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Far-red Light Alters Primocane Morphology of Red Raspberry

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***Abstract*. The objectives of the study were to determine whether raspberries responded to decreased red to far-red ratio and whether it was more effective at the beginning or end of the dark period. Increased proportions of far-red light increased the internode length when at the beginning of the dark period on the three raspberry cultivars 'Lauren','Reveille', and 'Titan'. Cultivars varied in that internode length also increased in ambient daylength compared to short days in 'Lauren' and 'Reveille', but not in 'Titan'. They also responded differently to photoperiod: 'Titan' and 'Lauren' grew under short days, whereas 'Reveille' ceased growth.**

Rubus ideaus L. has a perennial rootstock and biennial canes that grow vegetatively in the first and fruit in the second year. In the field, nodes appear on primocanes linearly over time, but cane height increases sigmoidally. Consequently, internode length is shorter at the beginning and end of the season (Jennings and Dale, 1982). When raspberries are grown in a greenhouse, the vegetative primocanes grow extremely vigorously and methods are needed to control height, which can result from variation in light quality, photoperiod, or temperature.

Several plant species have been shown to respond to changes in the ratio of red to far-red light. For example, Easter lilies (*Lilium longiflorum* Thunb.) exposed to twilight (low red to far-red ratio) have longer internodes than those grown without twilight (Blom et al. 1995). During twilight at sunset the red to far-red ratio is decreased from 1.1 to 0.7.

The objectives of this study were to determine if raspberries respond to decreased red and far-red light and whether it is more effective at the beginning or end of the dark period.

Materials and Methods

Rooted cuttings of three summer-bearing raspberry cultivars were planted in 3.8-L grow bags in a peat-based mixture (Professional Mix VPW 30; ASB Greenworld, Mt Elgin, Ont., Canada) 'Lauren' on June 15, 1997, 'Titan' on 3 and 20 May 1997, and 'Reveille' on 27 May, 2000. All plants were grown outside, except for the plants potted in 1997, which were used in a greenhouse experiment during Fall 1997 (Dale et al., 2002). Plants were watered daily through trickle irrigation, and fertilized with 85 g/pot of 100-d Nutricote 13N–5.6P–10.8K with micronutrients, placed on the surface of the growing medium once each year.

In Fall 2001, the plants were exposed to four lighting treatments (ambient, short-day, short-day with far-red at the beginning (BON-FR) or at the end of the night (EON-FR)) within a glass greenhouse at 42% N/L at 18/18 °C (day/night). Ambient photoperiod changed from 13.0 h in the middle of September to ≈9.5 h in the middle of December. The three short-day treatments received ambient light between 0800 and 1600 HR. At 1600 HR, a black-out cloth was pulled daily over each of the benches and at 0800 HR the next morning removed. The first short-day treatment received no supplemental light and thus received the 8-h photoperiod without twilight. Supplemental lighting (far-red) was given to the other two short-day treatments for 1 h under the blackout cloth. For the beginning of the night treatment the lights were turned on between 1600 to 1700 HR and for the end of the night treatment 0700 to 0800 HR respectively. The far-red light was generated by two10-W incandescent lamps covered with a Lee filter #120 Blue (Lee Filters, Toronto, Canada). The lamps were suspended ≈1 m above the plant canopy and covered ≈1 m^2 of bench space. The quantum flux density for this light source was 0.071 $\mu mol \cdot m^{-2} \cdot s^{-1}$ for the far-red light (700 to 750 nm) spectrum at plant level. The red to far-red ratio for the far-red light source was 0.055 (based on quantum sums for 650 to 700 and 700 to 750 nm, respectively). The estimated phytochrome photoequilibria (Pfr/Ptot) is 0.094 for the far-red light source (Sager et al., 1988).

The plants were pruned to two canes tipped at 70 cm from the base of the pot on 12 Sept. 2001. For 'Reveille', some plants were pruned to a single cane. All plants were watered on a per needed basis with 200 mg N/L using 20N–3.4P–16.6K fertilizer (Plant Products Co., Bramalea, Ont., Canada). The length, number of nodes and the appearance of the apical meristem (vegetative or terminal) were measured on 23 Dec. 2001 on each shoot that developed.

The experimental design was a split plot with two main plot replications (greenhouse compartments), with lighting treatments as main plots and cultivar as the subplots. There were two plants of 'Lauren' and four plants of 'Reveille' and 'Titan' per experimental unit. Due to the insignificance of main-plot error in the analysis, the data was analyzed as a completely randomized design.

Table 1. The effect of lighting treatments on three red raspberry cultivars on different morphological characteristics of the shoots following pruning during the fall.

Lighting treatment[z]	Shoot length (cm)	Nodes (no.)	Internode length (cm)	Vegetative shoots (%)
'Lauren'				
BON-FR	115 a[y]	26.3 ab	4.3 a	100 a
Ambient	106 a	29.5 a	3.6 a	83 ab
EON-FR	71 b	25.9 ab	2.7 b	75 b
Short day	58 b	22.5 b	2.4 b	75 b
'Reveille'				
BON-FR	25 a	13.7 a	1.8 a	12 a
Ambient	26 a	14.3 a	1.8 a	13 a
EON-FR	11 ab	14.4 a	0.8 b	0 a
Short-day	13 ab	15.9 a	0.8 b	0 a
'Titan'				
BON-FR	97 a	24.1 a	4.2 a	100 a
Ambient	53 b	21.0 a	2.4 b	89 b
EON-FR	43 b	23.1 a	1.8 b	83 b
Short-day	42 b	19.5 a	2.2 b	89 b
Significance				
Lighting (L)	***	NS	***	NS
Cultivar (C)	**	**	**	**
L × C	*	NS	NS	NS

[z]BON-FR = 1 h of far-red at the beginning of the 16-h dark period, EON-FR = 1 h of far-red at the end of the 16-h dark period, and a short day is an 8-h photoperiod without any twilight.
[y]Mean separation are by Duncan's multiple range test with letters denoting significance ($P = 0.05$) within cultivars.
NS,*,**,***Nonsignificant or significant at $P < 0.05$, 0.01, or 0.001, respectively. Data for percent vegetative shoots were transformed first using arcsin function. Data shows actual percentages.

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Results

The shoot length for BON-FR and ambient treatments were similar and about twice of either EON-FR or short days except for 'Titan', where ambient did not show increased shoot length compared to either EON-FR or short days (Table 1). 'Reveille' had the shortest shoots and the fewest nodes of all three cultivars as most of its shoots had terminated vegetative growth, while 'Lauren' and 'Titan remained vegetative. The number of nodes within each cultivar was not affected by the lighting treatment. Internode length responded in the same way as shoot length to the lighting treatments (Table 1).

Discussion

Increased proportions of far-red light increased internode length when at the beginning of the dark period on the three raspberry cultivars, similar to results for Easter lilies (Blom et al., 1995). These results were consistent with observations from the 2 previous years. Why the results for the ambient treatment for 'Lauren' and 'Reveille' were similar to BON-FR but not for 'Titan' is uncertain. However, ambient conditions differ from the BON-FR in the length of photoperiod, the red to far-red ratio during sunset, duration, and quantum flux of the far-red light during the twilight period, any of which could be responsible for the reported cultivar variation. The sigmoidal change in internode length experienced by raspberry plants grown at higher latitudes (Jennings and Dale, 1982) may be partially explained by the far-red response demonstrated here.

Cultivars also responded differently to photoperiod. 'Titan' and 'Lauren' were able to grow under short days, whereas 'Reveille' ceased growth. Studies have shown that terminal growth is affected by photoperiod, but none has reported differences between cultivars (Carew et al., 2000). Since raspberries grow extremely vigorously in greenhouses, methods to eliminate twilight could be used to shorten primocanes. However, the raspberry cane is biennial and the effects of twilight on the fruiting cane would need to be studied before this technique can be used commercially.

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