Variation in Plant and Soil Water Relations among Irrigated Blueberry Cultivars Planted at Two Distinct In-Row Spacings

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INTRODUCTION

Highbush blueberry is a shallow rooted crop that is highly sensitive to soil water deficits. When exposed to even mild episodes of drought, vegetative growth is rapidly reduced and fruit development is often diminished. However, despite this vulnerability, little is known about the water relations of this crop, particularly with regard to any variation that may occur among cultivars or through cultural practices.

The objectives of the current study were 1) to determine the effect of traditional and close in-row spacing on plant and soil water relations in common highbush blueberry cultivars and 2) to identify possible mechanisms that may enhance the ability of the cultivars to tolerate short-term episodes of soil water deficit.

MATERIALS AND METHODS

The study was conducted on a 0.15-ha field of highbush blueberry (*Vaccinium corymbosum* L.) established in October 1999 (Fig. 1). Three cultivars, 'Duke', 'Bluecrop', and 'Elliott', were planted at the site on fumigated silt loam soil. 'Duke' and 'Bluecrop' are the two most popular varieties grown in the Pacific Northwest and are typically harvested in late-June and early-July, respectively; 'Elliott' is a popular late-season variety harvested mid- to late-August. Each cultivar was spaced either 0.5 or 1.2 m apart within rows and 3.0 m apart between rows on raised beds amended with sawdust and ammonium sulfate fertilizer (66 kg N ha^{-1}) incorporated prior to planting. Each treatment plot consisted of a 6.1-m row of plants and was replicated five times. Treatments were arranged in a randomized complete-block design.

The field was irrigated by overhead impact sprinklers as needed between May and September at a rate of 25-50 mm $week^{-1}$; total irrigation applied in 2003 was 711 mm. Fertilizer was applied each spring as ammonium sulfate. Weeds, insects, and diseases were controlled with herbicides and pesticides as needed. Fruit was hand-picked following standard commercial practices beginning the third year after planting.

Plant and soil measurements were made in 2003 during the fourth growing season. Crop light interception was measured periodically in each plot using a line quantum sensor; readings were taken on both sides of the row in 75-mm increments between two adjacent plants, and then averaged and divided by above-canopy readings to estimate percent light intercepted by the canopy. Soil water content was measured using a neutron probe and galvanized-steel access tubes installed 1.5-m deep. One tube was located in the center of each plot at 0.2 m from the base of a plant; neutron counts (15-s intervals) were made (1 d before an irrigation) at each 0.3-m depth increment between 0.15-1.05 m from the soil surface. Stomatal conductance and stem water potential were used as indicators of crop water status and were measured bi-weekly in each treatment using a steady-state porometer and a pressure chamber, respectively. Both measurements were made at midday between 1330-1530 hours PST. Stomatal conductance was measured on a single leaf exposed to full sun from each plot.

Fig. 1. Field site at the North Willamette Research and Extension Center in Aurora, Oregon, USA.

Stem water potentials were estimated by measuring the water potential of a branch tip with three fully-expanded leaves that had been enclosed for at least 1 h in foil-laminated plastic bags.

RESULTS

Close in-row spacing of blueberry cultivars either had no effect or significantly reduced individual shoot dry weight compared to plants spaced further apart (Fig. 1a), but significantly increased the total amount of light intercepted by the crop canopy (Fig. 2). Close spacing also significantly increased water uptake from 0-0.6 m soil depth (Figs. 3a & b), demonstrating that closer spacing increased the overall water requirements of the crop.

Plant spacing had little effect on plant water relations of the cultivars. Regardless of cultivar or in-row spacing, stomatal conductance decreased rapidly as stem water potential approached -0.6 to -0.8 MPa (Fig. 4). We found, however, that 'Duke' maintained, on average, significantly higher stem water potentials and greater stomatal conductance than the other cultivars as soil water was depleted (Table 1), which may indicate that this cultivar has the highest tolerance to short-term soil water deficits. 'Bluecrop', on the other hand, had the lowest stem water potentials and stomatal conductance, and thus may be more sensitive to water deficits. 'Bluecrop' also had the lowest root mass (Fig. 1b) and root:shoot dry weight ratio (Fig. 1c) at either spacing, while 'Elliott' had the highest. 'Duke', in comparison, produced the deepest root system and extracted more water below 0.6 m when plants were closely spaced (Fig. 3c).

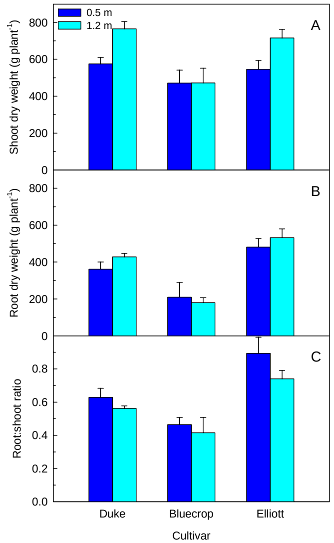

Fig. 2. Shoot (a) and root (b) dry weight and root:shoot dry weight ratio (c) of highbush blueberry cultivars ('Duke', 'Bluecrop', and 'Elliott') spaced 0.5 or 1.2 m apart within rows. Measurements were made in February 2003. Each bar represents the mean of five measurements and error bars represent ±1 standard error of the mean. Adapted from Strik and Buller (Acta Hort., in press).

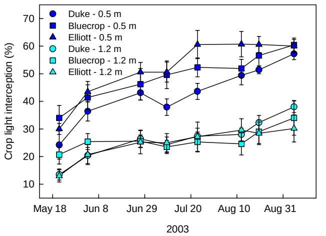

Fig. 3. Crop light interception of highbush blueberry cultivars ('Duke', 'Bluecrop', and 'Elliott') spaced 0.5 or 1.2 m apart within rows. Light interception was measured (between 1200-1300 h PST) at ground level on each side of the row at 0-1 m from the row center. Each symbol represents the mean of five measurements and error bars represent ±1 standard error of the mean.

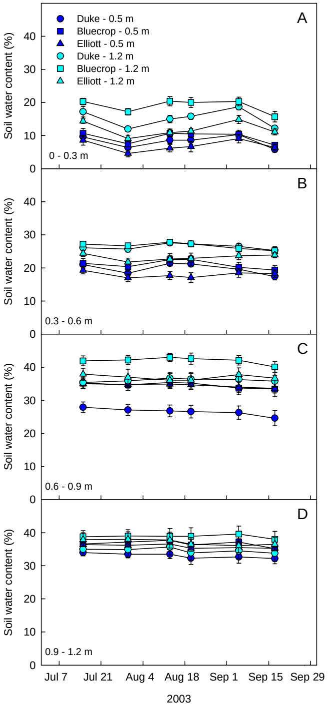

Fig. 4. Soil water content at 0-0.3 (a), 0.3-0.6 (b), 0.6-0.9 (c), and 0.9-1.2 (d) m depth increments for highbush blueberry cultivars ('Duke', 'Bluecrop', and 'Elliott') spaced 0.5 or 1.2 m apart within rows. Each symbol represents the mean of five measurements and error bars represent ±1 standard error of the mean.

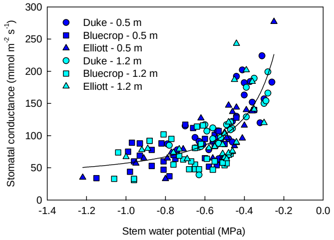

Fig. 5. Leaf stomatal conductance as a function of stem water potential for highbush blueberry cultivars ('Duke', 'Bluecrop', and 'Elliott') spaced 0.5 or 1.2 m apart within rows. Each symbol represents one measurement. The relationship was fitted with an inverse second order polynomial ($y = 6.10/x2 - 25.82/x + 25.38$ with $r2 = 0.57$ and $P<0.001$).

Table 1. Mean stomatal conductance and stem water potential of highbush blueberry cultivars ('Duke', 'Bluecrop', and 'Elliott') spaced 0.5 or 1.2 m apart within rows. Values indicate the seasonal average of seven sets of measurements made from May-September 2003.

Cultivar	In-row spacing (m)	Stomatal conductance (mmol m^{-2} s^{-1})	Stem water potential (MPa)
Duke	0.5	129 a[1]	-0.55 b
Bluecrop	0.5	83 cd	-0.72 c
Elliott	0.5	98 bcd	-0.62 b
Duke	1.2	115 ab	-0.46 a
Bluecrop	1.2	78 d	-0.72 c
Elliott	1.2	109 abc	-0.58 b
Analysis of variance			
Cultivar		<0.001	<0.001
Spacing		ns	<0.05
Cultivar*spacing		ns	ns

[1] Within columns, means followed by the same letter are not significantly different at $P<0.05$ using least square means.

CONCLUSIONS

The results of this study indicate that there is considerable variation in the morphological and physiological adaptations of the cultivars to tolerate short-term episodes of water deficits, such as deeper root systems or the ability to maintain higher plant water status, which may influence their irrigation water requirements throughout the growing season. The results also indicate that significantly more water is required when plants are spaced close together than when they are spaced further apart, although the difference in the total amount of water required was not determined. Irrigation requirements of each cultivar and plant spacing will be determined as the study continues in 2004.

ACKNOWLEDGEMENTS

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