Effect of Partial Rootzone Drying (PRD) on vineyard rootzone salinity

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Introduction

The Padthaway district is an established wine growing region dating back to 1964. Groundwater is the primary source of irrigation water which is yielded from the unconfined limestone aquifer. Annual groundwater salinity increases of between 5-18mg/L/yr (Harrington et al 2004) have been recorded in the aquifer beneath the irrigation area, which may threaten the long-term viability of the viticultural industry.

Water use efficiency is also becoming more crucial within the district especially with the planned implementation of the new water allocation plan in 2009. An irrigation technique designed to improve vine water use efficiency was developed by Brian Loveys of the CSIRO called Partial Rootzone Drying (PRD). This involves drying half of a vines root system while keeping the other half wet by frequent irrigation. After a certain period of time the ‘wet’ and ‘dry’ zones are alternated, allowing the former ‘wet’ zone to slowly dry while the ‘dry’ zone is irrigated (Loveys et al 2000). This alternation tricks the vines into thinking it is under drought stress, where by it produces abscisic acid (ABA). This hormone causes stomata to partially close thus reducing water loss and restricting shoot extension (Kriedemann & Goodwin, 2004)

Salinity effects on a grape vine include reduced water availability due to an osmotic effect that can reduce growth. Toxic effects can result from a high concentration of ions that can overwhelm the natural exclusion mechanisms of a vine and can result in severe leaf burn and eventual defoliation. Nutrient imbalances can also occur causing a reduced uptake of specific nutrients. Salinity in soil can become a hazard when levels exceed 4dS/m in grapevines (Nicholas, 2004). Own rooted vines tend to be more affected at this level, with some rootstocks being more tolerant. At these levels the economic threshold for yield decline become obvious and the visual symptoms appear on a regular basis.

Figure 1. Diagrammatic representation of how PRD is applied to grapevines
This project was designed to assess the affect of PRD on root zone salinity, with the aim to determine if reduced amounts of water being applied to a grapevine root system would reduce salinity present in the soil.

**Materials and Methodology**

*Site*

This trial was undertaken on the Constellation wines Padthaway 2 vineyard located approximately 8km south of the Padthaway township. The Shiraz vines used are own-rooted and planted in 1994. The vine and row spacing was 1.8m x 2.7m respectively and trained to a lazy VSP trellis system. Vines were irrigated with drip emitters 0.2m away from the planting row, with 2L/hr emitters. The PRD treatment had Netafim® joined tube where inline emitters were placed every 75cm but alternating down the two tubes.

*Trial Design*

Three treatments were applied:

1. Conventional (Conv) - using crop factors to determine irrigation
2. Reduced conventional (Red Conv) - using same amount of water as PRD but on both sides of the vine
3. Partial Rootzone drying (PRD) - irrigating one side of vine, until refill point is achieved and then swapped.

Figure 1 indicates the area allocated to each treatment. Each treatment has a C-probe measuring at 20,40,60,80 and 100cm depths and also gypsum blocks that have blocks located at 25, 50 and 75cm depths. Two sets of soil water extractors are also located within each irrigation treatment reading from depths of 25, 50 and 75cm. Irrigation did not commence until well into December where a traditional deficit irrigation program is practiced.
Figure 2. Trial Site Design. Yellow squares indicate location of soil moisture monitoring and soil water extractors.
Data Collection
Capacitance probes (C-probes) and gypsum blocks were installed under vine within each irrigation type (Figure 2), with two sets being located in the PRD site to monitor both sides of the vine. Sensor depths for the C-probes were at 20, 40, 60, 80 and 100cm and the gypsum blocks were located at 25, 50 and 75cm. The data is able to be logged and transmitted automatically in the case of the C-probes and semi-automatically with the gypsum blocks (G-bug) onto respective computer programs and assessed weekly during the irrigation season to determine lag times and the extent that soil moisture moves down the profile after irrigation and rainfall events. This data was also used to help determine when the swapping was to occur on the PRD component of the trial. Soil water extractor data was collected weekly during the irrigation season and fortnightly at all other times (Figure 3). Weather station data was collected from the local Bureau of Meteorology station located north of the vineyard.

![Figure 3. Soil water extractors soaking in water prior to being installed.](image)

It should also be noted that although the trial commenced in the 2006/7 season, due to the frosts very low crop yields/canopies were achieved. The 2007/8 season is a reflection of a more normal season in the Padthaway district.

Results

Irrigation

Table 1. Amount of water applied to PRD, Red Conv. and Conv. irrigation treatments during the growing season in 2006/7 and 2007/8.

<table>
<thead>
<tr>
<th></th>
<th>Oct 06 – Mar 07</th>
<th>Oct 07 – Mar 08</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Irrigation</td>
<td>Irrigation + Rainfall (92mm)</td>
</tr>
<tr>
<td>PRD</td>
<td>161</td>
<td>253</td>
</tr>
<tr>
<td>Red Conv</td>
<td>167</td>
<td>259</td>
</tr>
<tr>
<td>Conv</td>
<td>191</td>
<td>283</td>
</tr>
</tbody>
</table>
Water savings using PRD was approximately 10-15% in 2006/7, and 28% in 2007/8 for the time period mentioned and is numerically represented in Table 1. The 2007/8 irrigation was intentionally applied to have this 30% reduction, rather than using the soil water monitoring as the only guide as to when to swap, as was done in 2006/7. Yield was not collected to demonstrate if the reduced water application had an affect on yield, although anecdotally is seems as if there was not. Although the seasons were vastly different in relation to extremes in weather conditions the total water applied to the sites were similar in both years (283 and 293mm for 2006/7 and 2007/8 respectively. The reduced conventional treatment was not applied in the 2007/8 season and hence received similar water to the conventional treatment.

The commencement of irrigation occurred in late December as highlighted in Figure 4. PRD swapping sides commenced with 5 day intervals, which shortened to 3 days during the peak ripening period and then every second day during the heat wave in early March.

**Soil Water Extractor data**

Table 2. Soil Water salinity under irrigation treatments PRD, Red. Conv. And Conv for the three soil water extractor depths and the average across the three depths for growing seasons 2006/7 and 2007/8.

<table>
<thead>
<tr>
<th>SWE Depth</th>
<th>PRD Oct 06 – Mar 07</th>
<th>Red Conv</th>
<th>Conv</th>
<th>PRD Oct 07 – Mar 08</th>
<th>Red Conv</th>
<th>Conv</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>3.8</td>
<td>6.0</td>
<td>4.2</td>
<td>5.0</td>
<td>4.8</td>
<td>6.2</td>
</tr>
<tr>
<td>50</td>
<td>8.0</td>
<td>10.3</td>
<td>9.8</td>
<td>9.4</td>
<td>6.4</td>
<td>6.8</td>
</tr>
<tr>
<td>75</td>
<td>7.4</td>
<td>11.7</td>
<td>13.8</td>
<td>7.2</td>
<td>7.6</td>
<td>14.5</td>
</tr>
<tr>
<td>Av</td>
<td>6.4</td>
<td>9.3</td>
<td>9.3</td>
<td>7.2</td>
<td>6.2</td>
<td>9.2</td>
</tr>
</tbody>
</table>

The PRD treatment in both growing seasons had reduced soil water salinity when compared to the conventional treatment (Table 2). The trend was to see increasing salinities as soil depth increased, regardless of irrigation treatment. Extractor data was difficult to obtain at lower depths during the
irrigation deficit period (Nov-Dec) and peak ripening period (January–March) and this is demonstrated in Figure 5.

Figure 5 also demonstrates soil water salinity peaks at the end of vintage and on the lead up to the autumn/winter rainfalls. When adequate winter rainfall occurs the soil salinity declines with a plateau in early spring. In the spring of 2007 when vine root activity is at its peak and above ground growth is also occurring soil salinities begin to rise. This rise continues until the following winter period. Where large rainfall events are seen (as was the case in January 2007) there can be significant shifts in soil salinity, predominately in re-allocation further down the profile.

**Discussion**

The results presented in Table 2 would suggest that PRD is having a beneficial effect on the soil water salinity undervine. For this trend to be evident for 2 years running would suggest there is a carry over effect from the previous year. Reasons for the reduced salinity levels when using this treatment may be because of reduced amounts of water being applied, and thus less salt being added. Other thoughts include having a reduced canopy size that occurs as a result of the PRD treatment, results in a reduced mass flow effect, and thus less salt being up taken by the vine. One other reason potentially could be the production of abscisic acid (ABA) which occurs when a vine is placed under a PRD irrigation regime and this may have an effect on excluding the uptake of certain ions involved in soil salinity.
Figure 5. Soil Water extractor averages (EC) for 25, 50 and 75cm for PRD, Red. Conv. And Conv. Irrigation treatments from November 2006 – April 2008. Irrigation, rainfall and evapotranspiration are also represented.
References


