# Soil physical degradation due to drip irrigation in vineyards:

# Evidence and implications

Thesis submitted by

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This work is dedicated to Ian Parsons, Jim Scholfield and Tom Scholfield:

Three custodians of the land.

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# Abstract

Drip irrigation is the most common method of water application used in Australian vineyards. However it places physical and chemical stress upon soil structure, which may affect soil physical properties, soil water availability and grapevine functioning. Common soil types within Australian vineyards appear vulnerable to soil degradation and there is emerging evidence of such degradation occurring.

Two South Australian vineyards (one located at Nuriootpa in the Barossa Valley, the other in the McLaren Vale winegrowing region) were used to examine evidence of altered soil physical properties due to irrigation. Significantly higher soil strength and lower permeability was found under or near the dripper in irrigated soils. There was also evidence that irrigation increased subsoil bulk density at Nuriootpa. It was uncertain how irrigation caused these changes. While sodicity was present at Nuriootpa, it appeared the physical pressures exerted by irrigation, such as rapid wetting and prolonged wetness, also contributed.

To gauge the severity of the degradation at Nuriootpa, a modelling study assessed the impact of higher soil strength and salinity on grapevine transpiration. The SWAP model (Soil-Water-Atmosphere-Plant) was modified and then calibrated using soil moisture data from Nuriootpa. Simulations were conducted for different irrigation regimes and the model output indicated that degradation led to a reduction in cumulative transpiration, which was almost entirely due to higher soil strength. However the reduction was relatively minor and there was evidence of water extraction by roots in all soil layers. Hence the degradation, in terms of higher soil strength and salinity, was not considered a significant management problem in the short-term. Evidence of increased waterlogging and its consequences require further investigation.

Roots were observed in soils at Nuriootpa with penetration resistance (*PR*) much greater than 2 MPa, which was thought to completely impede grapevine root growth. It was hypothesised that roots avoided the physically hostile matrix by using biopores or structural cracks. A pot experiment tested this hypothesis and examined the relationship between soil strength, biopores and root growth for grapevines. Grapevine rootlings (cv. Cabernet Sauvignon) were grown into pots with varying degrees of soil compaction, with and without artificial biopores. No root growth occurred when $PR > 2$ MPa unless biopores were present. Pores also improved root growth in non-compacted soil when *PR* approached 1 MPa, which

suggested biopores influence root growth in soils regardless of compaction levels. Therefore *PR* should not be the only tool used to examine the rooting-potential of a vineyard soil. An assessment of soil structure, such as biopore density and size, should be incorporated.

In drip-irrigated vineyards, there is a possibility that degraded clayey subsoils could be ameliorated by manipulating zones of soil drying. At distances away from the dripper, drying events could generate shrinkage cracks that improve drainage and provide opportunities for root growth. From a practical perspective, drying events could be manipulated by moving the dripper laterally or by changing the irrigation frequency and intensity. The potential of this simple, non-invasive, ameliorative approach was investigated. Large, intact cores were sampled from Nuriootpa subsoil where degradation had been identified. Individual core bulk density was calculated using a formula that was derived by solving two common soil physics equations simultaneously. This proved to be an accurate and non-invasive method. Half the cores were leached with a calcium solution, and the saturated hydraulic conductivity ($K_s$) was measured on all cores before and after drying to a matric potential of –1500 kPa. Soil drying led to a significant increase in $K_s$, which indicated an improvement in structure through the creation of shrinkage cracks and heaving. Calcium treatment had no impact on $K_s$, but that could change with more wetting and drying cycles. Results indicated the need for further investigation in the field, where different compressive and tensile forces operate. Harnessing this mechanism may provide an attractive soil management option for growers.

The soil physical degradation identified is concerning for sustainable production in irrigated vineyards. Given the sites were representative of typical irrigation practices, such degradation may be widespread. While modelling suggested the impact of higher soil strength and salinity was minimal, these properties should be monitored because they may worsen with continuing irrigation. Furthermore, the impact of irrigation on subsoil permeability needs to be defined more accurately. An increased incidence of waterlogging could significantly restrict production, which was evident when overly wet growing seasons were modelled. If subsoil permeability was found to be significantly lower in irrigated soils, amelioration may be required. In this instance, the use of drying events to generate structure provides an option. Ultimately, the impact of drip irrigation on soil physical quality warrants further attention, and it is imperative to monitor the physical quality of vineyard soils to ensure sustainable production.

# Statement

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

I give consent to this copy of my thesis, when deposited in the University Library, being made available in all forms of media, now or hereafter known.

Signed: ……. Date:……

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# Publications arising from the thesis

At the time of writing, the following article describing work in this thesis has been submitted for publication:

Currie, D.R., C.D. Grant, R.S. Murray and M.G. McCarthy (2007). The impact of drip irrigation on soil physical properties in vineyards. *Australian Journal of Soil Research*. (under review).

Seminars and other presentations:

Currie, D.R., C.D. Grant, R.S. Murray, M.G. McCarthy (2004) Has drip irrigation affected soil physical properties in vineyards? Barossa Viticultural Group Technical Seminar, Tanunda, November 2004. Oral.

Currie, D.R., C.D. Grant, R.S. Murray, M.G. McCarthy (2004) Soil structural degradation in irrigated viticulture. Third Australian/New Zealand Soils Conference, Sydney, December 2004. Oral.

Currie, D.R., C.D. Grant, R.S. Murray, M.G. McCarthy (2005) Has drip irrigation degraded soil physical properties? CRCV Symposium, Mildura, June 2005. Oral.

Currie, D.R. (2005) Drip irrigation can degrade soil structure. Murray Valley Growers' Fieldwalks, Mildura, October 2005. Oral.

Currie, D.R., C.D. Grant, R.S. Murray, M.G. McCarthy (2006) Does drip irrigation degrade soil structure in vineyards. 18th World Congress of Soil Science, Philadelphia, July 2006. Poster.

Currie, D.R., C.D. Grant, R.S. Murray, M.G. McCarthy (2006) Drip irrigation can degrade soil structure in vineyards: evidence and implications. 5th International Symposium on Irrigation of Horticultural Crops, Mildura, August 2006. Oral.

Currie, D.R., C.D. Grant, R.S. Murray, M.G. McCarthy (2006) The potential of soil drying events to ameliorate degraded, clayey subsoils in vineyards: a laboratory investigation. National Soils Conference, Adelaide, December 2006. Poster.