media, and DeRuiter Seeds.

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Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.3048	ft	m	3.2808
0.0929	ft^2	m^2	10.7639
2.54	inch(es)	cm	0.3937
0.0254	mil	mm	39.3701
28.3495	oz	g	0.0353
1	ppm	$mg \cdot L^{-1}$	1
0.001	ppm	$mL \cdot L^{-1}$	1000
(°F – 32) ÷ 1.8	°F	°C	(°C × 1.8) + 32