Response of Merlot Grapevines to Drip and Sprinkler Irrigation in the Okanagan Valley

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Abstract

The effects of sprinkler versus drip irrigation on vine development and fruit maturation were explored over two years in a Merlot vineyard with a sandy soil in the Okanagan Valley in British Columbia. Sprinkler and drip irrigation treatments were applied to main plots, and cluster thinning treatments were applied to subplots in a spit-plot design. Irrigation was applied when the soil moisture content at 15-45 cm depth was depleted to less than 10%. Sufficient water was applied to wet the soil profile to below 45 cm. In the first and second years, respectively, sprinkler irrigation was applied 23 and 18 times, and drip irrigation was applied 31 and 21 times. During summer, stomatal conductance and photosynthesis rates were lower in drip- than in sprinkler-irrigated vines, regardless of the soil moisture content under the vines. Compared with sprinkler irrigation, drip irrigation reduced vine vigor, berry weight and yield in the first year, and reduced cluster weight and yield in non-thinned vines in the second year. In vines carrying similar yields, fruit matured earlier and had lower acidity under drip than under sprinkler irrigation. Monitored ambient temperatures revealed that daily maximum temperatures and GDD accumulation were higher under drip than under sprinkler-irrigation which accounted for the differences in fruit maturation.

Introduction

The Okanagan Valley is an arid viticultural area receiving less than 30 cm of rainfall annually. Currently most vineyards are sprinkler irrigated because sprinkler systems are in place for frost control, and experience has taught growers how to manage sprinkler irrigation to produce quality wine grapes. However, with increasing demands on the valley's water supply, growers are under pressure to conserve water by converting to drip irrigation.

We investigated how vines differ physiologically in response to sprinkler and drip irrigation by studying how canopy growth, leaf gas exchange and berry development are affected by the amount and spatial distribution of soil moisture. Anticipating that vine balance would be affected by irrigation method, we also studied the response of fruit development to cluster thinning under sprinkler and drip irrigation.

Methods

The research was conducted during 2003 and 2004 at Vincor's Sunrock vineyard near Osoyoos in the southern Okanagan Valley in British Columbia. The vineyard soil was a loamy sand. Vine spacing was 1.2 m in rows 2.4 m apart. Vines were trained to bilateral cordons with vertical shoot positioning.

A factorial combination of irrigation and cluster thinning treatments was applied in a split-plot design with irrigation treatments (sprinkler and drip) each applied to four 10-row x 30-vine main plots, and cluster thinning treatments (with and without) each applied to two two-vine subplots within each main plot. Soil moisture was monitored at 15 cm increments to a depth of 60 cm using segmented time domain reflectometry (TDR) probes (ESI, Victoria, B.C.) inserted 10 cm from emitters and 25 cm from vine trunks. Irrigation was applied when the average moisture level at 15-45 cm depth was depleted to 10%, and to wet the profile to a depth of *ca.* 45 cm (Fig. 1). Sprinkler irrigation wet the soil profile through the entire vineyard surface while the drip emitters, spaced at 40 cm, wet 50-cm-wide *ca.* spherical volumes which coalesced in the vine rows.

All vines were shoot thinned in May to retain 20 shoots. Cluster thinning was applied pre-veraison when berries were pea-sized, and removed the smaller cluster from shoots bearing two clusters.

Growing degree days (GDD, base 10°C) were calculated from temperatures monitored using shielded thermistors at mid-canopy height in main plots. Shoot lengths were measured in mid-July. Canopy gap area (%), viewed from between rows, was estimated pre- and post-veraison. Leaf gas exchange was measured several times during the growing seasons using a portable system (Li-Cor 6400). Berries were sampled periodically for °Brix, pH and titratable acidity (TA) measurements. Fruit was harvested when mature, based primarily on °Brix level.

Results and Discussion

Drip irrigations were applied more frequently than sprinkler irrigations (31 vs 23 times in 2003, and 21 vs 18 times in 2004), and the irrigation applications were non-synchronous (Fig.1). Vines developed shorter shoots and canopies with more gap area under drip than under sprinkler irrigation (Fig. 2). During July through early September leaf stomatal conductance and photosynthesis rates were more often found to be lower in response to drip than sprinkler irrigation regardless of soil moisture levels (Figs. 1 and 3). This reduction in leaf function was similar to that reported for vines under partial root-zone drying in which root systems are divided between wet and drying soil (Dry and Loveys, 1999).

Fruit maturation, indicated by °Brix, TA and pH levels, was advanced by *ca.* 2 weeks under drip relative to under sprinkler irrigation, despite vines having smaller canopies and lower photosynthesis rates (Fig. 4). In 2003, this may have been due in part to the smaller berries and lower yields carried by the drip-irrigated vines (Fig. 5). However, when drip and sprinkler irrigated vines carrying similar yields were compared, the fruit of drip-irrigated vines matured earlier and had lower acidity at maturity (non-tabulated data). The accelerated fruit maturation was likely influenced by the warmer maximum (mid-day) ambient temperatures in drip-irrigated plots during July and August that increased GDD accumulations by 117 GDD in 2003 and 73 GDD in 2004 relative to in sprinkler-irrigated plots (Fig. 6). Ambient temperatures in sprinkler-irrigated plots were probably reduced by the higher vine leaf area and transpiration rates and the heavier vegetation coverage on the vineyard floor. Regardless of irrigation method, fruit matured at *ca.* 1,500 GDD in 2003 and *ca.* 1,480 GDD in 2004. A similar degree of advanced maturation in Merlot in response to increased GDD accumulations was observed previously (Bowen et al., 2004).

Cluster thinning reduced cluster numbers by 40% in 2003 and by 45% in 2004, and there was no compensatory increase in berry size in either year (Fig. 5). In 2003, yield was reduced by cluster thinning and by drip irrigation which reduced cluster numbers and berry weight. In 2004, yield was reduced by cluster thinning, and by drip irrigation only in non-thinned vines where it reduced the number of berries per cluster (non-tabulated data).

Weight of developing berries in 2004 was lower in response to drip irrigation until the third week in September when berries lost weight under all treatments (Fig. 4). At harvest, which was nine days earlier for drip than sprinkler irrigated vines, berry weight did not differ between irrigation treatments (Fig. 5).

The earlier maturation in response to drip irrigation in both years was linked with higher pH and lower TA levels relative to °Brix levels (Fig. 4). The lower acidity resulting from maturation under warmer temperatures necessitated harvesting the fruit earlier than was desirable for hang time. Cluster thinning only exacerbated this problem in 2004, and had no effect on fruit development or basic composition in 2003, which indicates that vines were generally below production capacity. Increasing the crop load of vines under drip irrigation may help to slow the rate of fruit maturation and delay harvests until early October when TA and pH levels stabilize at more desirable levels.

Literature Cited

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Acknowledgements

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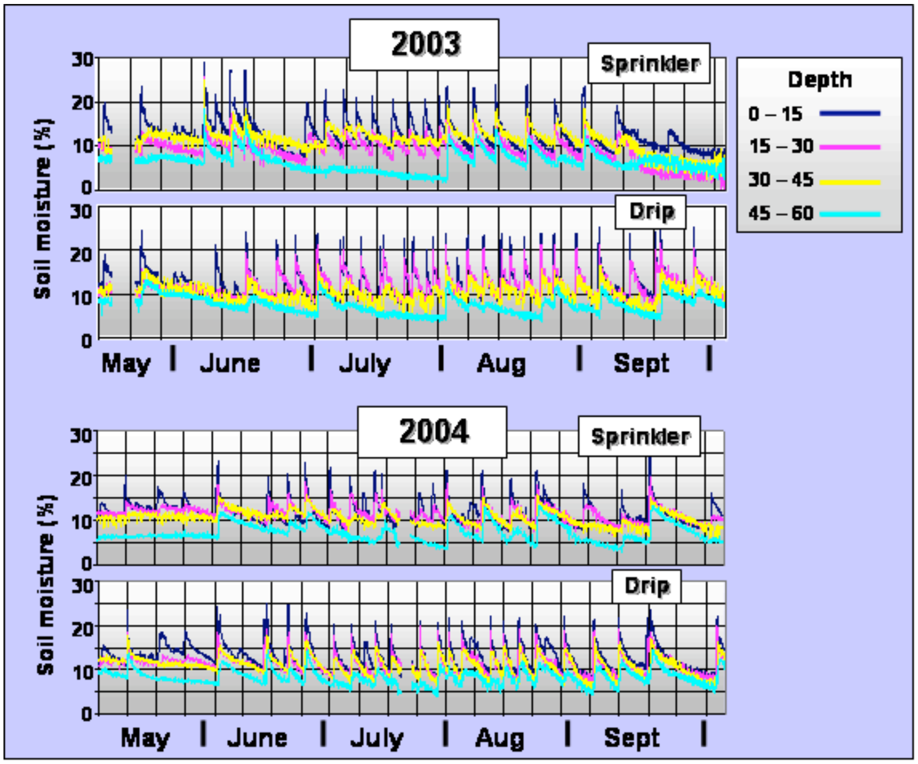

Fig. 1. Soil moisture measured 25 cm from vine trunks and at 15 cm depth increments in sprinkler and drip irrigated plots over the 2003 and 2004 growing seasons.

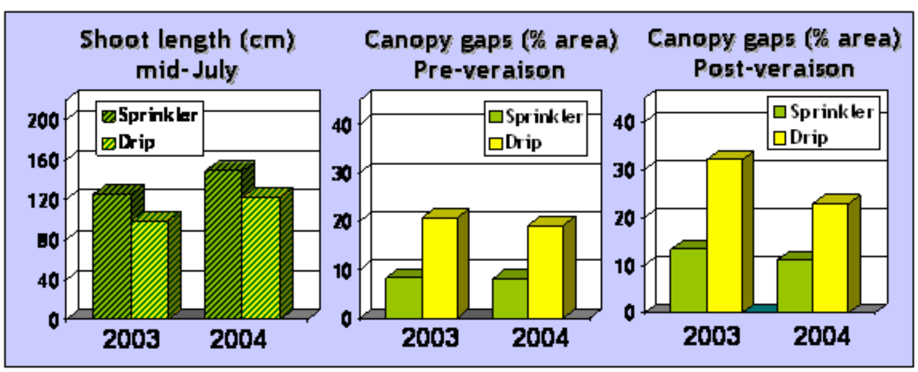

Fig. 2. Shoot length and canopy gap area in response to sprinkler and drip irrigation during the 2003 and 2004 growing seasons. Canopy gap area (%) was estimated when viewed perpendicular to the canopy plane from midway between rows. Pre-veraison estimates were made on 18 July 2003 and 13 July 2004. Post-veraison estimates were made on 3 September 2003 and 16 August 2004. Irrigation method affected all parameters in both years (P =0.05).

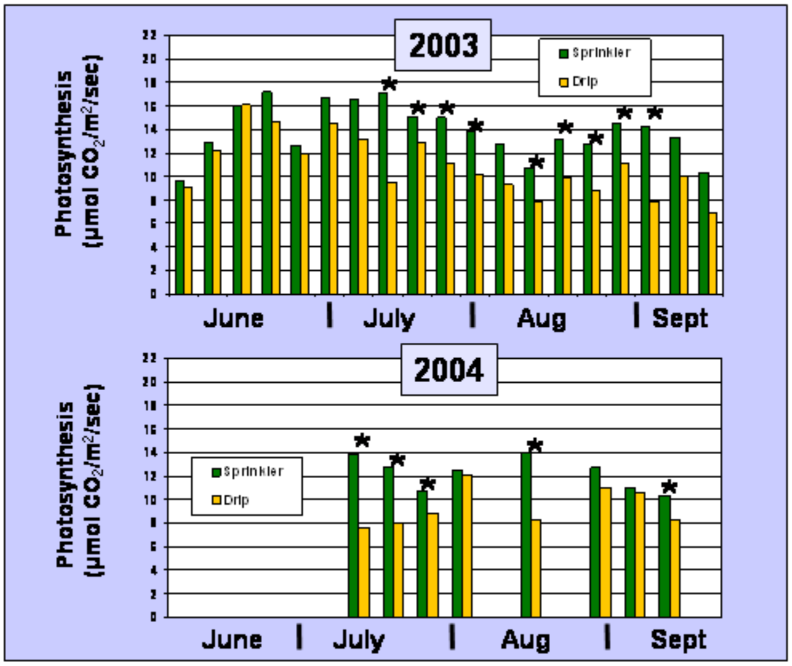

Fig. 3. Photosynthesis rates (µmol CO2/m2/sec) in sprinkler- and drip-irrigated vines during the 2003 and 2004 growing seasons. Asterisks (*) indicate significant (*P* =0.05) differences due to irrigation treatments. Cluster thinning had no effect on photosynthesis rates.

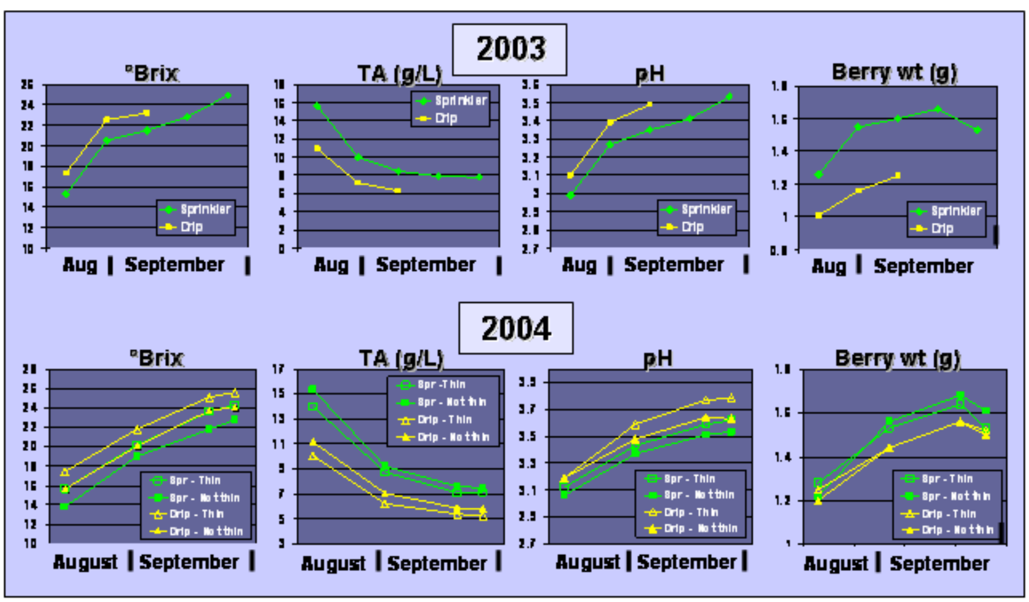

Fig. 4. Development of basic fruit composition and berry weight after veraison in response to sprinkler and drip irrigation and to cluster thinning. Effects of irrigation method were significant (*P*=0.05) in both years. Effects of cluster thinning were significant (*P* =0.05) only in 2004.

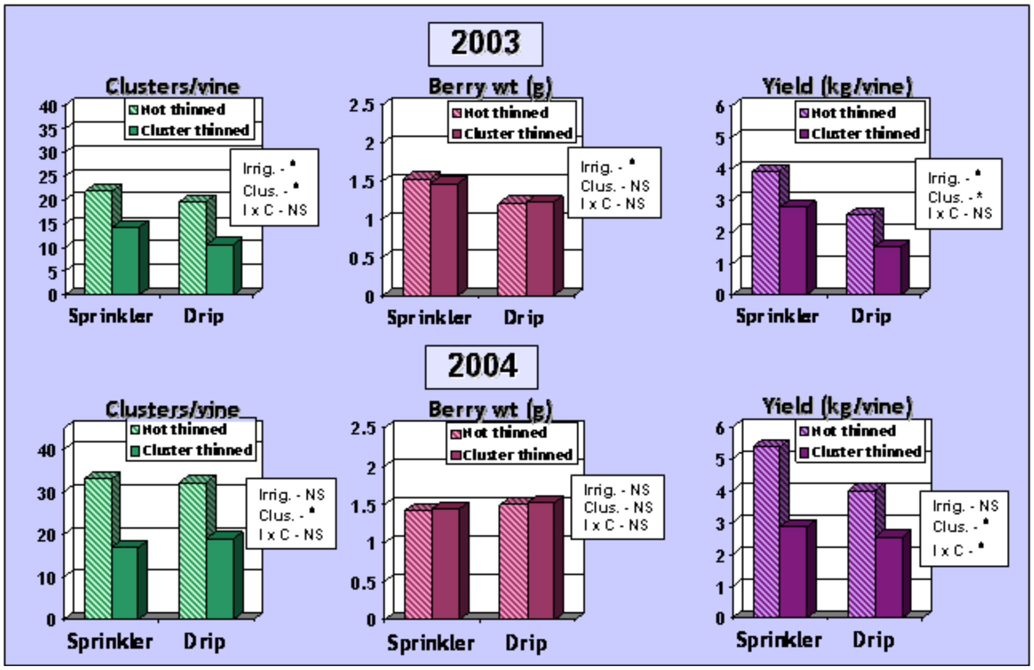

Fig. 5. Yield components at harvest in response to irrigation method and cluster thinning in 2003 and 2004. Harvest dates in 2003 and 2004, respectively, were September 10 and 22 for drip-irrigated vines, and September 26 and October 1 for sprinkler-irrigated vines. Insets show significance of treatment main effects and their interaction (*, $P < 0.05$; NS, not significant).

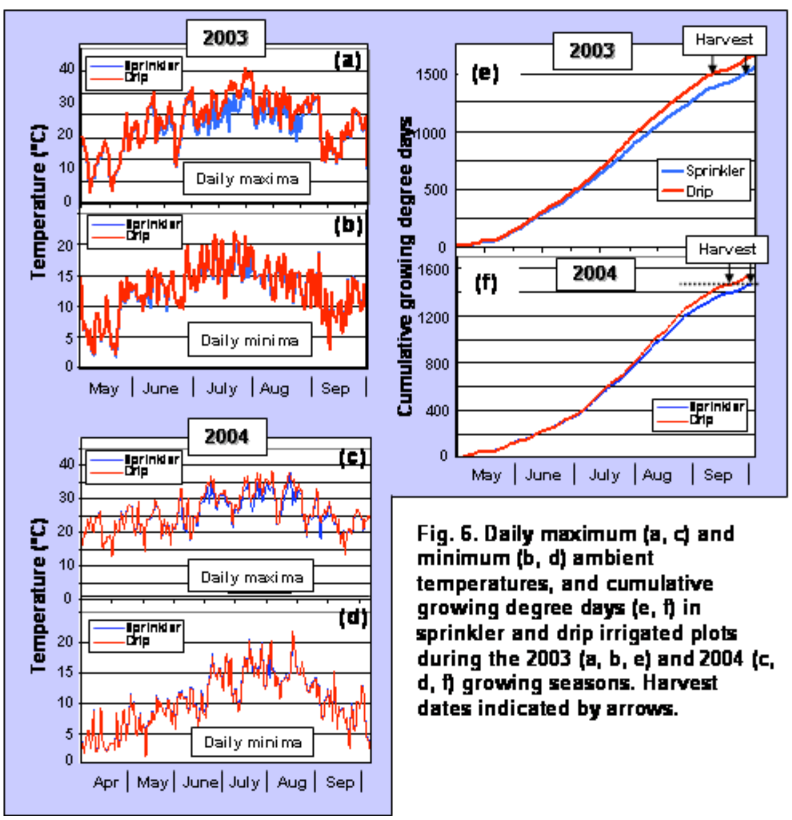

Fig. 6. Daily maximum (a, c) and minimum (b, d) ambient temperatures, and cumulative growing degree days (e, f) in sprinkler and drip irrigated plots during the 2003 (a, b, e) and 2004 (c, d, f) growing seasons. Harvest dates indicated by arrows.