THE EFFECT OF SOIL AND IRRIGATION MANAGEMENT ON GRAPEVINE PERFORMANCE

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CONTENTS

CHAPTER FIVE – THE EFFECT OF SOIL AND IRRIGATION MANAGEMENT ON GRAPEVINE VEGETATIVE GROWTH

CHAPTER SIX – THE EFFECT OF SOIL AND IRRIGATION MANAGEMENT ON GRAPEVINE YIELD

CHAPTER SEVEN – THE EFFECT OF SOIL AND IRRIGATION MANAGEMENT ON BERRY COMPOSITION

CHAPTER EIGHT – THE EFFECT OF SOIL AND IRRIGATION MANAGEMENT ON SOIL AND GRAPEVINE SALINITY

CHAPTER NINE – GENERAL DISCUSSION AND CONCLUSIONS

SUMMARY

The increasing demand worldwide for Australian wine has driven the recent expansion in vineyard plantings which in turn, has increased the requirement for irrigation water in grape growing regions. Large areas of Australia's national vineyard are already irrigated with relatively poor quality water and many districts have a limited supply of water available for irrigation. Therefore, improving the efficiency of vineyard irrigation is essential for the long term sustainability of the Australian wine industry. Reducing the volume of irrigation applied to vineyards can improve water use efficiency (WUE) and reduce vine vigour. However, it can be difficult to accurately apply the required degree of water stress and this may result in a yield reduction. An irrigation technique known as partial rootzone drying (PRD) involves applying a continuous water deficit to alternate sides of the root system while ensuring the other half is well watered. This has been found to increase WUE, reduce vine vigour, improve fruit quality but not affect vine yield.

Where the soil volume available for root growth is limited, so too is the resultant vine growth and yield, as access to water and nutrients is restricted. Shallow soil profiles present a major limitation to root development and grapevine vigour. In shallow soils, mounding topsoil from the vineyard mid row to form raised beds in the vine row has been found to improve vine growth and productivity. Soil mounds tend to have a higher moisture holding capacity than flat soil but the greater surface area of the mound can increase surface evaporation. Applying mulch to the mound surface has been shown to reduce evaporative soil moisture loss and conserve irrigation water.

The general hypothesis tested in this experiment was that: '*Combining soil mounding, straw mulch and partial rootzone drying (PRD) irrigation will improve grapevine growth and production and reduce levels of sodium and chloride in the vine.*'

The experiment was established on *Vitis vinifera* cv. Shiraz in a mature vineyard at Padthaway, South Australia, where the soil profile consisted of a shallow loam over

clay and limestone. Soils of the experimental site were classified as moderately saline because their electrical conductivity (EC_{se}) was greater than 4 dS/m. Three main factors, irrigation method (standard or PRD), soil mounding (flat or mounded) and surface cover (bare or straw mulch) were combined into a 2X2X2 factorial experiment such that the randomised block experiment comprised three replicates of eight treatments. The irrigation treatments were control (the application of water to both sides of the vines) and PRD (the application of water to one side of the vines only at any time). In the PRD treatment the frequency of alternating the 'wet' and 'dry' sides was determined according to soil moisture measurements and was typically every 5-7 days.

It was very difficult to accurately schedule the irrigation at this site to avoid applying a moisture deficit to the PRD treatment. The shallow soil profile dried very quickly following irrigation and there were problems with the accuracy of the soil moisture sensing equipment for the duration of the experiment. As a result, PRD vines experienced repeated, excessive soil moisture deficits such that vine growth and production were significantly reduced each season. Shoot length was measured weekly during the growing season, while photosynthetically-active radiation (PAR), leaf area and canopy volume were measured at full canopy. Shoot number and pruning weight were measured during dormancy. All measures of vegetative growth (with the exception of PAR) were reduced in response to PRD. The decrease in lateral shoot growth for PRD resulted in greater bunch exposure and PAR. As a direct result of the severe soil moisture deficits experienced by the PRD treatment, all components of yield were significantly reduced compared to the control treatment each season. In particular, bunch weight and berry weight were significantly lower in the PRD treatment compared to the control, which suggests a period(s) of severe soil moisture deficit was experienced. Despite the yield loss sustained by the PRD treatment, WUE was improved compared to the control treatment in the first two years of this experiment. Berry anthocyanin levels were higher for the PRD treatment than the control but this may be due to the reduction in berry size.

Weekly volumetric soil moisture monitoring showed that mounded soil was wetter than flat soil each year at similar horizons. In addition, the larger soil volume of the mounded treatment enhanced vine root development. Vegetative growth was greater in the mounded treatment than the flat treatment. Mounded vines grew more shoots than non-mounded vines, although there was no effect of mounding treatment on shoot length. The difference in shoot number was significant only in year 2, possibly due to the time required for vine roots to establish in the mounds. Pruning weight and mean shoot weight were higher for the mounded treatment each year and mounded vines grew more shoots than non-mounded vines in years 1 and 2. The increase in shoot weight of mounded vines, relative to non-mounded, was most likely due to the increase in lateral shoot growth which is supported by the lower PAR values of the mounded treatment compared to the flat treatment. Each year soil mounding resulted in higher vine yields than in flat soil beds as a direct result of the increased vine capacity of mounded vines. The mounded treatment had more shoots per vine than the non-mounded treatment and thus more bunches per vine. In addition, bunch weights were higher in the mounded treatment each year, due mainly to improved fruit set and more berries per bunch. Despite the mounded treatment resulting in a denser canopy than the non-mounded treatment this did not affect fruit composition in years 1 and 2. WUE was higher for the mound treatment in years 2 and 3 only, due to the volume of irrigation water applied being reduced, yet mounded vines continued to produce higher yields than non-mounded vines. In year 3, berries from vines grown in mounded soil had significantly higher pH than berries from vines grown in flat soil beds. Mounding treatment did not consistently affect berry anthocyanin or phenolic levels.

Soil moisture levels were higher in the mulch treatment than the bare treatment in all seasons. In contrast to the mounding treatment, wetter soil did not consistently lead to improved vine growth or yield. Mulched vines developed fewer roots than non-mulched vines which is likely to have limited vine access to water and nutrients. As a result, shoot growth was similar for both treatments each season. The only significant difference between treatments for pruning weight was found in year 3 and was due entirely to shoot weight. The mulched treatment had lower PAR than the bare treatment in year 3, probably the result of increased lateral shoot growth and thus increased shoot weight, although this was not significant. PAR was significantly higher for the mulch treatment, compared to the bare treatment, in year 1 only but this was not supported by significant increases in vegetative growth. The mulch treatment resulted in higher vine yield than the non-mulch treatment in years 1 and 3. This difference was significant in year 3 only when both bunch number and bunch weight were significantly higher for mulched vines. In year 1 only bunch weight was significantly higher for mulched vines. Differences between treatments occurred in year 2 for fruit composition, specifically juice TA and anthocyanin levels. The mulch treatment had significantly higher TA and a significantly lower anthocyanin concentration in berries than the non-mulch treatment in year 2. There was no evidence of increased shading in the mulched treatment relative to the bare treatment that year but the difference in anthocyanin concentration may be explained by the significantly smaller berries of the bare treatment.

Analysis of samples taken regularly from the soil profile and vine rootzone showed that there was no treatment effect on soil salinity but that soil EC_{se} increased with soil depth and time each year. Petiole samples were collected at flowering, veraison and pre-harvest and levels were deemed toxic by pre-harvest each year. The PRD treatment received approximately 60% of the salt applied to the control treatment. This did not reduce EC_{se} but did result in lower measures of sodium and chloride in petioles and juice at harvest. Vines grown in soil mounds had access to a greater volume of soil water than the non-mounded vines. The mounded treatment had higher levels of pre-harvest petiole chloride in years 1 and 3 but this was significant only in year 3. There was no consistent trend in levels of sodium and chloride in the juice from either mound treatment, although in year 3 berry extract chloride levels were found to be significantly higher in the mounded treatment than the flat treatment. Similarly, a consistent trend in sodium and chloride levels of petioles and juice was not evident for the mulch treatment. Although, in year 3 petioles of vines grown in bare soil were found to contain significantly more petiole chloride than those which had straw mulch applied.

The hypothesis that combining soil mounding, straw mulch and partial rootzone drying (PRD) irrigation will improve grapevine growth and production and reduce levels of sodium and chloride in the vine is rejected as there was not a consistent, cumulative effect of the three factors in this experiment.

STATEMENT

This thesis contains no material which has been accepted for an award of any degree or diploma in any University and to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference is made in the text.

I give my consent to this copy of my thesis, when deposited in the University library, being available for loan and photocopying.

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