Do Primocanes and Floricanes Compete for Soil Water in Blackberry?

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Abstract

A study was done to determine the hydraulic relationship between primocanes and floricanes in 'Marion' trailing blackberry and to identify any water limitations to plant and fruit development during alternate-year (biennial) production. Irrigation was applied weekly by drip and scheduled as needed to replace 100% of the estimated crop evapotranspiration (ET) requirements. On any given day, primocane water potential, measured using a pressure chamber, was nearly identical between 'on-year' (floricanes and primocanes present) and 'off-year' (only primocanes present) plants. Floricane water potential, on the other hand, was consistently lower (by 0.3–0.6 MPa) than primocane water potential throughout the fruiting season, especially during midsummer when crop water demands was high. Water potential was significantly correlated to evaporative water demands (expressed as reference ET) in both cane types, and when normalized to atmospheric conditions, remained nearly constant between irrigations. Such constant water potentials indicate that plant water status was not limited by soil water availability and hence would probably not benefit from extra or more frequent irrigation. However, based on different water potentials between cane types, it appears that primocanes and floricanes are hydraulically independent and therefore may compete for water in dry soil conditions.

INTRODUCTION

Though blackberry is a perennial crop, each cane it produces is biennial. New canes, known as primocanes, arise from buds on the base of old stems or the crown each spring and remain vegetative during their first growing season. After a winter dormant period, the primocanes become floricanes, producing flowers and fruit and then senescing after harvest. Both primocanes and floricanes exist simultaneously on a single plant, other than in the planting year, and share a single root system. During production, floricanes often shade primocanes trained along the ground (Bell et al., 1995) and potentially compete with them for water and nutrients (Pritts, 2004).

The objectives of the present study were to determine the hydraulic relationship between primocanes and floricanes in blackberry and to identify any water limitations to plant and fruit development that might be attributable to within-plant competition among the cane types. The study was done on plants grown in an alternate-year (AY) production system. In an AY system, both floricanes and primocanes are cut and removed after harvest (usually in October) so that only primocanes are produced the following 'off year'. Thus, fruit are produced every other year during 'on-years'.

MATERIALS AND METHODS

The study was conducted in 2004 and 2005 on a 0.09 ha field of 'Marion' trailing blackberry (*Rubus* spp. hyb) established at the North Willamette Research and Extension Center, Aurora, Oregon, USA (45°23′ N 122°75′ W) in April 2000. Soil at the site is a Willamette silt loam. Plants were spaced 0.6 or 1.5 m apart within rows and 3.0 m apart between rows, trained on a standard upright two-wire trellis system and maintained in alternate-year (AY; both spacings) production systems (Strik, 1992). Plants spaced 0.6 m apart were either topped (i.e., pruned) at 1.8 m once primocanes reached the top trellis wire or not topped during ‘off-years’; the primocanes of plants spaced at 1.5 m were never topped. Each treatment plot consisted of a 6.1 m row of plants that was replicated five times and arranged in a randomized complete-block design. Plots were separated within rows by 3.0 m of unplanted space to allow for separation by treatment during harvest. Production in each half of AY plots was alternated so that each year half the plot was in production (‘on-year’) while the other half was not (‘off-year’).

The field was irrigated by drip tubing with 3.8 $L \cdot h^{-1}$ emitters spaced 0.76 m apart, located on the trellis ≈0.45 m above the soil surface. Irrigation was applied weekly as needed (between May and September) at a rate of 25–50 $mm \cdot week^{-1}$ and monitored periodically with a turbine water meter (model W-120, Invensys Metering Systems, Uniontown, Pa., USA) installed at the inflow of the irrigation system. Enough water was applied during irrigations to meet or exceed 100% of the estimated crop evapotranspiration (ET) requirement (Hess et al., 1997). The total amount of irrigation applied was 432 mm in 2004 and 433 mm in 2005. Fertilizer was applied each spring following standard commercial practices (Hart et al., 2000). Weeds, insects, and diseases were controlled with herbicides and pesticides as needed. Fruit were harvested by machine on 28 June, 1 July, 6 July, 12 July and 19 July in 2004 using an over-the-row harvester; and hand-picked on 30 June, 6 July, 11 July, 18 July and 25 July in 2005. Plants were pruned after harvest on 29–30 September 2004 and 3–11 August 2005 by removing the senesced floricanes.

Daily weather conditions were obtained from a nearby U.S. Bureau of Reclamation AgriMet weather station located <1 km from the site. Reference ET was calculated from the weather data using the 1982 Kimberly-Penman equation (Wright, 1982). Primocane and floricane water potential was measured periodically in each treatment using a pressure chamber (model 600, PMS Instrument Co., Corvallis, Ore., USA), following the recommendations of Hsiao (1990); measurements were made at midday between 1330–1530 hours PST on single fully-expanded leaves enclosed for at least 1 h in foil-laminated plastic bags. Water potentials were measured on only ‘on-year’ plants in 2004, but on both ‘on-’ and ‘off-year’ plants in 2005. Changes in soil water content were measured periodically using a time-domain reflectometry (TDR) system (model Trase System I, Soilmoisture Equipment Corp, Santa Barbara, Calif., USA) and 0.30 m TDR probes. One probe was installed vertically near the center of each plot at 0.2 m from the base of a plant.

RESULTS AND DISCUSSION

According to analysis of variance, floricane and primocane water potentials were not significantly different among topping and spacing treatments on each measurement date in 2004 and 2005 and were therefore pooled across treatments.

Within a single plant, water potential was consistently lower in floricanes than in primocanes throughout fruit development in June and July 2004, but was quite similar between cane types after harvest until floricanes began senescing in early September (Fig. 1A). Floricane water potential declined gradually during fruiting to about -1.2 MPa by late harvest and then increased rapidly to -0.8 to -0.9 MPa after harvest. Primocane water potential, by comparison, declined throughout the summer, but never dropped below -0.8 MPa all season. Lower water potentials in floricanes may be attributed to greater resistance to water transport and/or to accumulation of solutes during fruiting (Kramer and Boyer, 1995). Brierley (1929) reported relatively poor xylem development in raspberry fruiting laterals, which structurally are quite similar to fruiting laterals on blackberry floricanes. Fewer xylem vessels may restrict water movement through floricanes, potentially leading to lower water status when water demands are high (i.e., during fruit ripening in mid summer). To our knowledge, no work has been published on osmotic potentials in blackberry.

Floricane water potential was also lower than primocane water potential during fruiting in 2005, with differences ranging from 0.4 to 0.6 MPa in June and July. Primocane water potential, however, was nearly identical between ‘on-year’ plants with floricanes and ‘off-year’ plants without floricanes (Fig. 2). Between June and August 2005, water potential of floricanes averaged -1.24±0.03 MPa, while water potential of primocanes averaged -0.71±0.02 MPa in both ‘on-year’ and ‘off-year’ plants. Soil water content declined steadily between irrigations whether plants were in an ‘on-year’ or an ‘off-year’, but was consistently 2–4% lower in ‘on-year’ than in ‘off-year’ plots. For example, between 12 July (day irrigation was applied) and 18 July (day prior to next irrigation), soil water content decreased from 36 to 24% in plots with ‘on-year’ plants, and from 38 to 28% in plots with ‘off-year’ plants.

Seasonal changes in water potential appeared most affected by fruiting and stage of plant development and only somewhat influenced by weather conditions (Fig. 1B). On a daily basis, however, water potential was highly correlated ($P < 0.001$) to reference ET (which is a function of weather conditions) in both cane types (Fig. 3). Thus, when normalized to reference ET (Fig. 2A), floricane and primocane water potentials remained nearly constant between irrigations (Fig. 2C). Apparently, weekly irrigation by drip was adequate to maintain plant water status between irrigations, even during peak harvest in July. Due to our well-watered conditions, we were unable to find any evidence for direct competition for soil water between primocanes and floricanes, though it does appear that they are hydraulically independent. Our next study will compare water uptake by each cane type in plants grown under drought.

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Figures

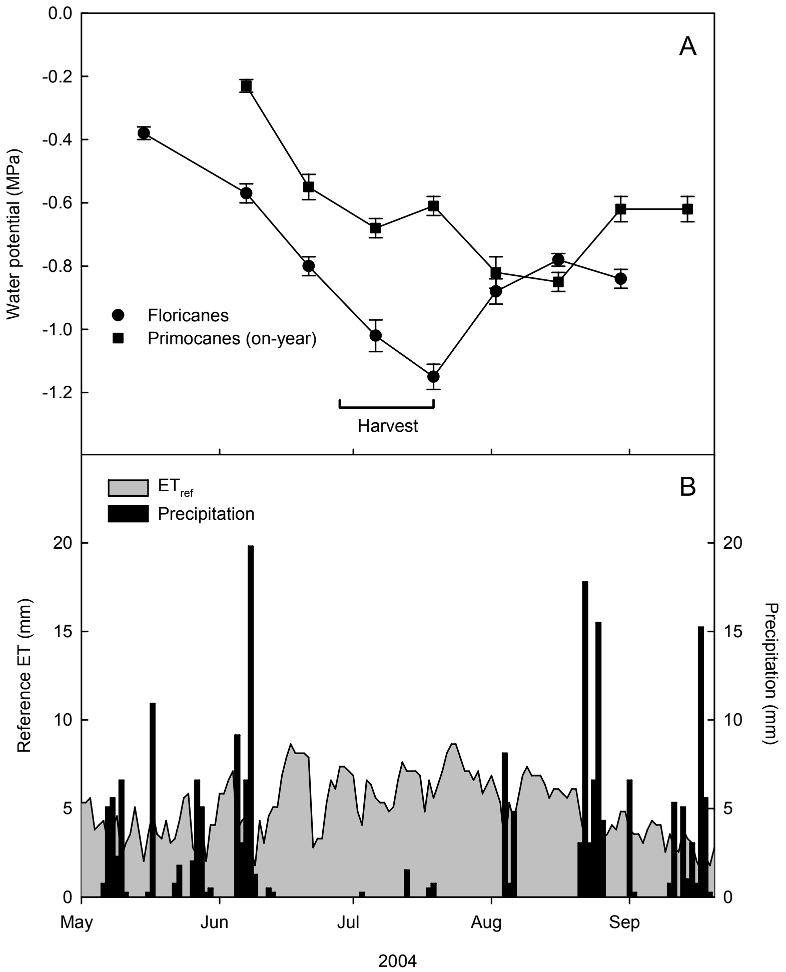

Fig. 1. A) Seasonal changes in water potential of floricanes and primocanes in ‘Marion’ blackberry grown in an alternate-year production system and B) reference evapotranspiration (ET) and precipitation measured at the site during the 2004 growing season. Floricane and primocane measurements were made on the same fruiting plants during an ‘on-year’ cropping cycle. Fruit were machine harvested in five pickings between 28 June and 19 July. Values in A) are the mean of five replicates and error bars represent 1 standard error.

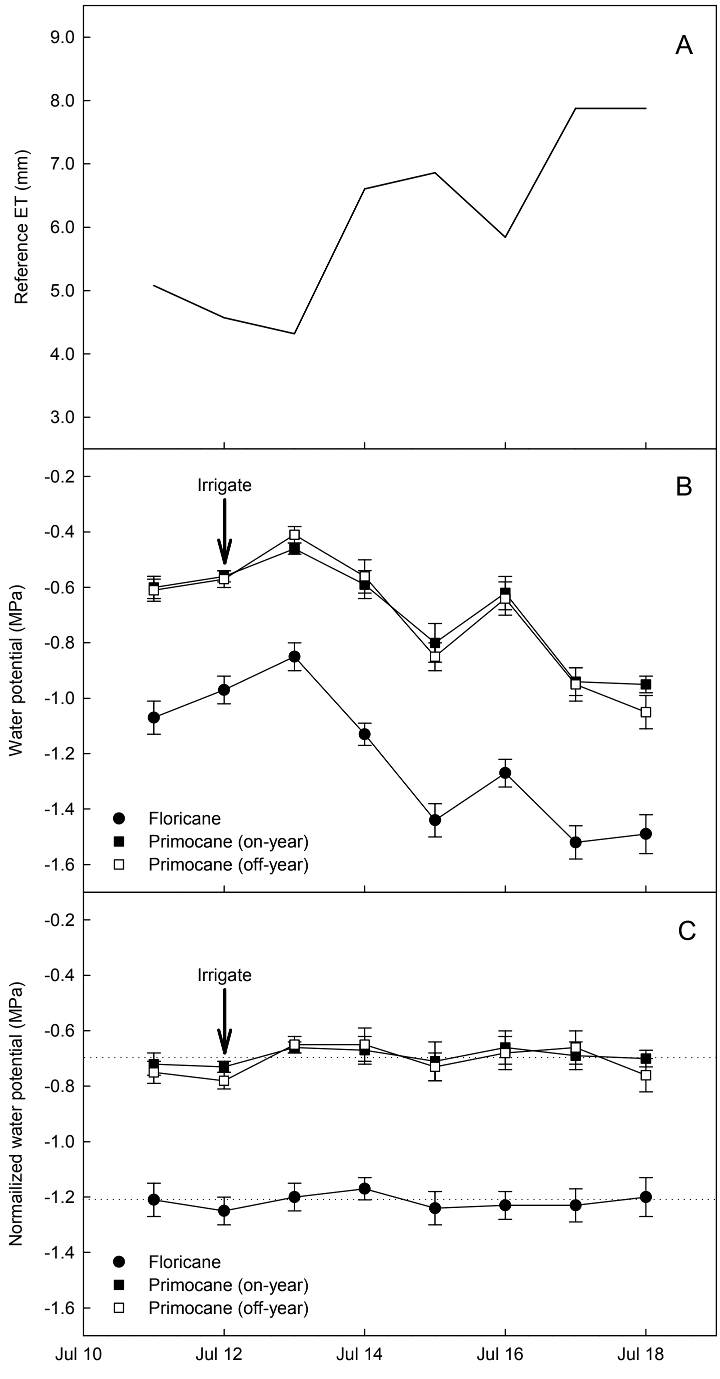

Fig. 2. A) Reference evapotranspiration (ET) and B) daily changes in water potential of floricanes and primocanes in 'Marion' blackberry grown in an alternate-year production system. Measurements were made in 2005 on fruiting (floricanes and primocanes) and non-fruiting (primocanes only) plants in 'on-' and 'off-year' cropping cycles, respectively. Plants were irrigated on 12 July and no precipitation occurred during measurements. In C), cane water potentials were normalized to changes in references ET. Values in B) and C) are the mean of five replicates and error bars represent 1 standard error.

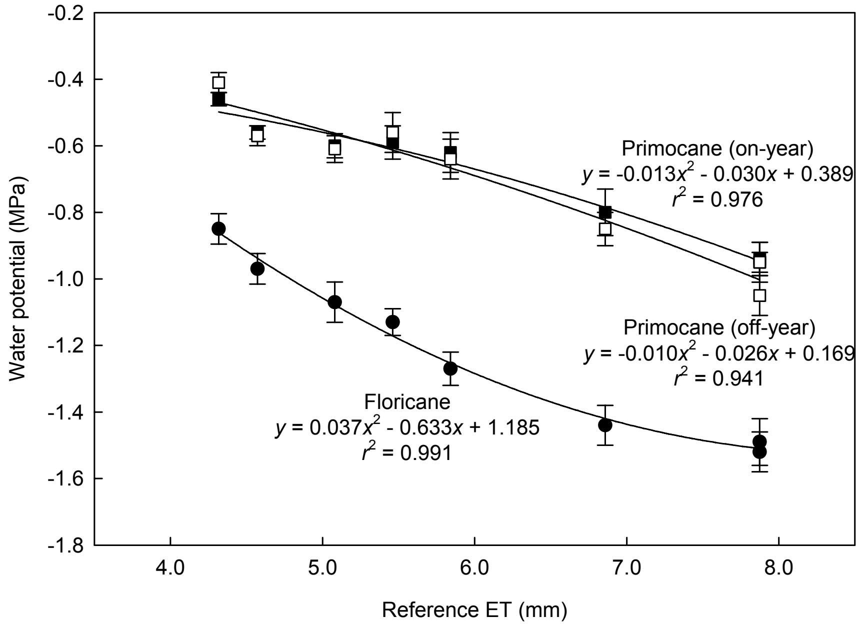

Fig. 3. Relationship between floricane and primocane (‘on-year’ and ‘off-year’) water potential and reference evapotranspiration (ET) in ‘Marion’ blackberry grown in an alternate-year production system. Data were same as those shown in Figure 2A and 2B, and were fit using second-order polynomial equations.