Soil salinity in drip irrigated vineyards of the MIA

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in a nutshell

- A study of drip irrigation in MIA vineyards was undertaken to assess the build-up of soil salinity
- At all vineyards it was found that salt concentrations in the root zone were below vine tolerance thresholds of 1.5 dS/m
- The results also showed that the salt concentrations in soils under drip irrigation actually tended to decrease with time, especially in between the rows – the inter-row area that was no longer watered
- It would appear that there is little danger of salt accumulation in the root zone in this context, probably due to the low salinity of the irrigation water source in the MIA (between 0.05 to 0.15 dS/m) and the potential for leaching by rainfall

In most perennial horticultural irrigation regions world-wide there is a transition from flood/furrow irrigation to drip irrigation. This is also true for the Murrumbidgee Irrigation Area.

The transition to 'high-tech' irrigation systems has been ongoing for some decades but there is now added impetus by recent initiatives for irrigators to implement high-tech systems in return for their water savings, which can then be used for environmental purposes. Changing over to high-tech irrigation is a strategy used by irrigators to assist in achieving higher water use efficiency, higher quality crop production and reducing environmental impacts such as surface runoff and deep percolation.

As farmers across the MIA strive to use less water and increase their water use efficiency by implementing drip irrigation systems, there is growing concern that salts may be accumulating in these soils. In arid zones of California there is recent evidence that salts are accumulating in the soils of orchards with drip irrigation. Salt accumulation under drip irrigation has also been documented in other semi-arid to arid regions of the world, namely Israel, Egypt and Saudi Arabia.

The potential problem of salt accumulation in soils under drip irrigation comes about through salt entering the root zone of plants and accumulating there, due to the low water application rates of drip irrigation systems. These salts can have detrimental effects on crop growth and yield, and research has shown that grapevines are moderately sensitive to salinity, with yield loss occurring from 1.5 dS/m and above; and up to 10% yield loss when salinity is 2.5 dS/m (ECe) or above.

Assessing salinity risk in the MIA

A study was carried out to determine the extent of salt accumulation in six drip irrigated vineyards in the MIA. The vineyards were sampled during the month of July 2004.

The vineyards chosen were those that had been using drip irrigation for between nine and eleven years, and one for four years. It was assumed that the vineyards using drip irrigation for nine years and more would have had enough time to develop a soil salinity distribution that reflected the water application using drip irrigation. The four years of drip irrigation vineyard was chosen as one that would be partially toward developing a salt distribution that reflected the drip irrigation. Table 1 describes the characteristics of the vineyards. Three of the six vineyards (numbers 2, 3 and 4) were also chosen because there was historical soil salinity data associated with them. This historical data was then used for comparison with current soil salinity data.

At each of the six vineyards the farmer was asked to locate a site with normal or above average growth and a site of reduced growth. At each of these sites, soil samples were taken along the vine row, ie under the dripper line, and in between the vine rows, ie into the inter-row area (Figure 1). Each soil core was taken to a depth of 80 cm (and divided into increments), as it was anticipated that the roots would not grow much deeper in these soil types, under the drip irrigation.

Salinity distribution

Salinity distribution along the row

Analysis of the soil cores from along the vine row showed that 10 of the 12 sites had a soil salinity less than 1.5 dS/m (the threshold for no yield loss) and 11 had salinity less than 2.5 dS/m (the threshold for 10% yield loss).

Figure 2 shows typical sections where the soil salinity was below the yield loss threshold. The soil salinity is uniformly low to a depth of 80 cm. There is a slight tendency of higher soil salinity halfway between emitters but the salinity is still below threshold levels.

Figure 3 shows the site with the highest salinity levels. Even at this most saline site, the top 40 cm of soil had salinity lower than the threshold level. This site, is vineyard 3 which had only been under drip irrigation for four years and had been a vineyard for only six years, previously being used for rice. Thus, this site is unlikely to yet have come to a new equilibrium with the changed irrigation conditions.

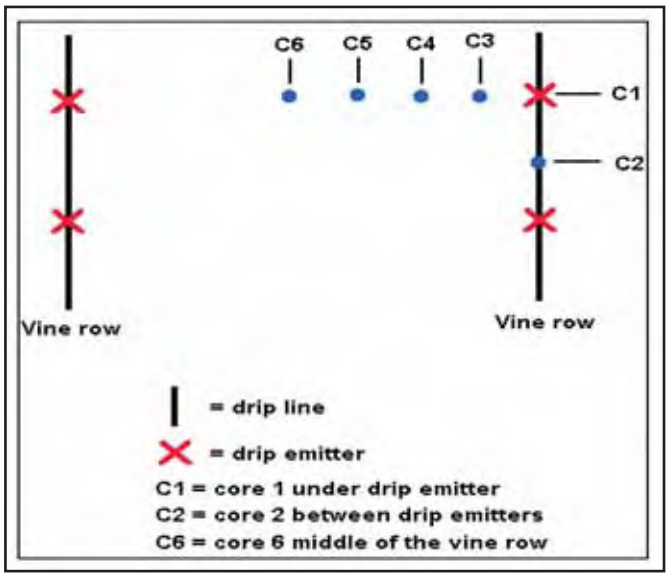

Figure 1: Plan view of soil sampling points at each site. The distance from C1 to C6 in between the vine rows was 160 cm, and cores along the vine row were at 40 cm increments.

Table 1: General information about the six vineyard sites sampled for soil salinity

Farm No.	1	2	3	4	5	6
Soil type	Loam	Clay loam	Clay loam	Medium clay	Loam	Loam
Years of drip irrigation	10	9	4	10	10	11
Emitter rate (l/h)	4.6	unknown	2.7	3	2.8	3.8 & 3.75
Emitter spacing (mm)	750	600	750	750	600	600
Grape variety	Black Shiraz	Black Siraz	Semillon	Chardonnay	Chardonnay	Semillon & Shiraz
Subsurface drainage	Y	Y	N	N	N	N
Site history	Long history of horticulture with flood/ furrow	Long history of horticultre with flood/ furrow	Previously rice, then 2 years furrow	Previously rice, vineyard established with drip irrigation	Previously non irrigated vineyard established with drip irrigation	Previously rice, vineyard established with drip irrigation

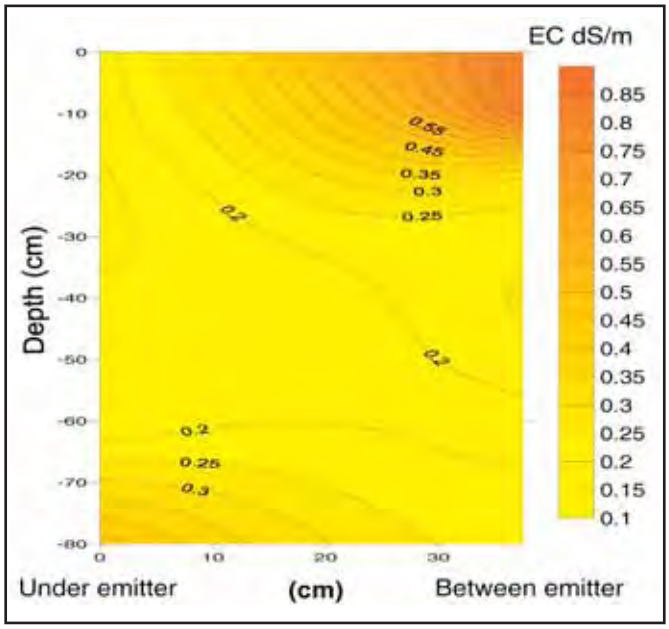

Figure 2: A site showing typical low soil salinity (ECe) along the vine row (Vineyard 1)

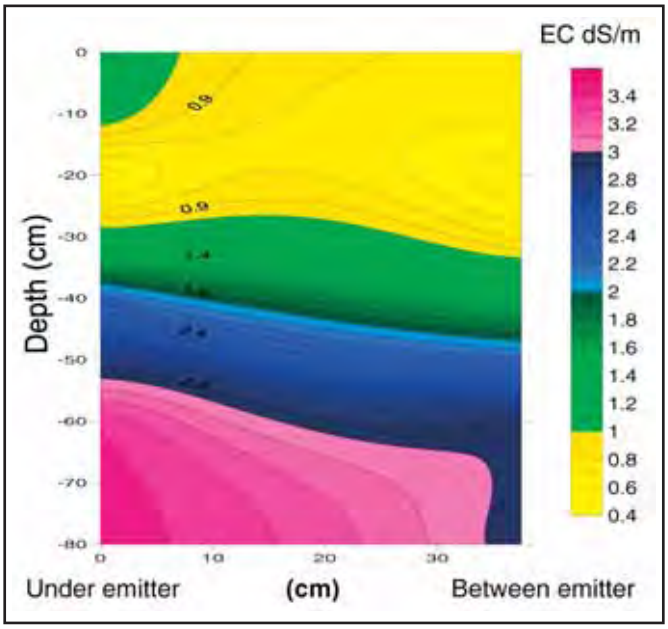

Figure 3: Highest soil salinity (ECe) measured along the vine row (Vineyard 3)

Salinity distribution into the middle of rows

Soil salinity distribution perpendicular to the vine row was much more variable than the salinity level and distribution along the row.

Of the 12 sites, seven showed what could be described as a uniformly low salinity across the section, an example is shown in Figure 4.

Of the other sites where there were higher salinities, the zone near the drip emitter was always below the threshold level. Sometimes this zone extended to depth, at other sites there was salinity at depth. Those sites that had low salinity below the emitter to the sampled depth of 80 cm were found to have increased salinity at around 60–100 cm away from the vine row exceeding threshold levels, examples of these salt distributions are shown in Figure 5.

Of the other sites where salinities were higher, there was one where the salinity appeared to increase uniformly with depth across the section (Figure 6).

In the other high salinity sites there were three that showed only a small zone of low salinity soil around the emitter with soil salinities increasing both with depth and perpendicularly away from the row, an example is shown in Figure 7. These three sites would have the most restricted rooting area of low salinity soil.

Mid row salinity changes 1996–2004

The mid row soil sampling regime in this study followed that of another study undertaken eight years previously in vineyards 2, 3 and 4. A comparison of the soil salinities is shown in Table 2. It can be seen that the mid row salinities have reduced dramatically over those eight years. The soil salinity in vineyard 3 has changed less than vineyards 2 and 4, as it has only been under drip irrigation for four years as compared with nine and ten years for vineyards 2 and 4 respectively.

Salinity low under drip irrigation

The soil salinity at the 12 sites could be broadly classified into:

- eight where soil salinity is uniformly well below levels likely to affect grapevines
- two with small areas of soil salinity above threshold levels
- two with large areas above potential salinity levels.

However, even at the most saline sites soil salinity was less than the threshold level directly under the drip emitter, at least to a depth of 50 cm and at least 25 cm away from the drip emitter into the middle of the vine rows. Hence in reality none of the vineyards are experiencing any adverse effects from soil salinity. The two sites with highest salinities had been under drip irrigation for the shortest time (four years) and hence are probably still in a transitional phase.

The six vineyards were chosen because they had been using drip irrigation for at least four years and it was anticipated

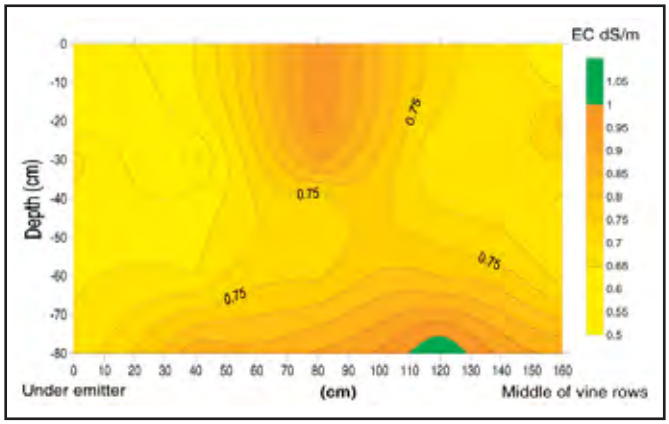

Figure 4: Uniformly low soil salinity (ECe) measured along a transect perpendicular to vine row (Vineyard 2)

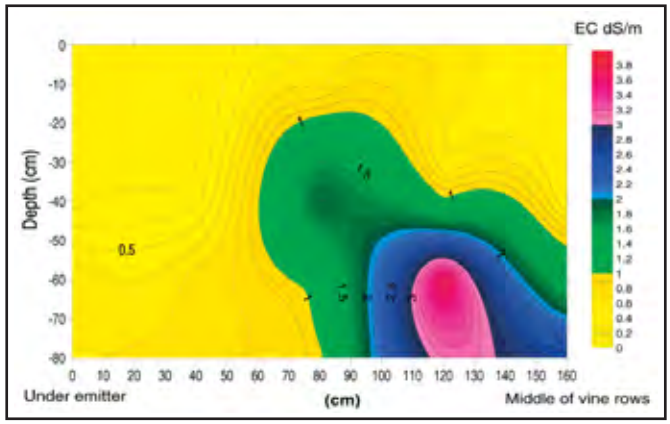

Figure 5: Low soil salinity under the row (ECe) to 80 cm, but increasing soil salinity away from the vine row, (Vineyard 4)

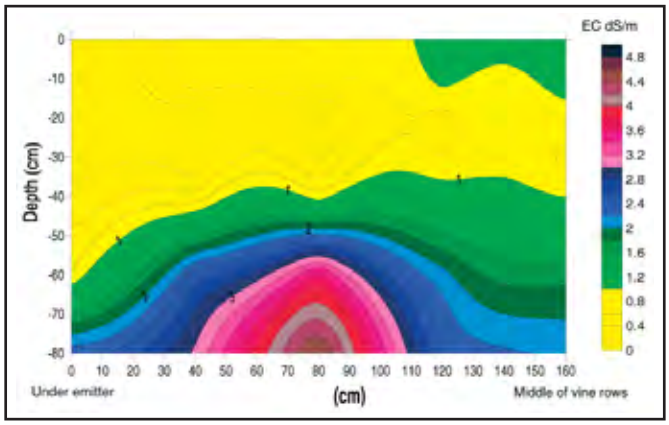

Figure 6: Increasing soil salinity (ECe) relatively uniformly with depth perpendicular to the row (Vineyard 6)

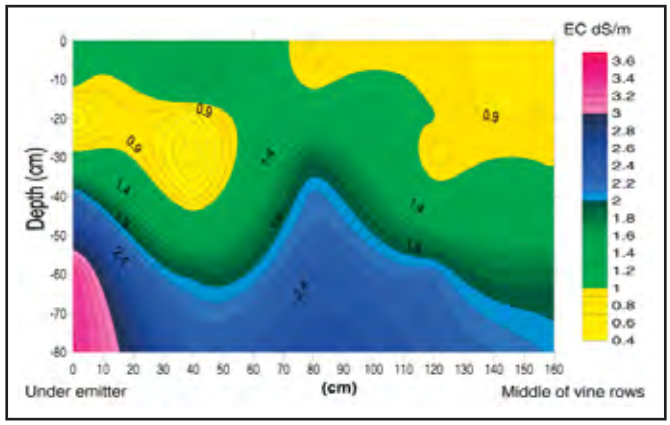

Figure 7: Increasing soil salinity (ECe) with depth, and perpendicular to the vine row (Vineyard 3)

that this would minimise any effects of previous irrigations methods on salt accumulation and distribution in the soil.

However, it appears that previous irrigation methods may have had an influence on the current salt distributions throughout the soil profiles.

Both vineyards 1 and 2 had a long history of horticulture with flood/furrow irrigation prior to drip irrigation installation in 1994–95. At vineyard 2 the salt concentrations were below 1 dS/m throughout the soil profile and the salt concentrations at vineyard 2 increased slightly with depth and away from the drip emitter. This is in contrast to the soil salinity results found at vineyards 3 and 6, where higher salt concentrations were evident in the surface soil layers as well as at depth. Both vineyards have had a history of rice farming prior to drip irrigation installation and the higher salt concentrations and wider distributions of salts exceeding 2 dS/m may be a remnant of the previous farming practice.

The four vineyards sampled in 1996 showed a decrease in soil salinity in the inter-row area in 2004. This decrease in soil salinity was in the range to 0.5–2.0 dS/m and occurred to the maximum sampling depth of 70 cm.

This positive result of decreased soil salinity in drip irrigated vineyards in the MIA is probably attributed to a number of factors.

- The quality of the irrigation water in the MIA is very good, ranging from 0.05 to 0.15 dS/m; this is in contrast to other arid zone irrigation areas of the world, where the salinity of the irrigation water ranges from 0.4–2 dS/m.
- The relatively low soil salinities in these soils prior to drip irrigation being implemented.
- There is sufficient rainfall, annual average 410 mm for leaching to occur.

...in conclusion

Several conclusions can be drawn from this study.

- Vineyards that had been drip irrigated for between four and eleven years did not show any hazardous build up of soil salinity in the root zone.
- Inter-row salinity had decreased to the sampling depth of 70 cm on farms that had been sampled in 1996 and again in 2004. This indicates that leaching by rainfall had occurred.
- Drip irrigation with high quality water (0.05–0.15 dS/m) in the MIA is unlikely to result in hazardous accumulation of soil salinity.

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Further information

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Table 2: Average soil salinity ECe (dS/m) in between the vine rows in 1996 and 2004

Sampling depth (cm below surface)	Vineyard 2			Vineyard 3			Vineyard 4		
	1996	2004	change	1996	2004	change	1996	2004	change
-5	1.16	0.54	-0.62	0.88	0.80	-0.08	1.82	0.68	-1.14
-15	2.4	0.60	-1.80	0.87	0.94	+0.07	1.77	0.50	-1.27
-25	3.14	0.46	-2.68	1.32	0.84	-0.48	1.58	0.43	-1.15
-35	3.04	0.42	-2.62	1.60	1.01	-0.59	1.58	0.42	-1.16
-50	2.66	0.65	-2.01	1.91	1.47	-0.44	1.65	1.04	-0.61
-70	2.37	0.72	-1.65	1.87	1.60	-0.27	1.60	1.69	+0.09