Direct Root-zone Deficit Irrigation: A Strategy to Enhance Water Conservation and Sustain Grape Production in Pacific Northwest

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Introduction

Subsurface micro-irrigation has been demonstrated to increase water use efficiency, but buried drip lines are subject to clogging of emitters and damage by rodents. This presentation illustrates the direct root-zone (DRZ) deficit irrigation technique to avoid these issues and deliver drip irrigation at greater depths (applied up to 3-foot below ground) than buried lines. Results from our study provides evidence that use of efficient irrigation application such as DRZ might both sustain vines and produce grapes during drought conditions while yielding grapes with potential to produce premium quality red wines in the hands of skilled viticulturists and enologists.

Hypothesis

Compared with surface drip (SD) irrigation, Subsurface direct root-zone (DRZ) deficit irrigation could increase water use efficiency, sustain grape yield, and increase grape quality by using less water.

Objectives

- Compare subsurface DRZ irrigation delivered at ca. 60, 30, and 15 percent of full rate of soil water replenishment in terms of plant water stress and fruit production
- Estimate the most appropriate depth zone to apply water
- Determine advantages of applying water in pulsed events versus uninterrupted delivery

Methods

- *Focal species:* Cabernet Sauvignon (Red wine grapes).
- *Experimental design and treatments:* A randomized complete block design experiment was conducted in a commercial block located on Kiona Vineyards from 2015 to 2016 (*Figure 1*). DRZ irrigation delivered water at 1, 2, and 3 ft. depths on a schedule determined by the growers to a control treatment of standard SD irrigation. Rates of water applied to the subsurface treatments were ca. 60, 30, and 15 percent of the SD application rate and were regulated by battery powered controllers (*Figure 2*). Irrigation was delivered as either continuous or pulsed application and compared to SD irrigation application.
- *Measurements:* 1) Grape yield, 2) grape quality, 3) stem water stress, and 4) irrigation amount.

Figure 1. Field site in Red Mountain AVA, WA

Figure 2. Battery powered controller in field site

Results

- No significant differences of grape yield and quality were attributed to either depth of delivery or pulse application.
- Vines receiving DRZ irrigation at reduced rates of commercial SD irrigation produced individual clusters with higher numbers of berries, yet smaller in size, than did clusters from vines receiving full rates of SD irrigation.

Table 1. Water use efficiency and grape production (2015)

2015	Surface Drip 100 %	DRZ 60 %	DRZ 30 %	DRZ 15 %
WATER USED Acre Feet	1.35	0.81	0.40	0.20
WATER USED Gallons/vine	16.25	9.75	4.88	2.44
PRODUCTION Tons/acre	4.54	4.08	3.40	3.18
EFFICIENCY Lbs./acre inch	560	840	1449	2650
RELATIVE EFFICIENCY	1.0	1.5	2.5	4.7

Table 2. Water use efficiency and grape production (2016)

2016	Surface Drip 100 %	DRZ 60 %	DRZ 30 %	DRZ 15 %
WATER USED Acre Feet	1.37	0.84	0.43	0.22
WATER USED Gallons/vine	17.59	10.27	5.13	2.57
PRODUCTION Tons/acre	6.73	3.79	2.96	2.20
EFFICIENCY Lbs./acre inch	818	752	1147	1667
RELATIVE EFFICIENCY	1.0	0.9	1.4	2.0

Table 3. Stem water stress of grapevine (2016)

	Plant	Water	Stress	(MPa)
Date	SD (100 %)	DRZ (60 %)	DRZ (30 %)	DRZ (15 %)
June 3	-0.53	-0.59	-0.64	-0.72
July 7	-0.64	-0.83	-0.93	-1.19
Aug 10	-0.87	-1.18	-1.52	-1.59

Abbreviations: SD – Surface Drip irrigation; DRZ – Direct Root-Zone deficit irrigation.

Table 4. Grape quality analysis (2016)

Component	Surface drip 100 %	DRZ 60 %	DRZ 30 %	DRZ 15 %
pH (acidity)	3.41	3.36	3.48	3.55
Titratable Acidity (g/L)	5.5	5.8	5.3	4.9
Brix (degrees)	25.5	27.1	27.6	28.6
Tannins (mg/L)	403	594	600	741
Anthocyanins (mg/L)	1015	1242	1298	1480

Next Steps

- Although this technique may conserve water and produce high quality grapes for producing premium red wines, questions remain around reduced production and long-term vine health. We are continuing to run this project, which will deepen our undertanding of DRZ irrigation technique on grapevine growth.
- Consideration is being given to adjusting the DRZ rates upwards and directly comparing equal rates of water application under SD and DRZ application during the next two growing seasons. This approach will help separate the influences of DRZ from SD as well as the influences of deficit irrigation applied through each method of delivery.

Acknowledgements

This research project was supported by the WA State Grape and Wine Research Program, WSDA Specialty Crop Block Program, project (K1768), Western Sustainable Agriculture Research and Education Program Graduate Student Grant (GW17-058), and China Scholarship Council. The authors wish to thank Scott Williams, general manager – Kiona Winery and Vineyards, Benton City, WA for providing access to land and resources for this project. We also thank Rick Hamman of Hogue Ranches, Bill Riley of Ste. Michael Wine Estates, Julia Kock of Klipsun Vineyards, and Jim Holmes of Ciel du Cheval Vineyard for serving as an Advisory Group to this research project and others either on-going or pending grant approval.