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Effects of Temperature and Light in High Tunnel Primocane Red Raspberry Production

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Abstract
High tunnel production of primocane red raspberries extendsthe growing season, decreases winter injury, increases cane height and growth rate, and improves overall fruit quality and yield. However, tunnels have the potential to increase light intensity levels and result in high air and soil temperatures, which are detrimental to primocane red raspberry production. Soil and air temperatures above 16°C (60.8°F) and 24°C (75.2°F) and light intensity levels beyond 600 μmol·m^{-2}s^{-1} have been shown to decrease water uptake, encourage premature bud-dormancy, delay time to ripening, and reduce fruit quality and weight. The proposed study is intended to 1) assess the relationship between temperature and light intensity and their effect(s) on primocane raspberry growth and development, 2) evaluate how effective shade cloth and soil mulch are in reducing temperature and light intensity levels of high tunnel red raspberry production, and 3) provide relatively inexpensive solutions to minimize temperature and light intensity damage in protected red raspberry production during the warm summer monthsin Iowa.

Keywords
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Disciplines
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Effects of Temperature and Light in High Tunnel Primocane Red Raspberry Production

RFR-A1209

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Introduction

High tunnel production of primocane red raspberries extends the growing season, decreases winter injury, increases cane height and growth rate, and improves overall fruit quality and yield. However, tunnels have the potential to increase light intensity levels and result in high air and soil temperatures, which are detrimental to primocane red raspberry production. Soil and air temperatures above 16°C (60.8°F) and 24°C (75.2°F) and light intensity levels beyond 600 $\mu mol \cdot m^{-2}s^{-1}$ have been shown to decrease water uptake, encourage premature bud-dormancy, delay time to ripening, and reduce fruit quality and weight. The proposed study is intended to 1) assess the relationship between temperature and light intensity and their effect(s) on primocane raspberry growth and development, 2) evaluate how effective shade cloth and soil mulch are in reducing temperature and light intensity levels of high tunnel red raspberry production, and 3) provide relatively inexpensive solutions to minimize temperature and light intensity damage in protected red raspberry production during the warm summer months in Iowa.

Materials and Methods

This study was located at the Horticulture Research Station, Ames, Iowa, under three identical 11.0 m-(36 ft) long by 4.3 m-(14 ft) wide tunnels. Dormant, 1-year old canes of the primocane red raspberry Autumn Britten, obtained from Nourse Farms, were planted in raised beds 9.1 m (30 ft) long and 61 cm (2 ft) wide, with 46 cm (1.5 ft) spacing within row and 1.2 m (4 ft) spacing between rows. Raspberry canes were planted on April 18, trained on temporary T-trellis, and watered and fertilized via trickle irrigation at recommended rates. Light transmission of tunnel polyethylene plastic covering was measured at 17 percent reduction via LI-COR (LI-1400) data logger and sensors. Main-plot treatment was obtained by a combination of shade cloth of 33 percent shade factor, in addition to the 17 percent reduction of tunnel-plastic. Shade cloth was applied on June 15 and removed on September 22, 2012. Sub-plot mulch treatment of switchgrass, *Panicum virgatum* L., was applied to a 15.2 cm (6 in.) depth on the soil surface at planting. Temperatures were measured continuously at 30-minute intervals with WatchDog™ B-Series temperature loggers placed at 10.2 cm (4 in.) soil depth and at primocane growing point. Light intensity was measured when skies were mostly sunny. Berries were harvested every 2 to 4 days and a total fruit weight, berry number, average berry weight, and dry berry weight per treatment was recorded. Vegetative growth was determined by end-of-season cane height, number of laterals, leaf number, and leaf area from five randomly selected canes of each plot.

Results and Discussion

The 2012 growing season was one of the warmest years on record in Iowa. Maximum field air temperatures ranged from 26.7° to 37.8°C for three straight weeks in July, with lows remaining in the mid-teens to mid-20°C, during this same period. Tunnels had to be vented and thus shade cloth did not change the ambient temperature under the main plot treatments (Figure 1a). Although 16°C soil temperatures were attained at the beginning of

June 2011, 16°C field soil temperatures were already reached on May 5, 2012. Higher soil temperatures were recorded in the control treatment plots (Figure 1b). Switchgrass mulch did have a positive effect of reducing the soil temperatures of the designated replications, with an average 2.8°C reduction between mulch and control treatments. In addition, increased berry weight was observed in the mulch treatments (Table 1). The treatment of shade cloth and switchgrass mulch showed greatest potential in reducing the soil temperature at a 4-in.depth.

Thirty-three percent shade cloth significantly reduced the light intensity level of the tunnel environments, with maximum readings recorded on summer solstice, June 21. Although the light intensity readings were well above the optimum levels of 600 $\mu mol \cdot m^{-2}s^{-1}$ throughout the growing season, the 33 percent shade cloth was able to achieve an optimum level as early as August 22; reducing potential light intensity levels by nearly 50 percent.

First year results showed that 33 percent shade cloth adequately reduced light intensity of the tunnel environment to achieve a 50 percent level reduction ($P \leq 0.05$). However, because of the climatic extremes of the 2012 growing season, reduced light intensity showed no effect on reducing tunnel air and soil temperature and thus no effects were observed on primocane growth and development. Average berry weight was reduced by using a soil mulch under the main plot treatments of shade or no shade. However, these data are from newly planted dormant crowns and not fully developed plant canopies, and total yields for the growing season are low, indicative of a newly established planting. Data from 2013 will provide a more accurate projection of cane growth and development due to an increase in plant crown maturity as well as provide additional information under a different climatic growing season.

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Table 1. Effect of shade cloth (main plot) and soil mulch (sub-plot) treatment effects on growth and fruiting characteristics of primocane-fruiting Autumn Britten red raspberry and light intensity in the high tunnel.

		Growth and Development Characteristics[1]				Yield[1]			Light intensity
Treatments		Cane ht. (cm)	No. of leaves	Leaf area	No. of laterals	No. of berries	Avg. wt. (gms)	Total yield (gms)	$\mu mol \cdot m^{-2}s^{-1}$
Shade									1302.88 a
	No mulch	160.13	109.13	2877.80	31.53	433.33	2.69 a	1164.17	
	Mulch	158.23	198.20	4979.70	94.47	370.00	2.27 b	945.61	
No shade									655.14 b
	No mulch	111.07	151.53	3262.23	67.13	503.33	2.71 a	1348.86	
	Mulch	129.70	192.33	3905.53	47.80	577.00	2.55 a	1481.66	
		NS	NS	NS	NS	NS		NS	

[1]Means separation, Tukey adjustment $P \leq .05$. Means within a column followed by the same letter do not differ.
[NS]Non-significant.

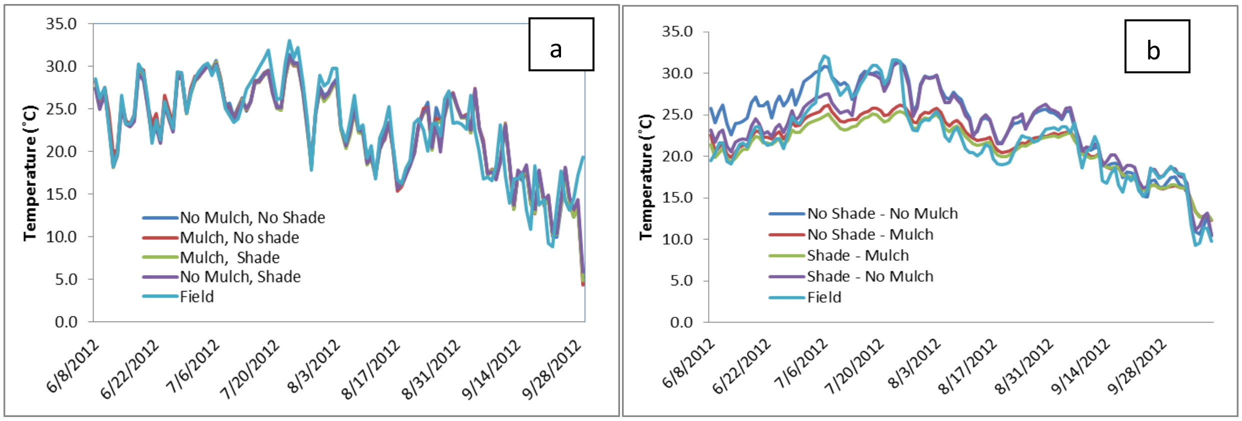

Figure 1. a) Daily temperature averages at cane growing point height. b) Weekly 4-in. soil depth temperatures under main and sub-plot treatments. Temperatures were logged at 30-minute intervals and daily averages were mapped.