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Temporal and spatial soil salt distribution within sites drip irrigated with supplementary (re-use) or saline water

Detailed Report

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Government
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Megan Sebben

Summary

Australia's water resources are in a serious state, both in reduced quantity and declining quality due to rising salinity levels. In the future, the availability of good quality irrigation water resources will be exposed to further risk from reduced rainfall and increased evaporative demand as a result of climate change. To ensure sustainable crop production in the future, it is imperative that more efficient methods of irrigation are identified and their impact on water use, root zone salinity and nutrient loss thoroughly evaluated.

The aim of this project was to increase our understanding of the effects of supplementing saline water sources, such as winery wastewater, for irrigation of vines and orchards. The project specifically addressed the impacts of saline and wastewater application via drip irrigation on soil salt distribution. These outcomes were achieved through the monitoring of existing field sites and the interpretation of current datasets.

Four sites, all located in South Australia, were investigated during the course of this project. Each site has been treated as a separate module in this report. The sites under investigation were:

- McLaren Vale (vineyard). The site was sub-divided into two sites (BB1 and BB2) which were irrigated with reclaimed water from the Willunga Basin Water Company using conventional and sub-surface drip irrigation, respectively.

- Willunga (almond orchard). The site was drip irrigated using saline bore water from three surface dripper lines (site SS1) and from a single surface dripper line (site SS2).

- Currency Creek (vineyard). The site was subdivided into four treatment blocks each irrigated with Finniss River water using conventional drip irrigation. Treatment 1 received water from rainfall and irrigation, plus an additional leaching irrigation, Treatment 2 received the same as Treatment 1 plus mulch, Treatment 3 received water from rainfall and irrigation, and Treatment 4 received the same as Treatment 3 plus mulch.

- Langhorne Creek (vineyard). The vineyard was irrigated with dam water from Lake Alexandrina using conventional drip irrigation. As salinity levels in Lake Alexandrina increased, the irrigation water was mixed with less saline water from other sources.

Monitoring of salt distribution through the soil profiles was undertaken at each site using SoluSAMPLER™ solution extractors. The extractors were installed at 30, 60 and 90 cm depths at between three and seven locations within each site. Where pre-existing data were available, the soil water solution electrical conductivities (ECsw) measured were compared with electrical conductivity values determined from saturated soil paste extracts (ECe) or 1:5 soil/water suspensions ($EC_{1:5}$). Where possible, attempts were made to establish the relationships between ECsw and ECe/$EC_{1:5}$ values at each site.

The data obtained were used to produce plots of the spatial and temporal EC distributions through the root zones. The outcomes from this project have led to an increased understanding of the impacts of using saline and wastewater sources in conjunction with drip irrigation techniques. With the addition of further monitoring and analyses, the results of this study will assist in overcoming the constraints of saline and wastewater use imposed by its effects on salt distribution and soil properties.

Root Zone Salinity in Logan's Legacy Vineyard, McLaren Vale

Executive Summary

The purpose of this report was to examine the effects of conventional and subsurface drip irrigation on the accumulation of salt in the soil profile. Salinity data from a South Australian vineyard were analysed to determine the temporal and spatial distributions of salt under the vines. An attempt was made to establish a relationship between salinity values obtained from saturated soil paste extracts (ECe) and soil water salinity (ECsw).

The major findings from the investigation were:

- The data collected were sporadic and highly variable, therefore clear relationships were difficult to ascertain.
- Salt accumulation was more rapid and variable under conventional drip irrigation (CDI) than under subsurface drip irrigation (SDI).
- The average conversion from ECe to ECsw was ECsw = 2.6 x ECe; however this conversion ranged from 0.7 to 5.3 x ECe.

While it is clear that root zone salinity data are highly variable, this report recommends that further sampling and analyses be undertaken at the site to examine the impacts of the irrigation methods on salt accumulation in the root zone.

Introduction

Soil salinity and root-zone salinity damage can have major impacts on plant yield and survival. Critical threshold salinity values for own rooted vines have been established using the electrical conductivity (EC) of saturated soil paste extracts (ECe) (Zhang *et al*, 2002). These values represent, as a guide, thresholds for maximum production and reduced yield levels.

Plant yield and performance can be related to soil root zone salinity using measurements of ECe; however this laboratory method can be tedious and costly where ongoing monitoring is required. EC values can also be obtained using suction cups (e.g. SoluSAMPLER™). Where frequent monitoring is required, suction cups can be used to obtain soil water salinity (ECsw) values, which are representative of the salinity levels directly experienced by the plant roots. Previous studies have shown ECsw to be approximately twice the ECe in a range of sandy loam to silty clay loam field soils (Biswas *et al.* 2007; Biswas *et al.* 2008).

This study represents a preliminary analysis of ECe and ECsw data obtained from a monitoring site during the period 2006-2008. The purpose of the investigation was to use this data to determine how the irrigation method employed influenced the spatial and temporal distributions of salt under the vines. An attempt was also made to determine the relationship between ECe and ECsw at the site.

Materials and Methods

A trial was established in McLaren Vale, South Australia on own rooted Shiraz vines. Soil type was loamy sand to clay loam over light medium clay to medium clay. The vines were irrigated with reclaimed water from the Willunga Basin Water Company (average irrigation water quality = 1.2 mS.cm^{-1}) using conventional drip irrigation (CDI) at Site One (BB1) and sub-surface drip irrigation (SDI) at Site Two (BB2). Monitoring commenced on November 30, 2005.

To examine the spatial and temporal accumulation of salt in the root zone, suction cups (SoluSAMPLER™) were installed in nests of three at seven locations under each irrigation treatment. Samples were collected fortnightly from 30, 60 and 90 cm depths and analysed for ECsw. ECe data were obtained annually between August and September from soil cores extracted at 0, 15 and 30 cm along the drip line and 25, 50, 100 and 150 cm along the mid-row. Sub samples were taken from each core at 0 to 10 (2008 only), 30, 60, 90, 120 and 150 cm depths. Data from three replicates were available for 2008 only. For both 2006 and 2007, one ECe value averaged from two replicates were available. The data were graphed using Microsoft Excel to determine the impact of irrigation method on salt accumulation through the soil profile. Attempts were made on January 21 and 29 2010 to collect additional soil water samples; however the solution extractors at both sites were either dry or contained a sample inadequate for analysis.

Results

ECe vs ECsw

ECe values obtained from the 2006 core samples indicated a difference in the salt distribution through the soil profile at each site during the first year of monitoring (Table 1).

Table 1 ECe values at a range of depths and distance from the drip line (DL) under Conventional Drip Irrigation (BB1) and Sub-Surface Drip Irrigation (BB2) during 2006

Depth (cm)	Distance from DL (cm)	ECe (mS/cm)	
		BB1	BB2
30	0	1.77	2.64
60	0	2.82	3.41
90	0	5.13	2.64
120	0	3.74	3.00
150	0	3.36	3.46
30	15	1.94	2.97
60	15	3.20	3.28
90	15	3.87	2.96
120	15	3.43	2.71
150	15	3.13	3.14
30	30	2.52	3.20
60	30	5.33	3.64
90	30	3.62	3.31
120	30	3.97	4.75
150	30	3.58	4.12

One ECsw value only was obtained during this period (ECsw = 5.2, -30 cm). This value is approximately 2.5 x ECe at BB1 and 1.8 x ECe at BB2.

For the 2007-2008 data, ECsw ranged from 0.7 to 5.3 times greater that ECe (Table 2).

Table 2 Comparison between ECe and ECsw values obtained under BB1 and BB2, 2007-2008

Year	Site	SoluSampler depth (cm)	Average ECe (mS/cm)	Average ECsw (mS/cm)	ECsw/ECe
2007	BB1	30	1.15	6.1	**5.3**
		60	3.34	9.6	**2.9**
		90	3.02	8.8	**2.9**
	BB2	30	1.93	2.7	**1.4**
		60	2.12	5.3	**2.5**
		90	3.13	8.3	**2.6**
2008	BB1	30	2.17	5.0	**2.3**
		60	1.97	5.1	**2.6**
		90	3.12	10.5	**3.4**
	BB2	30	3.19	2.3	**0.7**
		60	3.37	7.7	**2.3**
		90	3.61	N/A	**N/A**

When combined with the 2006 data, the average conversion from ECe to ECsw is ECe x 2.6. Visual comparisons between ECe and ECsw are presented for BB1 and BB2 in Appendix 1 and Appendix 2, respectively.

SDI vs CDI

The change in ECsw over time was evaluated for each site. Between May 2005 and May 2009 there was a temporal increase in ECsw occurring at -90 cm, and a decrease at -30 and -60 cm (Figure 1). Variability in ECsw at -30 cm also increased with time. At site BB2, ECsw gradually increased with time at all depths (Figure 2). Soil water salinity was consistently greatest at -90 cm, followed by -60 and -30 cm. Throughout the soil profile, ECsw was greater and more variable at site BB1 than at site BB2.

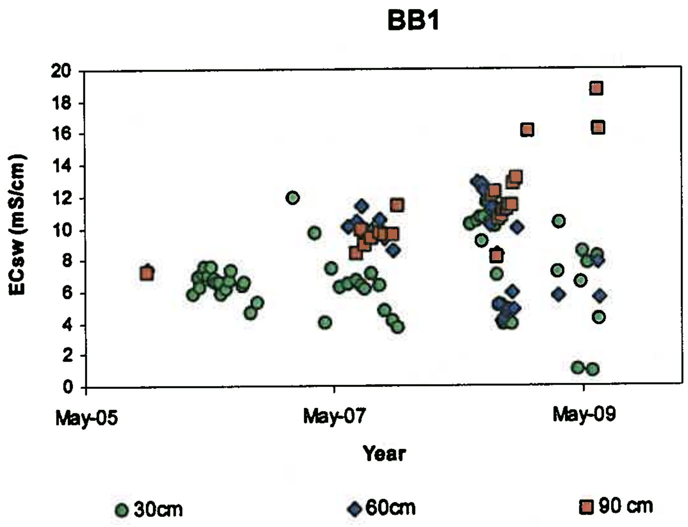


Figure 1 Change in ECsw at Site BB1 between May 2005 and May 2009 .

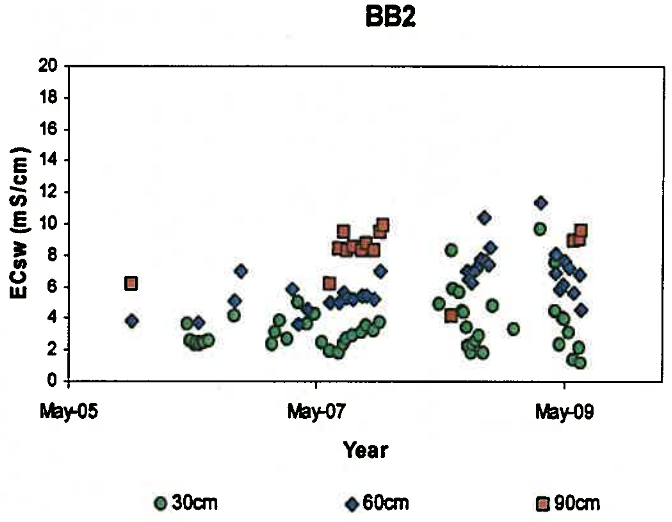


Figure 2 Change in ECsw at Site BB2 between May 2005 and May 2009.

The temporal and spatial variations in ECe under each irrigation treatment are presented in Figures 15 to 20 (see Appendix 3). The data were variable; however two general patterns could be observed. The salinity distribution through the soil profile at BB1 was slightly parabolic as salt accumulated in the middle of the root zone. At BB2, the salinity increase with depth was linear. Over time, the soil salinity change at BB2 was more marginal than at BB1.

At site BB1 both underneath and 15 cm from the drip line, ECe in the top half of the root zone has decreased since 2006. At depths greater than 100 cm, salinity was generally higher in 2008 than 2007 (Figures 15 and 17). At 30 cm from the drip line, this pattern was reversed (see Figure 19). At site BB2 underneath the drip line, ECe was generally greater in 2008 than 2006, and less than ECe data obtained in 2007 (Figure 16). Figure 18 shows that the ECe 15 cm from the drip line was greatest in 2008 until approximately -120 cm, where salinity levels were slightly less than those recorded in 2007. At 30 cm from the drip line, ECe during 2008 was similar to 2006 at the top of the soil profile; greatest in the middle of the root zone, and less than 2006 and 2007 below -120 cm (Figure 20).

Appendix 4 shows a year-by-year comparison of ECe under each irrigation treatment at 0, 15 and 30 cm from the drip line. By 2008, the soil under subsurface drip irrigation was more saline than that under conventional drip irrigation (Figures 21-29).

Conclusions

ECsw data from the site suggest that salt accumulation was more rapid and variable under conventional drip irrigation (CDI) than under subsurface drip irrigation (SDI). Root zone salinity is a dynamic process; therefore data obtained provide insight to a snapshot in time only. A fixed relationship between the electrical conductivity of soil paste extracts (ECe) and soil water (ECsw) was difficult to determine. The average conversion from ECe to ECsw under the vines was found to be ECsw = 2.6 x ECe; however, during 2007 and 2008 this conversion ranged from 0.7 to 5.3 x ECe.

Appendix 1: Comparison between ECe and ECsw at BB1 (CDI)

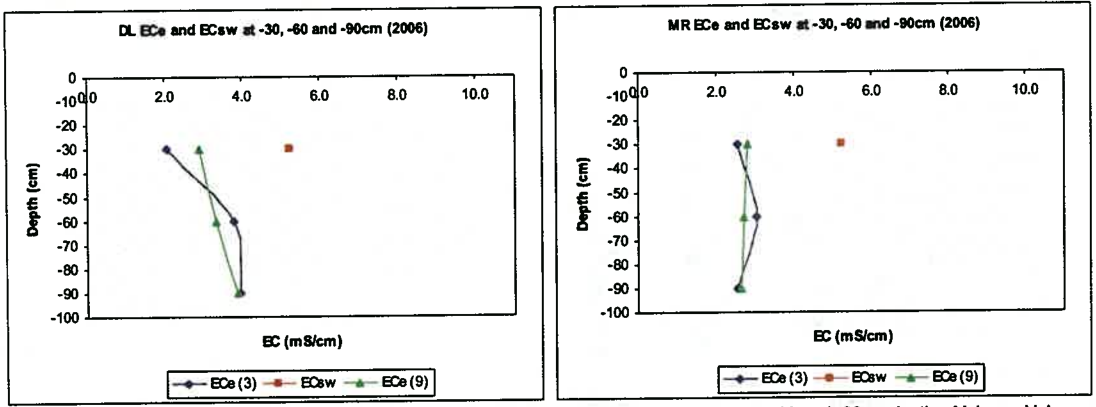


Figure 3 and 4: ECe and ECsw obtained along the drip line (Fig 3) and Mid-Row (Fig 4) at -30, -60 and -90cm depths, McLaren Vale, 2006. The blue line represents data calculated at one depth only; the green line represents ECe at a particular depth calculated as an average of the three surrounding ECe values. The red line shows ECsw data collected using the SoluSAMPLER at a given depth.

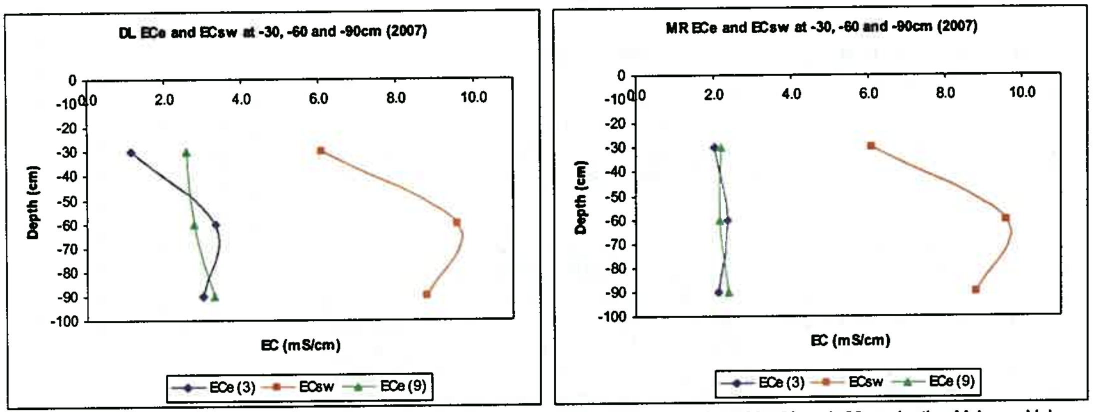


Figure 5 and 6: ECe and ECsw obtained along the drip line (Fig 5) and Mid-Row (Fig 6) at -30, -60 and -90cm depths, McLaren Vale, 2007. The blue line represents data calculated at one depth only; the green line represents ECe at a particular depth calculated as an average of the three surrounding ECe values. The red line shows ECsw data collected using the SoluSAMPLER at a given depth.

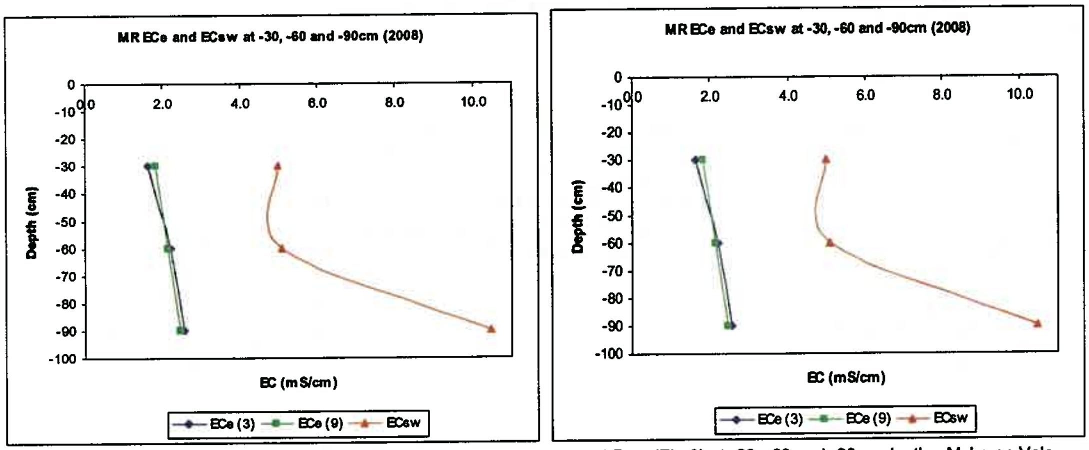


Figure 7 and 8: ECe and ECsw obtained along the drip line (Fig 7) and Mid-Row (Fig 8) at -30, -60 and -90cm depths, McLaren Vale, 2008. The blue line represents data calculated at one depth only; the green line represents ECe at a particular depth calculated as an average of the three surrounding ECe values. The red line shows ECsw data collected using the SoluSAMPLER at a given depth.

Appendix 2: Comparison between ECe and ECsw at BB2 (SDI)

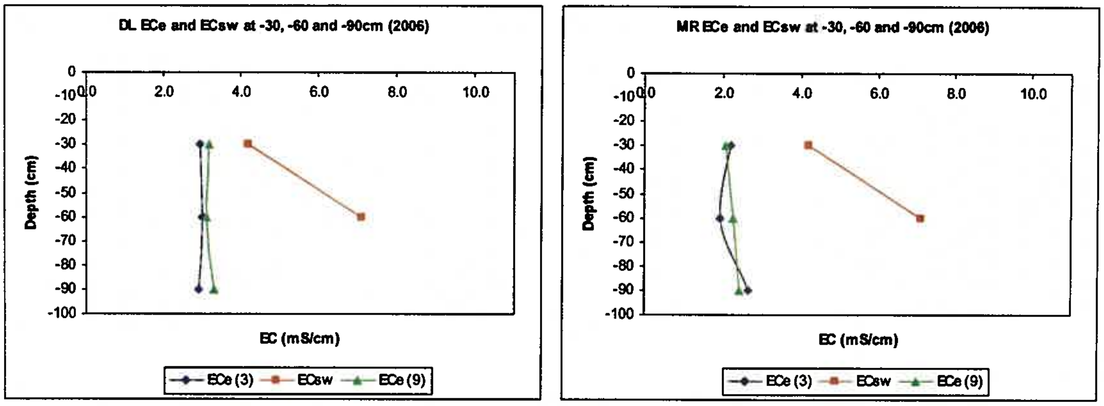


Figure 9 and 10: ECe and ECsw obtained along the drip line (Fig 9) and Mid-Row (Fig 10) at -30, -60 and -90cm depths, McLaren Vale, 2006. The blue line represents data calculated at one depth only; the green line represents ECe at a particular depth calculated as an average of the three surrounding ECe values. The red line shows ECsw data collected using the SoluSAMPLER at a given depth.

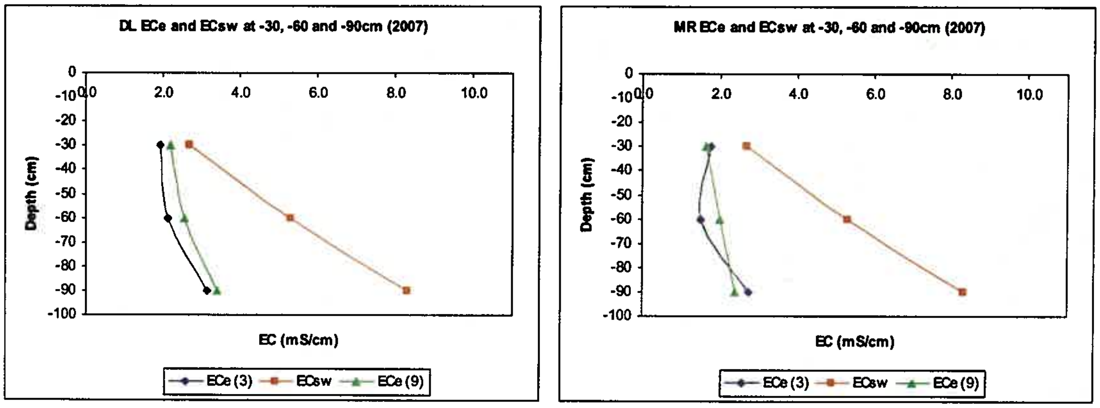


Figure 11 and 12: ECe and ECsw obtained along the drip line (Fig 11) and Mid-Row (Fig 12) at -30, -60 and -90cm depths, McLaren Vale, 2007. The blue line represents data calculated at one depth only; the green line represents ECe at a particular depth calculated as an average of the three surrounding ECe values. The red line shows ECsw data collected using the SoluSAMPLER at a given depth.

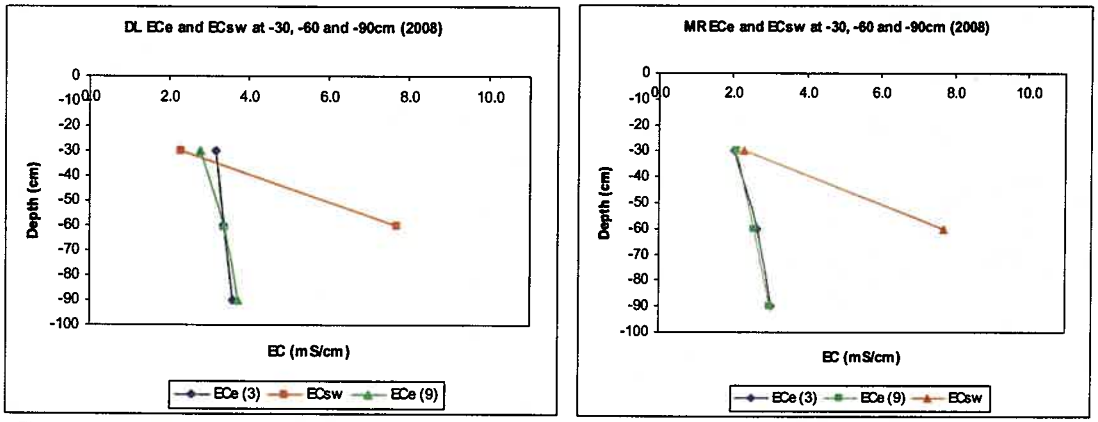


Figure 13 and 14: ECe and ECsw obtained along the drip line (Fig 13) and Mid-Row (Fig 14) at -30, -60 and -90cm depths, McLaren Vale, 2008. The blue line represents data calculated at one depth only; the green line represents ECe at a particular depth calculated as an average of the three surrounding ECe values. The red line shows ECsw data collected using the SoluSAMPLER at a given depth.

Appendix 3: Variation in ECe along the Drip Line (DL)

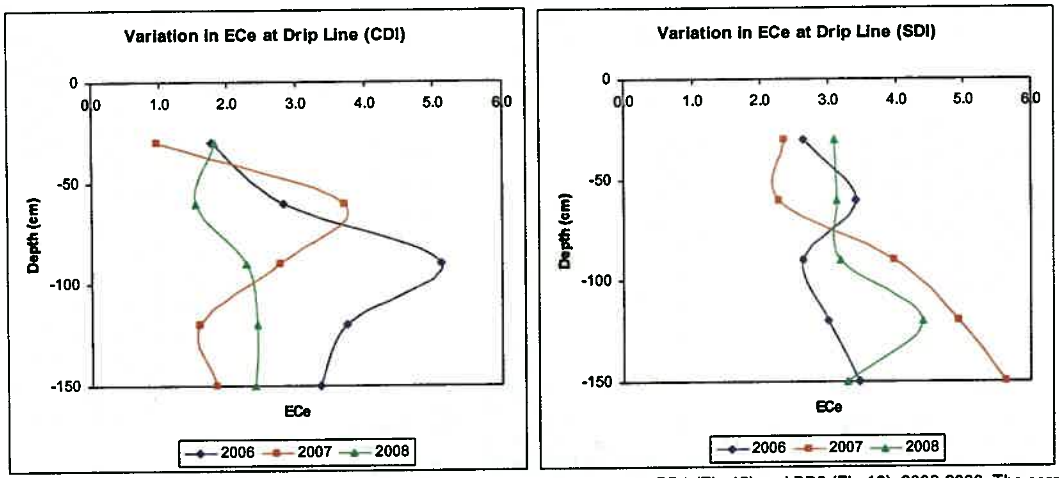


Figure 15 and 16: ECe data obtained from soil cores sampled below the drip line at BB1 (Fig 15) and BB2 (Fig 16), 2006-2008. The cores were analysed at -30, -60 -90, -120 and -150cm depths.

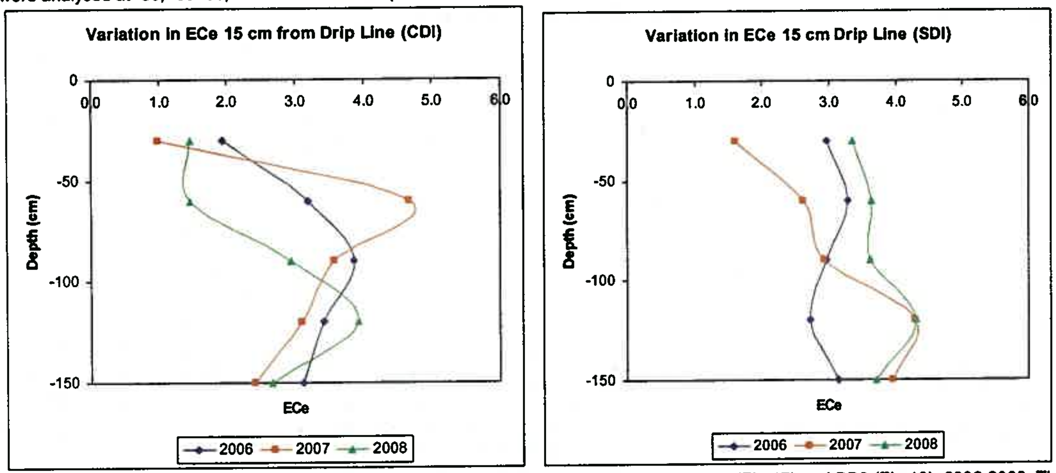


Figure 17 and 18: ECe data obtained from soil cores sampled 15cm from the drip line at BB1 (Fig 17) and BB2 (Fig 18), 2006-2008. The cores were analysed at -30, -60 -90, -120 and -150cm depths.

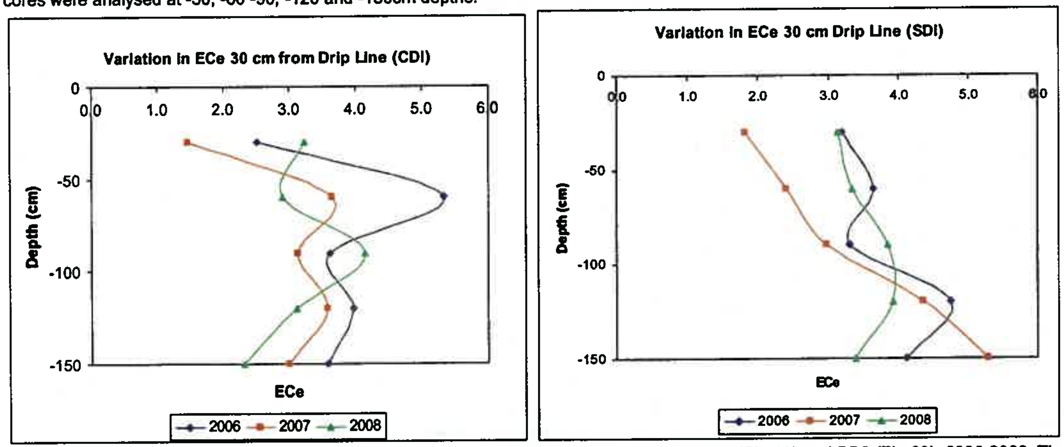
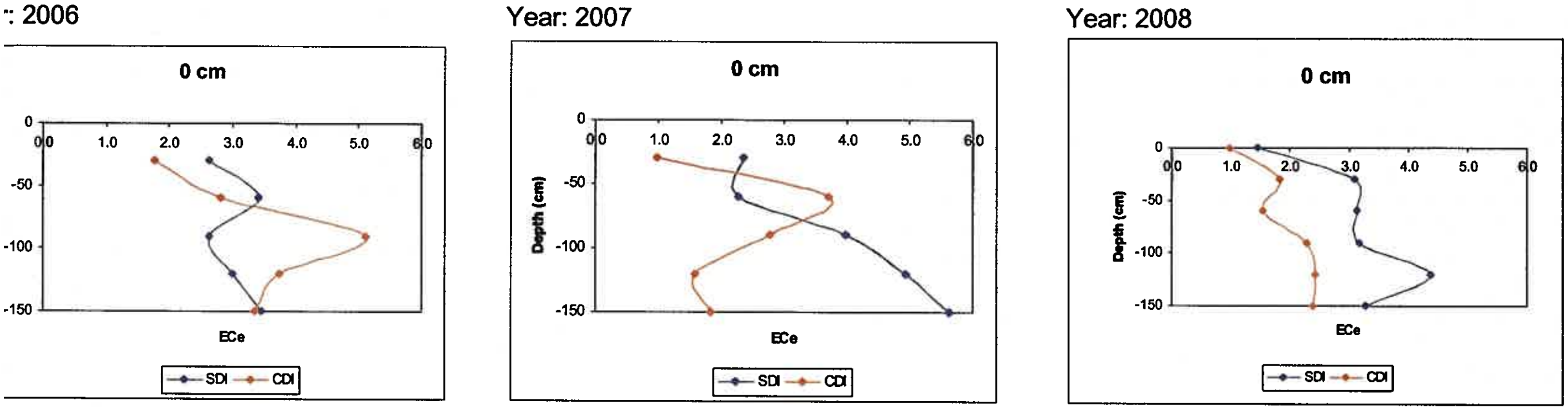
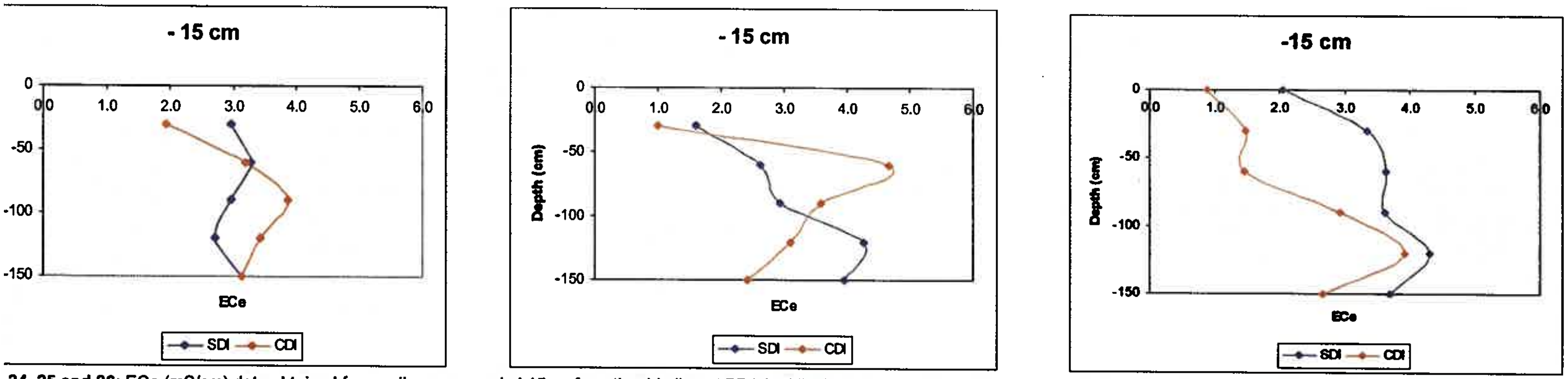


Figure 19 and 20: ECe data obtained from soil cores sampled 30cm from the drip line at BB1 (Fig 19) and BB2 (Fig 20), 2006-2008. The cores were analysed at -30, -60 -90, -120 and -150cm depths.

endix 4: ECe Comparison between CDI and SDI me[illegible]ds



21, 22 and 23: ECe (mS/cm) data obtained from soil cores sampled below the drip line at BB1 (red line) and BB2 (blue) 2006-2008. The cores were analysed at -30, -60 -90, -120 and -150cm depths.



24, 25 and 26: ECe (mS/cm) data obtained from soil cores sampled 15cm from the drip line at BB1 (red line) and BB2 (blue) 2006-2008. The cores were analysed at -30, -60 -90, -120 and -150cm depths.

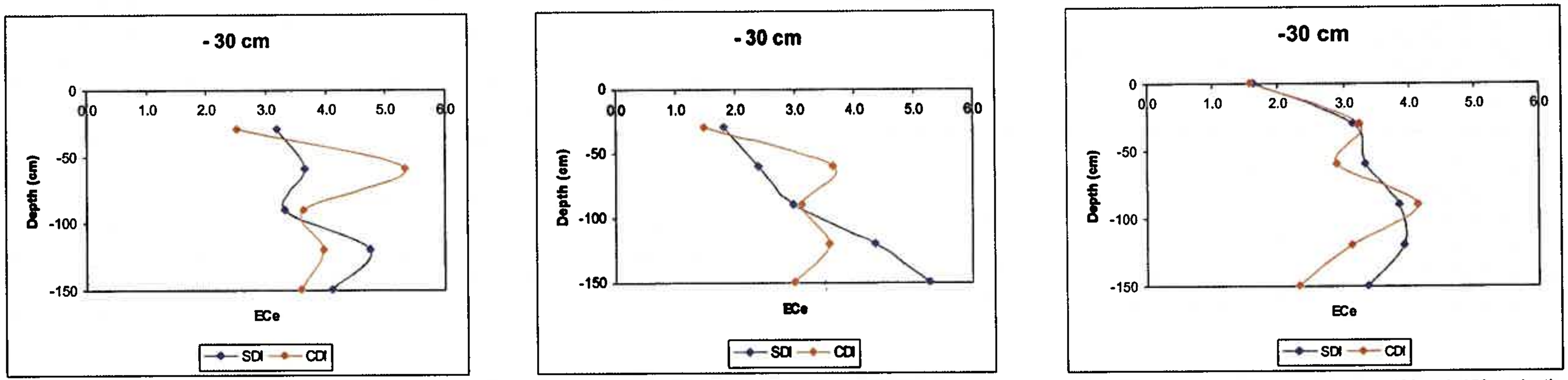


Figure 27, 28 and 29: ECe (mS/cm) data obtained from soil cores sampled 30cm from the drip line at BB1 (red line) and BB2 (blue) 2006-2008. The cores were analysed at -30, -60 -90, -120 and -150cm depths.

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Root Zone Salinity in Sunnyside Almond Orchard, Willunga

Executive Summary

The purpose of this report was to examine the effects multiple drip irrigation lines on the accumulation of salt in the soil profile. Salinity data from a South Australian almond orchard were analysed to determine the temporal and spatial distributions of salt through the soil profile. An attempt was made to establish a relationship between salinity values obtained from saturated soil paste extracts (ECe) or 1:5 soil/water suspensions ($EC_{1:5}$), and soil water salinity (ECsw).

The major findings from the investigation were:

- The data collected were sporadic and variable, therefore clear relationships were difficult to ascertain.
- The average soil water salinity was greater during the summer months (Site 1(SS1, three surface drip lines) = 13.09 $mS.cm^{-1}$, Site 2 (SS2, single surface drip line) = 12.89 $mS.cm^{-1}$) than during the winter months (SS1 = 4.54 $mS.cm^{-1}$, SS2 = 5.11$mS.cm^{-1}$).
- At SS1, salinity increased with depth from -30cm to -90cm.
- The average conversion from $EC_{1:5}$ to ECsw was *ECsw = 1.4 x* $EC_{1:5}$. This figure ranged from 1.03 to 1.69 x $EC_{1:5}$.
- The average conversion from ECe to ECsw was *ECsw = 3.9 x ECe*. This figure ranged from 2.2 to 6.9 x ECe.

While it is clear that root zone salinity is a dynamic process, this report recommends that further sampling and analyses be undertaken at the site before any conclusions can be made.

Introduction

Almond is regarded as a salt-sensitive tree crop (Maas, 1990). In view of this sensitivity, the management of irrigation and soil salinity in almond orchards is a critical factor for nut production and plant survival.

The orchard under investigation was irrigated with moderately saline water using precision (drip) irrigation, and therefore must be managed correctly to prevent salt build-up in the soil profile. The salinity of saturated soil paste extracts (ECe) can be related to plant yield and performance. This method accounts for soil texture but can be tedious. The salinity of 1:5 soil/water suspensions ($EC_{1:5}$) can be used to estimate soil salt content, however can be subject to errors caused by water contents more dilute than field conditions (Shaw, 1999). Where regular monitoring is required, solution extractors, e.g. SoluSAMPLER^{TM}, can be used to assess root zone salinity by measuring the salt content of the soil solution (ECsw) within the soil profile. This value is representative of the salinity levels directly experienced by the plant roots. It should be noted that the successful use of solution extractors requires sufficient moisture in the soil profile.

This study represents a preliminary analysis of ECe, $EC_{1:5}$ and ECsw data obtained from a monitoring site during the period 2006-2009 (Biswas *et al*, unpub). The purpose of the investigation was to use the data to determine how the irrigation method employed influenced the spatial and temporal distribution of salt under the orchard. The relationships between ECe, or $EC_{1:5}$, and the corresponding ECsw values, were also examined.

Materials and Methods

The field site was located in an almond orchard in Willunga, South Australia. The orchard was planted in 1997 at 6.2 m row and 4.0 m tree spacing. Solution extractors (SoluSAMPLER^{TM}) were installed at 30, 60 and 90 cm depths and were analysed for ECsw. The soil type was classified as alluvial clay. The site was subdivided into two smaller sites (SS1 and SS2), approximately 30 m apart. SS1 and SS2 were irrigated with bore water using three surface drip lines at Site 1 (SS1) and a single surface drip line at Site 2 (SS2). Monitoring commenced on 19 April, 2006

During October 2007, the irrigation at SS1 was increased from one drip line to three parallel drip lines at 0.75 m spacing, with drippers located every 3.0 m along the line. SS2 was irrigated with drippers located every 3.0 m along a single drip irrigation line. Irrigation was applied daily at a rate of 8.0 mm d^{-1}. The water was sourced from a bore located on the property approximately 400 m from the experimental site and at a depth of 120 m (EC 1.6 to 3.0 mS cm^{-1}). Between 14 October and 3 December 2006, eight applications of liquid fertilizer were delivered to SS1 via the drip irrigation system. Each application consisted of 18.3 kg ha^{-1} equivalent of NH_4NO_3. At both SS1 and SS2, broadcast fertilizer was applied on 1 May and 15 July 2007 at 5.0 kg ha^{-1}(Biswas *et al*, unpub).

SoluSAMPLERs were installed in nests of three at three locations under each treatment site. Samples were collected from -30, -60 and -90 cm 15 cm from the dripper line and 150 cm from the tree at SS1, and 150 cm from three consecutive trees at SS2. During October 2007, additional suction cups were buried at -150 cm. At SS1, ECe data were obtained annually between September and October from soil cores extracted from 0, 50, 100 and 150 cm along the drip line. Sub samples were taken from each core at -30, -60, -90, -120 and -150cm. The data obtained were then graphed using Microsoft Excel to investigate the impact of irrigation method on salt accumulation through the soil profile.

Results

$EC_{1:5}$ /ECe

$EC_{1:5}$ values obtained from the 2006 SS1 cores indicated that the salt content of the soil was greatest directly underneath the dripper line at -30 cm (Table 1).

Table 1 $EC_{1:5}$ samples obtained from soil cores extracted from SS1 during October 2006

YEAR	SITE	DISTANCE (cm)	SAMPLE DEPTH (cm)	ECe mS/cm (1:5 soil:water)
2006	SS1	0	30	5.83
			60	2.85
			90	2.04
			120	2.26
			150	2.38
		50	30	3.21
			60	2.39
			90	2.40
			120	2.12
			150	3.56
		100	30	2.04
			60	1.38
			90	1.46
			120	1.47
			150	1.70
		150	30	1.08
			60	0.98
			90	1.40
			120	1.63
			150	1.88

The salinity decreased until approximately 90 cm, at which point it was relatively constant with depth. The salt content 50 cm from the dripper line was variable; however a decrease in salinity to approximately -100 cm, followed by an increase, can be observed. EC$_{1:5}$ values recorded 100 and 150 cm from the dripper line were relatively uniform with depth. At 100 cm, a slight decrease in EC$_{1:5}$ with depth was favoured, and at 150 cm, an increase in EC$_{1:5}$ was evident (Figure 1).

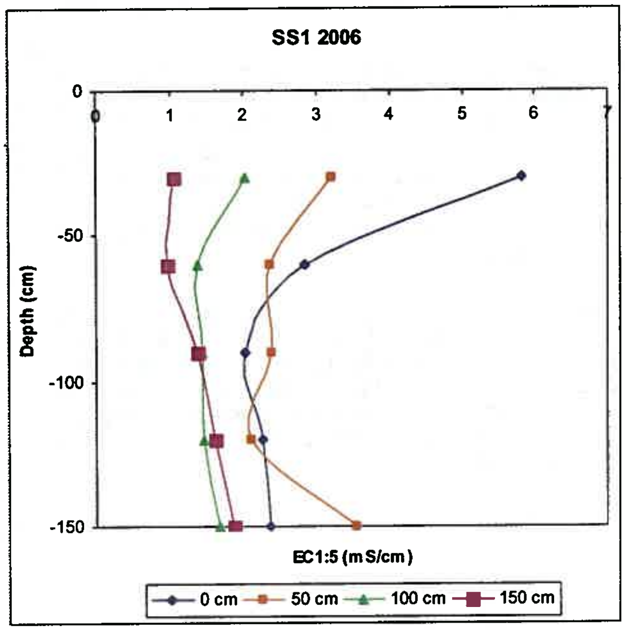

Figure 1 EC$_{1:5}$ values obtained from SS1 during October, 2006 at five depths at four distances from the dripper.

ECe values obtained from the 2007 cores samples are presented in Table 2. The cores were extracted from the sites where the -150cm SoluSAMPLERs were installed, referred to as Reps 1, 2 and 3.

Table 2 ECe values at SS1 determined from soil cores extracted during September 2007

YEAR	SITE	REP	SAMPLE DEPTH (cm)	ECe (mS/cm)
2007	SS1	1	30	2.54
			60	0.93
			90	0.26
			120	0.66
		2	30	4.29
			60	1.55
			90	0.69
		3	30	2.34
			60	1.99
			90	1.10
			120	0.42
			150	0.63

The data from Table 2 is reproduced in Figure 2. The figures suggest that on average, the soil salt content decreased with depth at the particular location under investigation. Few conclusive observations could be made as difficulties with sample collections resulted in a lack of available data from the site.

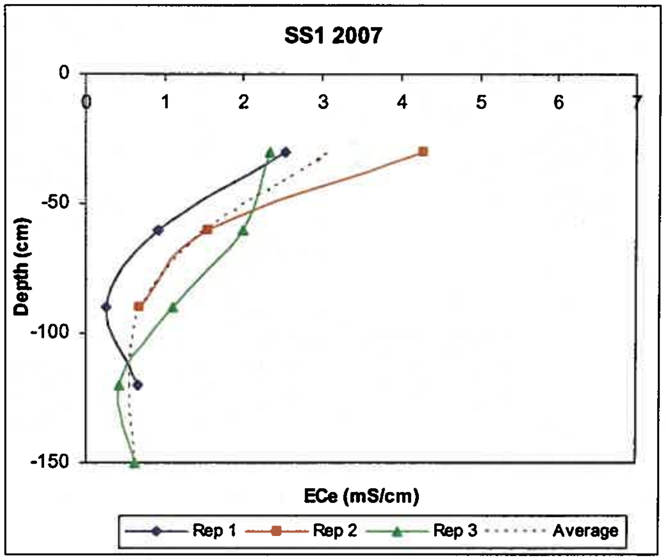

Figure 2 ECe data obtained from three replicate soil cores extracted at SS1 during September, 2007.

Comparisons between ECe under each irrigation treatment could not be made due to a lack of sufficient data from SS2.

ECsw

The change in ECsw with depth and time at SS1 and SS2, are presented in Figures 3 and 4 respectively.

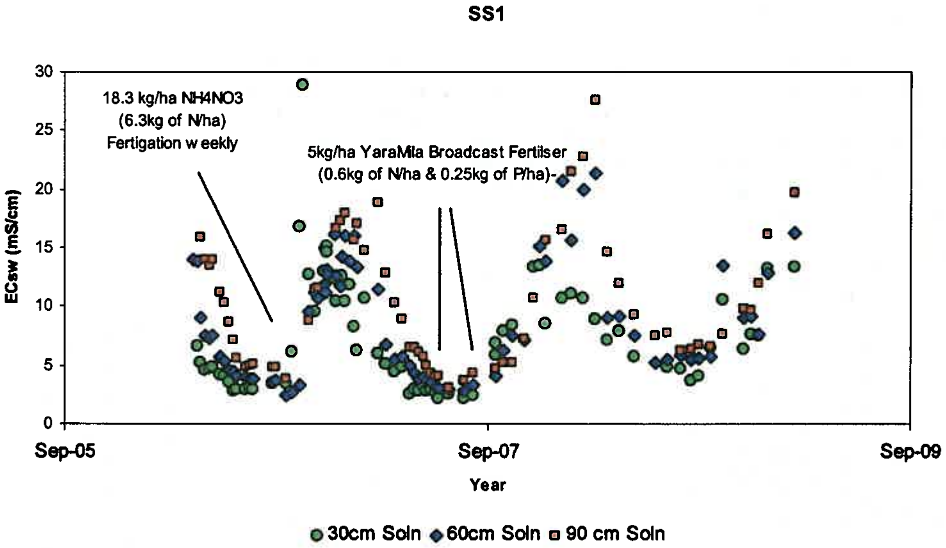

Figure 3 ECsw measurements from SS1 during 2006-2009. The black lines represent the periods during which fertilisers were applied to the site.

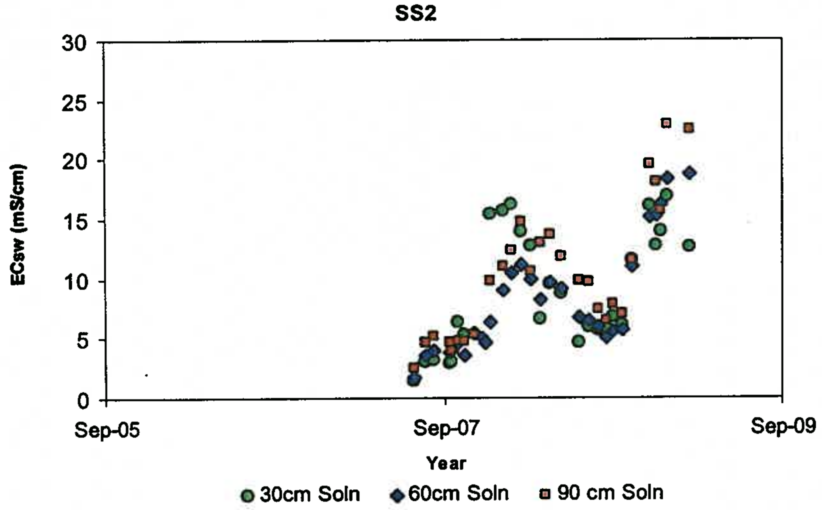

Figure 4 ECsw measurements during 2007-2009. The black line represents an application of fertiliser to the site.

The salt content of the soil water at SS1 increased with depth for the duration of the monitoring period during the 2006-07 and 2007-08 growing seasons (Figure 3). The peaks in ECsw correspond to the summer months, where it is expected that the soil water salinity will increase due to increased evapotranspiration, and increased irrigation with relatively saline bore water. In the first peak, a lag time of approximately one month was evident between the peak at -30 cm (15 mS.cm^{-1}) and at -90 cm (18 mS.cm^{-1}).These peaks occurred during mid-December 2006 and mid-January 2007 respectively. During the second growing season, this lag time increased to three months. The -30cm peak occurred during mid-December 2007 (13.4 mS.cm^{-1}) and during mid- March 2008 at -90cm (27.6 mS.cm^{-1}). Both peaks occurred after fertiliser application events, which were found to contribute up to 2% only of the salts moving through the soil profile (Biswas *et al*, unpub).

Monitoring at SS2 commenced during 2007. The data were more variable than at SS1, therefore the relationship between salt content and depth was not as clear. The monitoring concluded during early March 2009, thus only one peak was analysed (Figure 4). On average, the salinity of the soil water was greatest at -90 cm; however during the 2007/08 summer months, the soil water salinity at -30 cm was greater than that at -60 and -90 cm. The respective ECsw maxima at -30, -60, and -90 cm were 16.3 mS.cm^{-1} (6 Feb 08), 11.1 mS.cm^{-1} (27 Feb 08), and 14.8 mS.cm^{-1} (27 Feb 08). At SS1, the depth boundaries were more clearly defined by changes in salt content than at SS2.

SS1 and SS2 data overlain with ECsw measurements from -150 cm are presented in Figures 5 and 6 Data were collected for 15 and 17 month periods only.

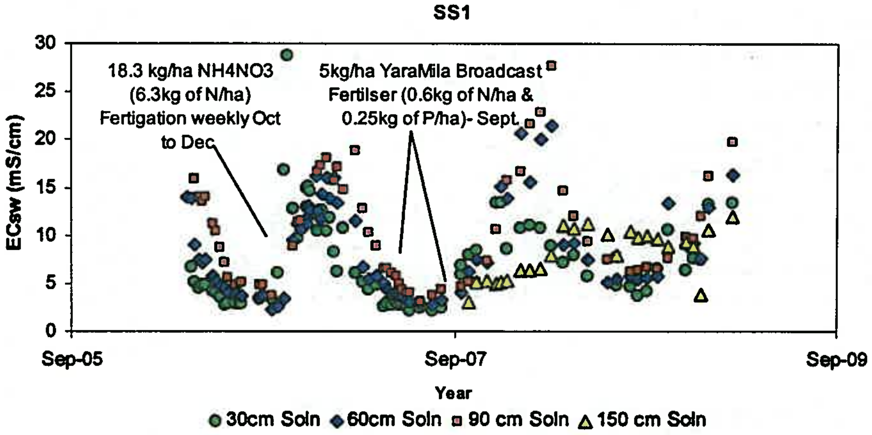

Figure 5 ECsw measurements at four depths during 2006-2009.

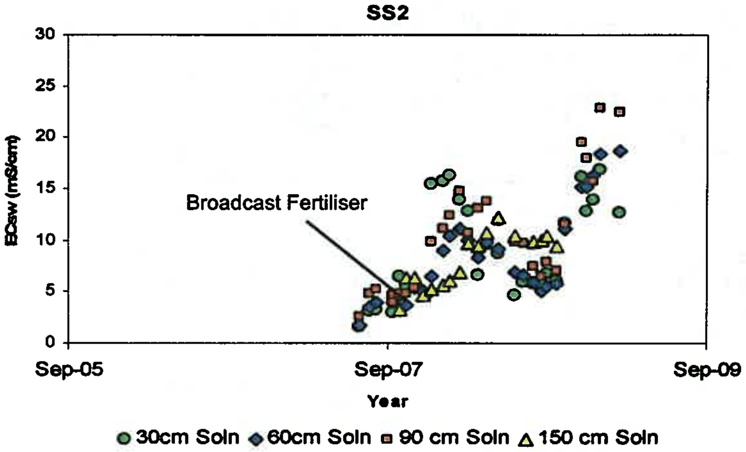

Figure 6 ECsw measurements from four depths during 2007-2009..

At both sites, the soil water salinity at -150 cm was less than at the shallower depths from the end of spring through to early to mid-autumn, and greater from late autumn through to mid-spring. At SS1, the peak ECsw (11.3 mS.cm^{-1}) was recorded during late May 2008 (-150 cm was not monitored during the previous season). This peak was lower and broader than peaks at the other soil depths. At SS2, the ECsw maximum (12.1 mS.cm^{-1}) was recorded on 27 May 2008. During the 2008 winter months, ECsw values did not return to the levels recorded during 2007 at any soil depth. ECsw data are missing where no liquid or insufficient soil water samples were collected during summer. ECsw data obtained from both sites during the comparable time period (October 2007 to October 2008) are summarised in Table 3.

Table 3 Comparisons between ECsw data obtained from SS1 and SS2 between 12 October 2007 and 29 October 2008

SITE	PERIOD	DEPTH	MAX ECsw (mS/cm)	MAX SS1-MIN SS2	DATE RECORDED	MIN ECsw (mS/cm)	MIN SS1 - MIN SS2	DATE RECORDED
SS1	12 October 2007 - 29 October 2008	-30	13.4		12/12/2007	7.9		12/10/2007
SS2		-30	16.3	-2.9	6/02/2008	5.3	2.6	26/10/2007
SS1		-60	21.4		18/03/2008	6.3		12/10/2007
SS2		-60	11.1	10.3	27/02/2008	4.6	1.7	12/10/2007
SS1		-90	27.6		18/03/2008	5.2		12/10/2007
SS2		-90	14.8	12.8	27/02/2008	4.8	0.4	12/10/2007
SS1		-150	11.3		27/05/2008	3.1		12/10/2007
SS2		-150	12.1	-0.8	27/05/2008	3.2	-0.1	12/10/2007

ECe/EC$_{1:5}$ vs ECsw at SS1

Table 4 EC$_{1:5}$, ECe and ECsw values determined at SS1 during the period 2006-2007

Year	SoluSAMPLER depth (cm)	Total average ECe (mS/cm)	Total average EC$_{1:5}$ (mS/cm)	Total average ECsw (mS/cm)	ECsw/EC$_{1:5}$	ECsw/ECe
2006	-30	NA	4.52	6.06	1.34	NA
	-60	NA	2.62	2.71	1.03	NA
	-90	NA	2.22	3.76	1.69	NA
2007	-30	3.06	NA	6.85	NA	2.24
	-60	1.49	NA	4.06	NA	2.73
	-90	0.68	NA	4.72	NA	6.90

During 2006, EC$_{1:5}$ measurements were obtained from soil core samples (Table 4). When compared to ECsw data collected during the same month, ECsw was found to be approximately 1.4 x EC$_{1:5}$. During 2007, ECsw data were found to be an average of 3.9 x ECe; however this value ranged from 2.2 to 6.9 x ECe. Comparisons between EC$_{1:5}$/ECe and ECsw are presented in Figures 7 and 8.

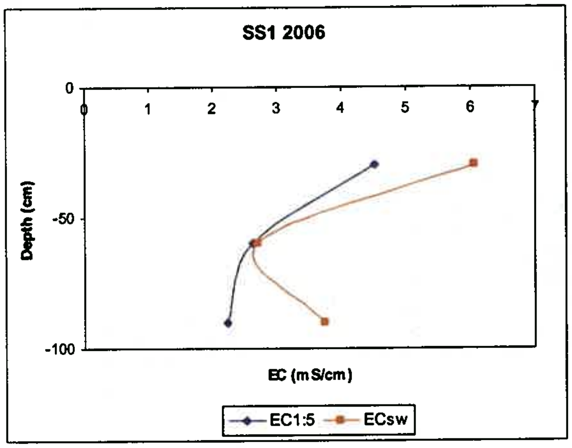

Figure 7 Average EC values obtained from 1:5 soil/water suspensions (blue) and soil water samples (red) at SS1 during 2006

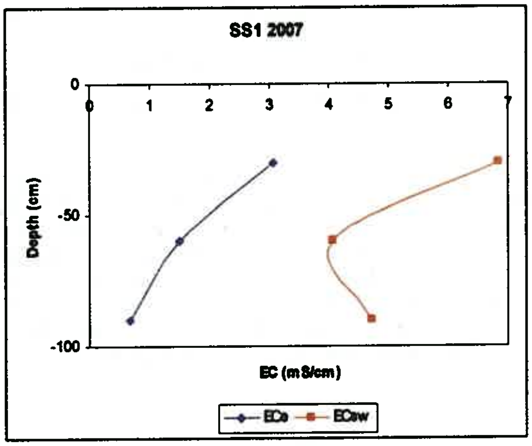

Figure 8 Average EC values obtained from saturated soil paste extracts (blue) and soil water samples (red) at SS1 during 2007

The relationship between ECe and ECsw could not be investigated for SS2 due to a lack of available data; therefore the influence of irrigation method on this relationship could not be determined.

Conclusions

ECsw data from the site suggest that salt accumulation is greatest during the summer months and increases with depth through the root zone. The data obtained from the single dripper line site (SS2) appear more variable than under three dripper lines (SS1). Both sites appear to be increasing in both salinity and variability with time; however further sampling is required before any conclusive observations can be made

The dynamic nature of root zone salinity processes make relationships between the electrical conductivity of soil paste extracts (ECe) or 1:5 soil/water suspensions ($EC_{1:5}$) and soil water (ECsw) difficult to ascertain.. ECe and $EC_{1:5}$ data were available for SS1 only. The average conversions from $EC_{1:5}$/ECe to ECsw were found to be ECsw = 1.4 x $EC_{1:5}$; and ECsw = 3.9 x ECe; however these conversions were highly variable.

Resources

1. Biswas, T, Ryder, M, Pitt, T, n.d, 'Root zone water, salinity and fertilizer monitoring and management for almond under precision irrigation.'

2. Maas, E.V, 1990, 'Crop salt tolerance', in Tanji, K.K. (ed.) 1990, *Agricultural Salinity Assessment and Management Manual,* A.S.C.E., New York.

3. Shaw, R.J, 1999, 'Soil Salinity – Electrical Conductivity and Chloride' in Peverill, K.I. Sparrow, L.A. Reuter, D.J., (eds) 1999, *Soil analysis, an interpretation manual*, CSIRO. Australia

Root Zone Salinity in Brooks Vineyard, Currency Creek

Executive Summary

The productivity and survival of irrigated vineyards relies heavily on adequate salinity management strategies. Much of the irrigation water used in the Currency Creek wine region is sourced from streams which, due to reduced flows, become highly saline during the peak growing season. This report, using data obtained from two previous studies (Biswas *et al*, unpub and Zurcher, 2008), attempted to investigate the impacts of different irrigation treatments on the spatial and temporal distributions of salt under the vines.

The main findings of the study were:

- A post-harvest (30 January 2007) leaching irrigation of 13.2 mm did not successfully flush salt through the root zone. Salinity increased by 0.5 mS.cm^{-1} at -30cm (January 22 to January 31), increased by 0.1 mS.cm^{-1} at -60 cm (January 23 to February 1), and increased by 0.1 mS.cm^{-1} at -90 cm (January 23 to February 1). At -60 cm, a temporary decrease in salinity of 0.2 mS.cm^{-1} was observed on February 2, followed by an increase of 0.3 mS.cm^{-1} on February 3.
- The application of an 11.0 mm spring leaching irrigation (11 September 2007) reduced the soil water salinity at -60 cm by 2.1 mS.cm^{-1} (September 7 to September 14) and by 0.9 mS.cm^{-1} at -90cm (September 7 to September 14), and increased salinity at -30 cm by 2.3 mS.cm^{-1} (September 6 to September 13).
- At the sites under normal plus a leaching irrigation, the addition of mulch (T2) increased the average ECsw by 2.6 mS.cm^{-1} at -30cm, 8.3 mS.cm^{-1} at -60cm, and 6.7 mS.cm^{-1} at -90cm.
- At the sites under normal irrigation, the addition of mulch (T4) decreased the average ECsw by 1.7 mS.cm^{-1} at -30cm, by 1.8 mS.cm^{-1} at -60cm and increased the average ECsw 2.2 mS.cm^{-1} at -90cm.

Due to the break down of an irrigation pump during winter 2007, the trial was unable to be undertaken during the desired time period. This report recommends that the trial be repeated after the onset of winter rains to ensure that irrigation water electrical conductivity (EC) and evaporation are low, and that soil moisture content is high. Additional monitoring should also be undertaken at the site to include soil data, particularly during periods where the soil is too dry to obtain samples with the suction cups used during this trial.

Introduction

Irrigation water generally contains dissolved salts; therefore salinity management of irrigated vineyards is critical to their production and survival. Significant water savings have been made in semi-arid regions such as the Lower Murray River, where the use of precision irrigation practices have improved water use efficiency (WUE) (Biswas *et al*, unpub). As water is applied to meet crop demand only, much of this salt accumulates in the root zone if leaching is inadequate. To maintain irrigation sustainability and to prevent plant toxicity, it is important that a compromise between high WUE and an adequate leaching of salts is met. The critical productivity threshold salinity for own rooted vines, as measured by the electrical conductivity of soil saturated paste extracts (ECe) was found to be 1.8 mS.cm^{-1} (Zhang *et al*, 2002).

Much of the irrigation water used in the Currency Creek wine region is sourced from the streams of the Eastern Mt Lofty Ranges, which are recharged by winter rainfalls. Flows from the Finniss River are minimal during the peak growing season, resulting in very high water salinities (average 3.4-6.0 mS.cm^{-1} from November 06 to March 07, Biswas *et al*, unpub). Prolonged drought periods have intensified the problem due to a lack of water available for salt removal, resulting in a build up of salt in the root zone. It is imperative that root zone salinity is correctly managed to ensure sustainable wine grape production.

This study provides an overview of the Currency Creek site based on soil water salinity (ECsw) data obtained during 2006-2008 (Biswas *et al*, unpub and Zurcher, 2008). The purpose of the investigation was to use the data to determine how the irrigation of the vineyard influenced the spatial and temporal distribution of salt in the vine rootzone.

Materials and Methods

The field site was established in a 5 year old vineyard located in Currency Creek, South Australia, on own rooted Cabernet Sauvignon vines. The vines were planed at 3.0 m row and 1.5 m plant spacing. The soil type was classified as a sandy clay loam over yellowish friable clay. Solution extractors (SoluSAMPLER™) were installed at 30, 60 and 90 cm depths and were analysed for ECsw. The site was irrigated with Finniss water using conventional drip irrigation. Monitoring took placed between November 2006 and January 2008.

The site was subdivided into four treatment blocks. Treatment 1 received water from rainfall and irrigation, plus an additional leaching irrigation, Treatment 2 received the same as Treatment 1 plus surface under-vine mulch, Treatment 3 received water from rainfall and irrigation, and Treatment 4 received the same as Treatment 3 plus mulch (Zurcher 2008, p. 25).

During the 2006/07 vintage, the property received 345 mm of rainfall and 184 mm of irrigation water from the Finniss River (Biswas *et al*, unpub). Suction cups (SoluSAMPLER™) were used to monitor the movement and accumulation of salt through the soil profile. The suction cups were installed in nests of three at three locations under the vines. Samples were collected from -30, -60 and -90 cm within 15 cm of the dripper line. Samples were collected at weekly to fortnightly intervals to determine the salinity of the soil water and to assess the movement of salt through the soil profile.

Results

Vine row

Minimum and maximum ECsw values for samples collected along the vine row during 2007 are presented in Table 1. Where the treatment number is labelled "All", this refers to the data obtained by Michael Cutting (SAMDBNRM). ECsw was consistently at a minimum at 30 cm depth, and increased in salinity with depth.

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Table 1 Soil water salinity (ECsw) from each treatment site along the vine row, recorded between 24 June 2007 – 25 November 2007

Treatment number	SoluSAMPLER Depth (cm)	Max ECsw (mS/cm)	Date recorded	Min ECsw (mS/cm)	Date recorded
All	-30	7.6	7-Nov-07	1.3	20-Jul-07
1	-30	7.6	7-Nov-07	1.3	20-Jul-07
2	-30	8.1	24-Jun-07	4.9	13-Sep-07
3	-30	10.3	26-Sep-07	5.9	24-Aug-07
4	-30	8.5	24-Jun-07	3.2	17-Sep-07
All	-60	10.9	26-Jun-07	4.7	14-Sep-07
1	-60	10.9	25-Jun-07	4.9	14-Sep-07
2	-60	16.5	8-Nov-07	13.6	14-Sep-07
3	-60	15.7	27-Jul-07	13.4	25-Jun-07
4	-60	14.2	7-Aug-07	10.6	27-Jul-07
All	-90	9.4	26-Jun-07	6.6	18-Sep-07
1	-90	9.3	14-Aug-07	6.9	18-Sep-07
2	-90	16.9	14-Aug-07	12.4	15-Sep-07
3	-90	17.4	25-Nov-07	11.6	27-Jul-07
4	-90	17.9	14-Aug-07	11.9	25-Jun-07

The highest ECsw values (in mS.cm^{-1}) recorded at each depth were 10.3 (-30 cm, treatment 3, September), 16.5 (-60 cm, treatment 2, November) and 17.9 (-90 cm, treatment 4, August). The minimum values obtained were 1.3 (-30cm, treatment 1, July), 4.7 (-60 cm, combined data, September), and 6.6 (-90 cm, combined data, September).

In Figure 1, the 2007 vine row data have been averaged across all depths and are presented as average root zone salinity (ECsw). The data were obtained from the Treatment 1 site only, as this site contained the majority of the available data due to longer term monitoring being undertaken at the site.

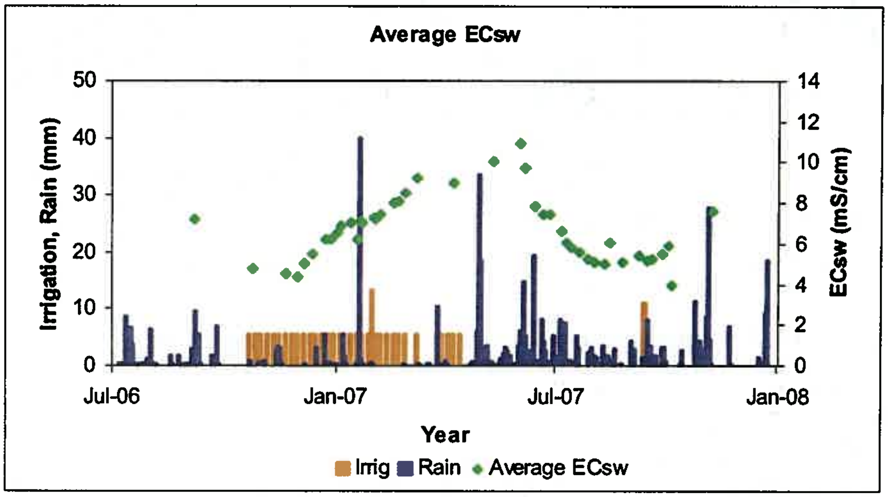

Figure 1 Average soil water salinity (ECsw) for 30, 60, 90 cm depth, rainfall and irrigation recorded at the Currency Creek site during 2006-2007.

Across the root zone, the ECsw maxima occurred between March and June (Max = 10.9) and the minima occurred between July and October 2007 (Min = 4.0). Low ECsw readings were also recorded between October and December 2006 (Min = 4.4). The peak ECsw values were likely to be caused by irrigation with saline water (approximately 4.0 mS.cm^{-1}). Irrigation was applied at a rate of only 1.1 mm/day (Biswas *et al*, unpub); therefore water available for leaching was negligible. The long orange bar present at the end of January represents a leaching irrigation event. When viewed against the average ECsw data, it is evident that this event had very little impact on root zone salinity. During the summer months, irrigation water was also more saline (approximately 5.0 mS.cm^{-1}, Biswas *et al*, unpub).

The purpose of the trial was to demonstrate that applying a leaching irrigation after the onset of winter rains will flush salts from the root zone more effectively than post harvest irrigations, due to already increased soil moisture content. Between July and August 2007, the irrigation pump at the site broke down; therefore the opportunity to apply a winter leaching irrigation was missed (Biswas *et al*, unpub). The first leaching irrigation was applied on 11 September 2007 (11.0 mm), and was repeated the following day to push the water through the soil profile. The effects of these two irrigation events on root zone salinity at different depths are shown in Figure 2.

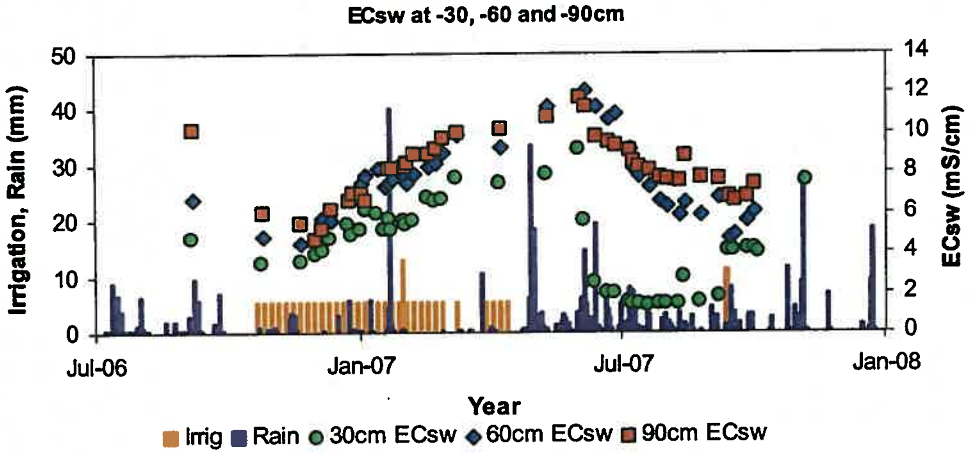

Figure 2 Root zone soil water salinity (ECsw) for 30, 60, 90 cm depth, rainfall and irrigation recorded at the Currency Creek site during 2006-2007

The data in Figure 2 show that after the leaching irrigation event, the soil water salinity at -30 cm increased from 1.8 mS.cm^{-1} (6 September) to 4.1 mS.cm^{-1} (13 September). This figure remained constant until early October. The soil water salinity at -60 cm decreased from 6.8 mS.cm^{-1} (7 September) to 4.7 mS.cm^{-1} (14 September), then steadily increased back to 6.1 mS.cm^{-1} (2 October). At -90 cm, the soil water salinity decreased from 7.6 mS.cm^{-1} (7 September) to 6.7 mS.cm^{-1} (14 September), and steadily increased to 7.4 mS.cm^{-1} by 2 October. The data in both figures suggest that the leaching event applied during September was more effective in decreasing the salt content of the soil through the root zone than the leaching event applied at the end of January.

Soil water salinity data collected from sites 1 and 3 only between 2 June 2008 and 14 December 2008 are presented in Table 2.

Table 2 Soil water salinity (ECsw) from each treatment site along the vine row, recorded between 2 June 2008 - 14 December 2008

Treatment number	SoluSAMPLER Depth (cm)	Max ECsw (mS/cm)	Date recorded	Min ECsw (mS/cm)	Date recorded
1	-30	11.0	17-Dec-08	1.8	1-Sep-08
3	-30	9.7	12-Nov-08	1.3	25-Jun-08
1	-60	10.5	12-Aug-08	5.8	8-Oct-08
3	-60	14.2	2-Sep-08	13.3	23-Sep-08
1	-90	8.5	8-Oct-08	5.0	20-Aug-08
3	-90	12.0	23-Sep-08	10.6	2-Sep-08

During 2008, the soil water salinity maxima (mS.cm^{-1}) were 11.0 (-30 cm, treatment 1, December), 14.2 (-60 cm, treatment 3, September) and 12.0 (-90 cm, treatment 3, September). The salinity minima were 1.3 (-30 cm, treatment 3, June), 5.8 (-60 cm, treatment 1, October) and 5.0 (-90 cm, treatment 1, August). Deeper in the root zone (-60 to -90 cm), the minimum salinity values recorded during 2008 were significantly less (approximately one half) at site 1 than at site 3. Salinity maxima at treatment site 3 were also consistently greater at these depths. In both cases, this pattern is reversed at the shallower levels (-30 cm).

All data collected along the vine row at each treatment site is presented in Figures 3-6. Soil salt content is consistently less at -30 cm than at greater depths.

Treatment 1

During June at site 1, salinity at -30 cm was significantly less than at -60 and -90 cm, which were similar at this time. Through to early spring, ECsw at -30 and -90 cm increased gradually and decreased at -60 cm. Post the leaching irrigation, salinity at -60 cm and -90 cm decreased slightly and increased significantly at -30 cm. Salinity at all depths then increased through to the summer months, when data collection ceased due to a lack of sufficient soil moisture. This pattern was similar in the 2008 data; however in the absence of a September leaching irrigation, a greater spike in ECsw can be observed around August and September. Both years recorded similar ECsw values at -60 cm during October, and ECsw was less in 2008 at -30 cm and greater at -90 cm.

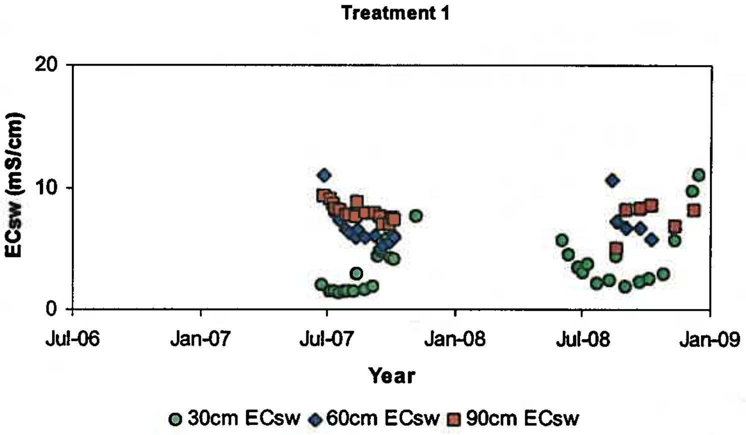

Figure 3 Soil water salinity (ECsw) data obtained from three depths between mid 2007 and Jan 2009 from site 1..

Treatment 2

Data at site 2 were collected between June and November 2007. During this time, salinity at -30 cm was less than at greater depths through the root zone. Unlike the data collected at treatment site 1 (where a clear distinction can be observed), salt content of the soil water at treatment site 2 was very similar at -60 and -90 cm during this time. ECsw at all depths decreased after the September leaching irrigation. The difference between salinity values at -30 cm and those at greater depths was also more significant at treatment site 2 than treatment site 1. Average salinity values at site 2 were greater at all depths than those recorded at the previous site.

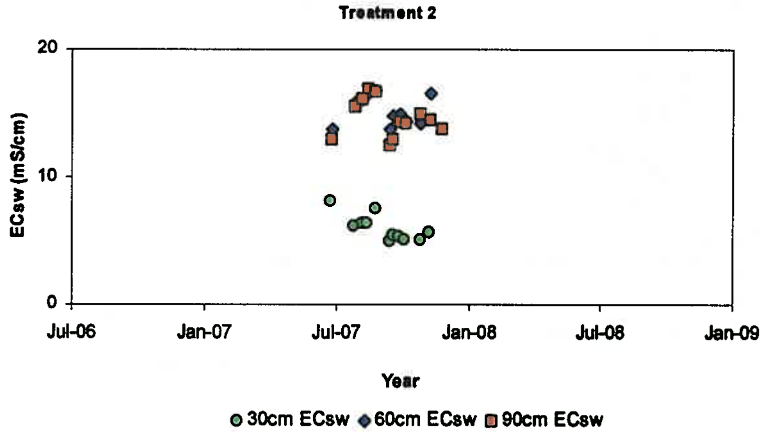

Figure 4 Soil water salinity (ECsw) data obtained from three depths between mid 2007 and Jan 2009 from treatment site 2.

Treatment 3

Similar to site 2, the ECsw values recorded at site 3 were greater than those recorded at the first treatment site. Salinity values at -30 cm were consistently less than those at -60 and -90 cm, which once again recorded very similar values up until later October, where the ECsw at -90 cm was greater than at -60 cm. This pattern continued until data collection ceased during late November. During 2008, the highest salinity readings at this site were recorded at -60 cm; however very little data at depths greater than 30 cm was available during this period. Salinity values recorded at -60 and -90 cm were similar to those recorded at site 2, whereas the data collected at -30 cm was greater at treatment site 3. The difference between the salinity at -30 cm and at greater depths was slightly less (<1.0 $mS.cm^{-1}$) at treatment site 3 than at site 2.

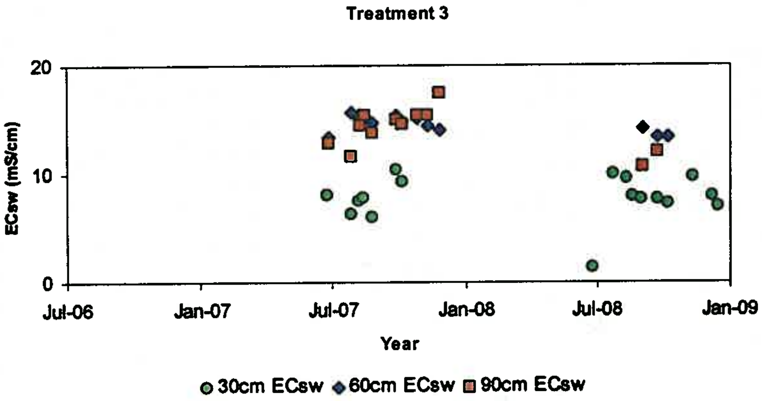

Figure 5 Soil water salinity (ECsw) data obtained from three depths between mid 2007 and Jan 2009 from treatment site 3.

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Treatment 4

The salinity of the soil water at treatment site 4 had a greater range of values than those from the previous three sites. At -30 and -60 cm, the values recorded were less than those at site 3; however the data obtained from -90 cm were more saline than at the other sites (up to 20 $mS.cm^{-1}$). At site 4, soil water salinity clearly increased with depth through the soil profile, accumulating at the bottom of the root zone.

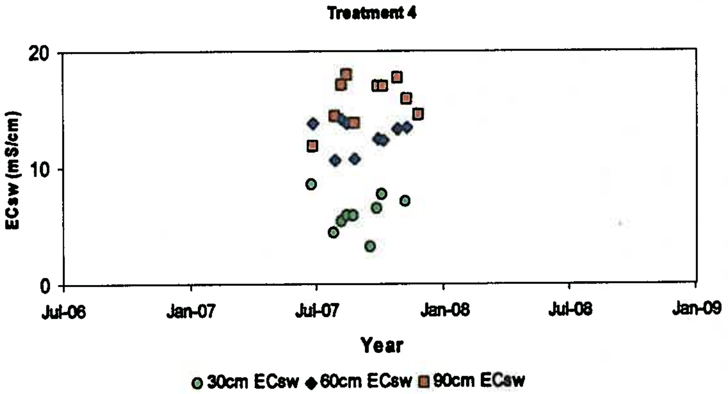

Figure 2 Soil water salinity (ECsw) data obtained from three depths between mid 2007 and Jan 2009 from treatment site 4..

While data collection at most sites was limited due to low soil moisture contents during the warmer months, it is evident from the above figures that, for the soil type and site under investigation, applying mulch to a site otherwise receiving an identical irrigation treatment to an adjacent site may result in elevated soil water salt contents.

Mid row

Soil water salinity data collected along the mid row during 2007 are shown in Table 3.

Table 3 Soil water salinity (ECsw) from each treatment site along the mid row, recorded between 24 June 2007 – 25 November 2007

Treatment number	SoluSAMPLER Depth (cm)	Max ECsw (mS/cm)	Date recorded	Min ECsw (mS/cm)	Date recorded
1	-30	3.2	24-Jun-07	1.5	24-Aug-07
2	-30	4.4	6-Aug-07	3.4	24-Jun-07
3	-30	4.8	24-Aug-07	5.4	24-Jun-07
4	-30	2.9	24-Aug-07	1.3	26-Jul-07
1	-60	3.8	7-Aug-09	3.4	27-Jul-07
2	-60	10.6	25-Aug-07	7.3	25-Jun-07
3	-60	16.9	25-Aug-07	10.1	25-Jun-07
4	-60	10.3	27-Jul-07	7.3	25-Jun-07
1	-90	8.4	25-Jun-07	5.3	25-Aug-07
2	-90	21.0	25-Aug-07	18.5	7-Aug-07
3	-90	19.6	14-Aug-07	12.9	25-Jun-07
4	-90	18.0	25-Aug-07	9.3	27-Jul-07

The salinity maxima (mS.cm^{-1}) were 4.8 (-30 cm, site 4, August), 16.9 (-60 cm, site 3, August) and 21.0 (-90 cm, site 3, August). The salinity minima were 1.3 (-30 cm, treatment site 4, July), 3.4 (-60 cm, treatment site 1, July) and 5.3 (-90 cm, treatment site 1, August).

No data were collected after the September leaching irrigation at site 1 (Figure 7) therefore the impact of this additional irrigation on root zone salinity through the mid row could not determined.

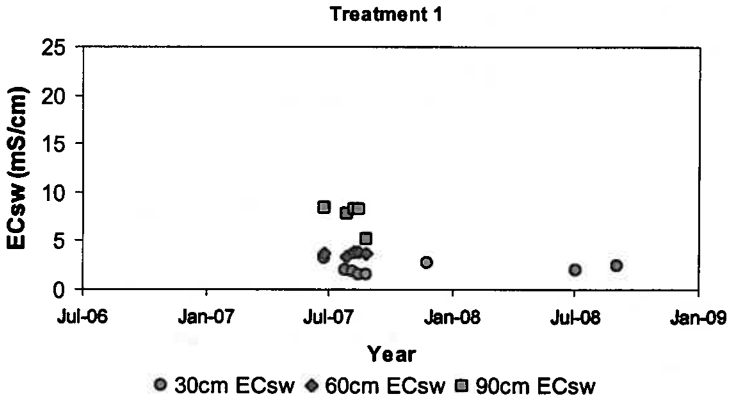

Figure 7 Soil water salinity (ECsw) data obtained along the mid row from three depths between mid 2007 and Jan 2009, from treatment site 1.

The addition of mulch (site 2) to the same irrigation application as site 1 resulted in an elevated soil salt content along the mid row similar to that observed in the vine row data (compare Figures 7 & 8). This may be the result of nutrients from the mulch leaching through the soil profile. Lower ECsw values at shallower depths may also be the result of mulch retaining moisture in the soil and reducing soil evaporation (Zurcher, 2008).

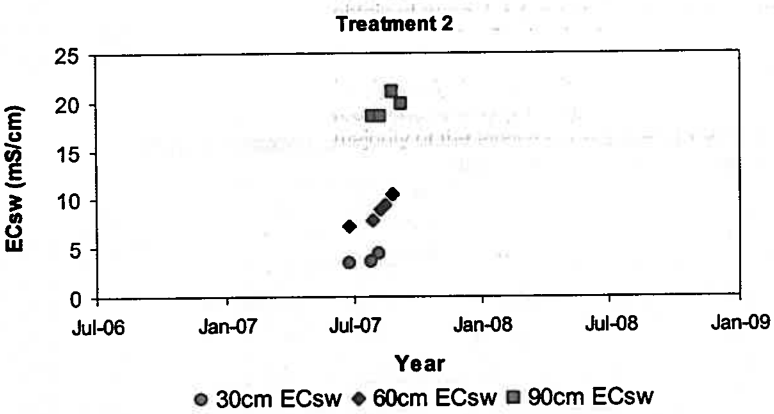

Figure 8 Soil water salinity (ECsw) data obtained along the mid row from three depths between mid 2007 and Jan 2009, from treatment site 2..

Data collected from along the mid row at site 3 (Figure 9) indicated that, similarly to the vine row data, the ECsw was lowest at -30 cm and values obtained from -60 and -90 cm are again relatively uniform.

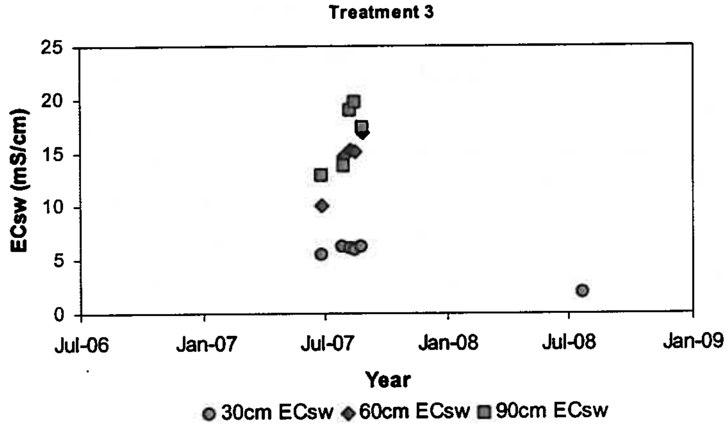

Figure 9 Soil water salinity (ECsw) data obtained along the mid row from three depths between mid 2007 and Jan 2009, from treatment site 3.

The -30 cm ECsw at site 4 was lower than at the previous site, and may be the result of reduced soil evaporation caused by the application of mulch. Unlike treatment site 3, the ECsw values at site 4 were significantly different between -60 and -90 cm. ECsw at -60 cm was much lower at site 4 than treatment site 3. Data obtained at -90 cm were similar for both sites.

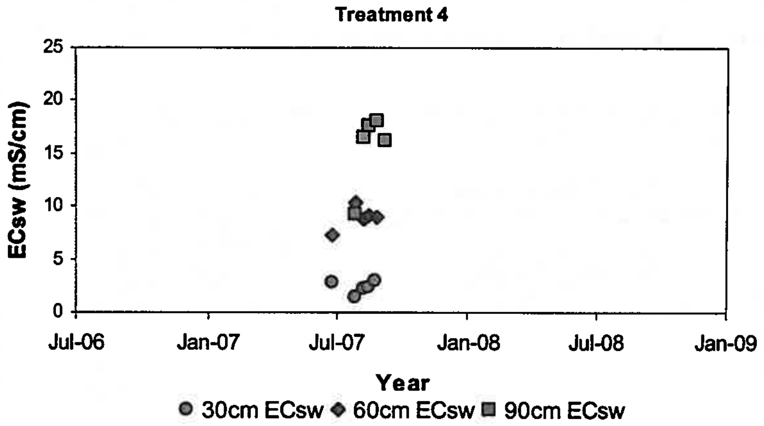

Figure 10 Soil water salinity (ECsw) data obtained along the mid row from three depths between mid 2007 and Jan 2009, from treatment site 4.

The data obtained from the trial suggest that the application of leaching irrigations may be more effective if undertaken during a period of higher soil moisture content, e.g. after the onset of winter rains, and during the period when the electrical conductivity of the irrigation water is also at its lowest. Due to the break down of the irrigation pump during the winter months of the Biswas et al trial, this was not able to be tested during the optimum time period; however the leaching irrigation applied during mid September still appeared to flush salts through the root zone more effectively than the post-harvest summer leaching irrigation.

Conclusions

Irrigating with high salinity water increases the risk of salt accumulation in the root zone. During the summer months, flows from the Finniss River are significantly reduced and the salinity of the river water increases. In an attempt to mitigate these salinity risks, monitoring was undertaken to determine the optimum time for the application of leaching irrigations, so as to flush salts in the soil and move them below the root zone. Soil water salinity (ECsw) data obtained from the site suggest that leaching irrigations are most effective when applied during periods of higher soil moisture content, and when irrigation water is least saline. Due to the breakdown of the irrigation pump during the winter months, this was not able to be tested during the desired period; however the data still show that a leaching irrigation applied during early spring is more effective at mobilising salts in the soil profile than traditional post harvest irrigations for the site under investigation. This report recommends that this trial be repeated during the mid winter months in order to better determine the influence of soil moisture and lower irrigation water EC on the movement of salts through the soil profile. The data obtained between treatment sites also suggest that the application of mulch will help to reduced soil water salinity in the upper regions of the soil profile; however the leaching of nutrients from the mulch may also contribute to higher salinity values deeper in the root zone.

The collection of soil data, such as saturated soil paste extracts, would also be useful for developing a salinity management strategy at the site, particularly during periods where the soil is too dry to monitor the site using solution extractors.

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Root Zone Salinity in Langhorne Creek

Executive Summary

The purpose of this report was to examine the influence of decreased irrigation water quality on salt accumulation in the vine root zone. Soil water salinity (ECsw) data obtained from a Langhorne Creek monitoring site during 2006-2009 were analysed to determine the spatial and temporal distributions of salt under the vines.

The main findings from the investigation were,

- The average salinity of irrigation water from Lake Alexandrina increased from 1.3 $mS.cm^{-1}$ during October 2006 to March 2007 to 3.1 $mS.cm^{-1}$ during October 2007 to March 2008.
- As the salinity of the irrigation water increased, the average soil water salinity between -30 and -90 cm under the vines also increased.
- Soil water salinity increased with depth through the soil profile.
- Between January 2006 and March 2009, the average ECsw at the site increased from 3.9 $mS.cm^{-1}$ to 7.5 $mS.cm^{-1}$.

During October 2008 to March 2009, Lake Alexandrina water was mixed with less saline water from other sources to mitigate root zone salinity risks. This report recommends that ongoing monitoring be undertaken at the site to determine the impacts of decreasing the irrigation water salinity on salt accumulation in the root zone.

Introduction

Root zone salinity management of irrigated vineyards is critical for plant yield and survival. Critical threshold salinity values for own rooted vines were established by Zhang et al (2002) using the electrical conductivity (EC) of saturated soil paste extracts (ECe). These values represent, as a guide, thresholds for maximum production and reduced yield levels.

Using measurements of ECe, root zone salinity values can be related to plant yield and performance. Where ongoing monitoring is required, suction cups can also be used to obtain soil water (ECsw) samples at more frequent intervals. The EC values obtained from soil water samples are representative of the salinity levels directly experienced by the plant roots. Previous studies have shown ECsw to be approximately twice the ECe in a range of sandy loam to silty clay loam field soils (Biswas *et al.* 2007; Biswas *et al.* 2008).

This study represents a preliminary analysis of ECsw data obtained from a monitoring site during the period 2006-2009. The purpose of the investigation was to determine the spatial and temporal distributions of salt under the vines as the salinity of the irrigation water increased.

Methods and Materials

A monitoring site was established in Langhorne Creek, South Australia on own rooted Cabernet Sauvignon vines. To examine the spatial and temporal accumulation of salt in the root zone, solution extractors (SoluSAMPLER™) were installed at 30, 60 and 90 cm depths within 15 cm of the dripper line at three locations under the vines, and analysed for ECsw. Soil type was loamy sand over loamy medium clay. The vines were irrigated with dam water pumped from Lake Alexandrina (average irrigation water quality = 1.3 $mS.cm^{-1}$) using conventional drip irrigation (CDI). The row under investigation was irrigated using conventional drip irrigation (CDI) at a flow rate of 2.0 $L.hr^{-1}$.The pump inlet was located 2.5 km west of Milang. When the water level dropped during late 2007, the channel was dredged further out into the lake. During late 2008 and 2009, the water from Lake Alexandria was mixed with water from other sources, including groundwater, to reduce the irrigation water salinity. Monitoring commenced on January 26, 2006.

Results

ECsw at all monitored depths, water quality, and the amount of irrigation water applied during 2006-2009 are presented in Figure 1.

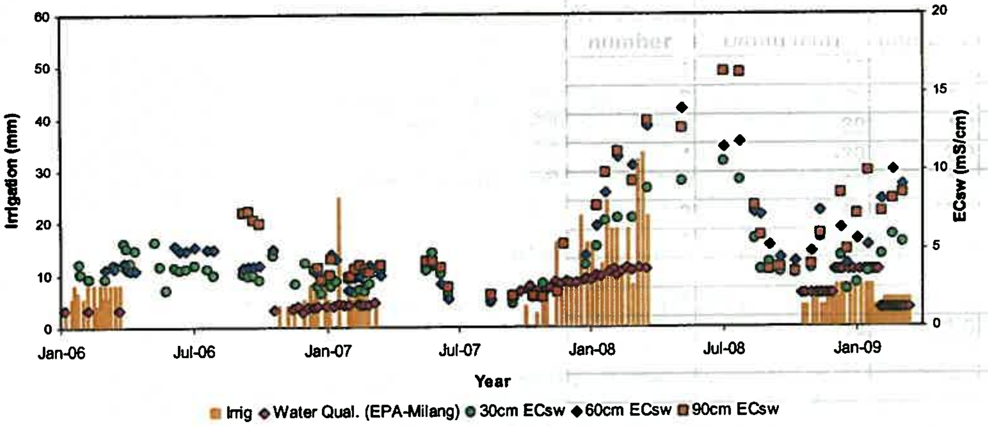

Figure 1 ECsw, irrigation and irrigation water quality data and ECsw at three depths from a Langhorne Creek vineyard, between January 2006 to March 2009.

From the onset of monitoring until late 2007, the salinity of the irrigation water remained constant (approximately 1.3 mS.cm^{-1}) (Figure 1). During late 2007, the water levels in Lake Alexandrina decreased significantly (see Figure 2), and consequently, the salinity of the irrigation water increased. The average irrigation water electrical conductivities (ECiw) for each irrigation period are shown in Table 1. The volume of irrigation water applied also increased during late 2007 due to rainfall deficiencies.

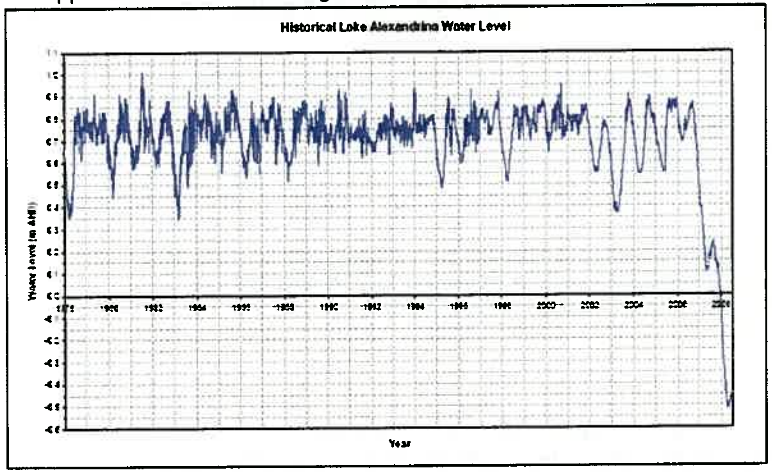

Figure 2 Historical Lake Alexandrina Water level data from 1978 to 2008
Source: Department of Water, Land and Biodiversity Conservation, 2010

Table 1 Average irrigation water electrical conductivity (ECiw) and average soil water salinity (ECsw) determined from ECsw measurements at 30, 60 and 90cm under the vines.

Irrigation period	Average irrigation water EC (mS/cm)	Average ECsw (mS/cm)
Jan-06 to Mar-06	1.1	3.9
Oct-06 to Mar-07	1.3	3.4
Oct-07 to Mar-08	3.1	6.2
Oct-07 to Mar-09 (1)	2.1	4.7
Oct-07 to Mar-09 (2)	3.6	5.4
Oct-07 to Mar-09 (3)	1.2	7.5

The data show that as the ECiw increased (average irrigation water salinity during late 2007-2008 = 3.1 mS.cm^{-1}) and the irrigation volume increased, the average root zone salinity calculated between -30 and -90 cm under the vines also increased rapidly (3.4 mS.cm^{-1} during 2006-2007 to 6.2 mS.cm^{-1} during 2007-2008). For the duration of the monitoring period, ECsw increased with depth through the soil profile. Peak ECsw values were observed during early July 2008, approximately 3.5 months after irrigation was complete. These peaks were followed by a rapid decrease in ECsw, most likely due to the onset of winter rains.

The irrigation water quality during the 2008-2009 irrigation period is shown in Figure 1 as three flat lines of water quality data points. During this time, the water pumped from Lake Alexandrina had become increasingly saline (EC = 5.5 mS.cm^{-1} as recorded in Milang by the Environmental Protection Agency on 09/01/2009), and was therefore combined with water from other sources, such as groundwater, to decrease the ECiw. Detailed information regarding these water sources was not available at the time this report was compiled. The irrigation water was mixed to three different water qualities during the 2008-2009 irrigation period, and are marked in Table 1 as EC values (1), (2) and (3). Average root zone salinity increased after irrigation commenced; however a significant decrease in ECsw at all depths can be observed during mid-January (18/01/2009) due to a large rainfall event (22.0 mm) on January 13. This event may have helped to flush salts through the soil profile, delaying the rate at which salt accumulation occurred. From December 1 2008 to January 29 2009, the EC of the irrigation water increased from 2.1 mS.cm^{-1} to 3.6 mS.cm^{-1}, resulting in ECsw increasing at all depths. From February 1 2009, the EC of the irrigation water was reduced to 1.2 mS.cm^{-1}. ECsw continued to rise at all depths until March 4 2009, where ECsw at -30 and -60 cm began to decrease. These initial decreases in electrical conductivity may have been the result of irrigation with less saline water; however monitoring ceased on this date, therefore no conclusive observations could be made. Between January 2006 and March 2009, the average ECsw at the Langhorne Creek site increased from 3.9 mS.cm^{-1} to 7.5 mS.cm^{-1}.

Conclusions

Due to the accumulation of salts in the vine root zone, precision (drip) irrigation of vineyards with saline water poses potential risks to plant productivity and survival. In recent years, the water quality and quantity of Lake Alexandrina has decreased significantly, therefore careful monitoring of sites irrigated with Lake Alexandrina water must be undertaken in order to mitigate salinity risks. ECsw, water quality and irrigation data from a Langhorne Creek monitoring site suggest that a decrease in irrigation water quality is contributing to increased soil water salinity. Attempts to mitigate this increase have included the mixing of irrigation water from a number of different sources; however further monitoring at the site must be undertaken before the impact of this method can be determined.

Resources

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