Subsoil hydraulic conditions in drip-irrigated vineyards

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Abstract

In order to assess soil structural changes under irrigation in drip-irrigated vineyards, we have measured water infiltration rates at the boundary of topsoil and subsoil (30-60cm) at 78 points in 10 established (>5 years) vineyards in South Australia, mainly concentrated on texture-contrast soils in the Barossa Valley. A rapid, simple technique was developed for the preparation of subsoil surfaces suitable for reliable infiltration measurement with a CSIRO disc permeameter. The measured infiltration rates were in the range 0.015 - 480 mm/hour (4×10^{-9} - 1×10^{-4} ms^{-1}). Over all measurements, 72% were below 10 mm/hour and 37% were below 1 mm/hour. These values are sufficiently low to ensure intermittent to persistent waterlogging, consequent aeration problems for plant growth and poor leaching of salts. Measurements made directly beneath drippers were compared either with those made half-way between well-spaced (≥2m) drippers or else with those made at external, non-irrigated control points. No compelling evidence of systematic soil structural decline under drippers was found.

Introduction

Good water infiltration into soil is essential for soil conservation, adequate leaching of accumulated salts and the avoidance of aeration problems in irrigated production. This is an important issue in fine-textured soils and also in texture-contrast soils where infiltration is frequently restricted at the boundary between a clay subsoil and a sandier topsoil. Irrigation has the capacity to degrade soil structure (Murray and Grant, 2007) either because of prolonged soil wetness (Cockroft and Olsson, 2000) or because of applications of saline water alternating with water of good quality (i.e. rain) (Clark, 2004). There is some concern that even in precision irrigated production, where irrigation is focussed on small areas, application intensities are deceptively high (up to thousands of mm/year) and also that water quality may be poor. In order to assess soil structural changes under irrigation in drip-irrigated vineyards, we have measured water infiltration rates at the boundary of topsoil and subsoil at 78 points in 10 established (>5 years) vineyards in South Australia, mainly concentrated on texture-contrast soils in the Barossa Valley.

location	easting	northing	soil	observation depth (cm)	year est.
Waite Campus, Urrbrae	138°38.0’	-34°58.0’	Red brown earth	40	2002
Research Rd., Stockwell	139°02.3’	-34°24.9’	Deep loamy texture contrast soil	23-40	1998
Basedow Rd., Tanunda	138°58.6’	-34°31.5’	Hard red-brown texture contrast soil	35	1989
Basedow Rd., Tanunda	138°58.5’	-34°31.6’	Cracking Clay soil	40	1994
Belvidere Rd., Ebenezer	139°00.4’	-34°25.5’	Sand over clay	45	1972
Branson Rd., Greenock	138°55.4’	-34°26.5’	Hard red-brown texture contrast soil	35-50	1977
Radford Rd., Angaston	139°02.7’	-34°31.1’	Hard red-brown texture contrast soil	42	1981
Biscay Rd., Bethany	138°57.6’	-34°32.7’	Cracking Clay soil	35	1982
Currency Creek	138°49.5’	-35°24.4’	Gradational loamy sand over light clay	35	2002
Nuriootpa	139°00.3’	-34°28.5’	Red Brown Earth	40	1992

Table 1: *Study site location and information*

Methods: Study sites were excavated by hand to the texture-contrast boundary, or to 35-40 cm in the absence of a boundary, and the bottom of the hole was levelled. If necessary, the subsoil surface was allowed to dry until it was no longer in a pronounced plastic state. This surface was then grooved to about 5-10 mm depth along regular lines with a long, sharp blade and new “fracture surfaces” were created by tilting the blade; debris was removed with a vacuum. This approach appeared to cause minimal smearing and distortion of the soil macropores that are frequently responsible for most water movement (Figure 1).

Figure 1: *A subsoil surface prepared for infiltration measurements; macropores and roots are clearly visible.*

For each measurement, the sorptive phase of infiltration was recorded and the final infiltration rate was measured (after at least 24 hours) with a CSIRO disc permeameter designed for ponded measurements. Measurements were made using a "paired site" approach, either directly under drippers and between drippers (separated by ≥2 metres) or else directly under drippers and at nearby, external, non-irrigated control sites either at the nearest, untrafficked point within each vineyard or else just outside the vineyard.

Results: Measured infiltration rates (Figure 2) were in the range 0.015–480 mm/hour (4×10^{-9} - 1×10^{-4} ms^{-1}). Over all measurements, 72% were below 10 mm/hour and 37% were below 1 mm/hour.

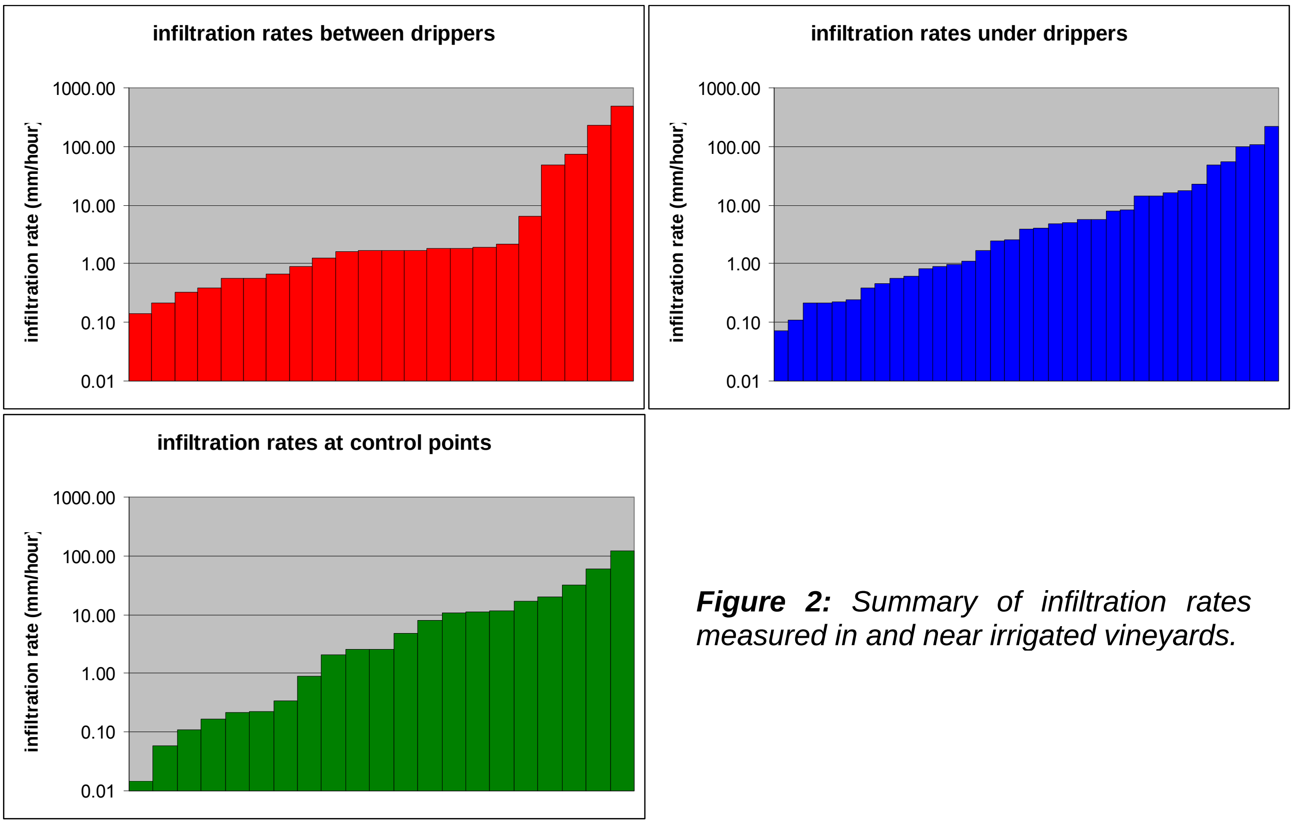

Figure 2: *Summary of infiltration rates measured in and near irrigated vineyards.*

The overall distributions of infiltration rates directly under drippers, between drippers and at non-irrigated control sites (Table 2) were not substantially different.

	<0.1 mm/hour	<1 mm/hour	<10 mm/hour	<100 mm/hour
between drippers	0%	36%	82%	91%
under drippers	3%	38%	62%	91%
non-irrigated control	10%	37%	71%	95%

Table 2: *Overall distribution of measured infiltration rates.*

In most cases, infiltration rates between drippers were similar to paired measurements made directly beneath an adjacent dripper (Figure 3a). However, in about one third of cases, they were substantially larger. This may have been due to inferior soil structure under drippers or to blockage of macropores by vine roots.

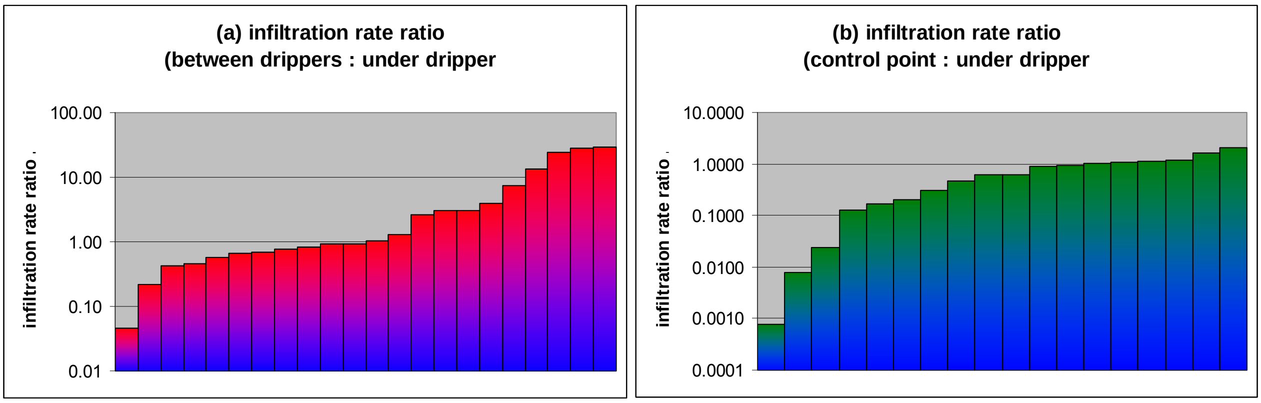

Figure 3: *Infiltration rates between drippers and at control points expressed as a ratio to that directly under a nearby dripper.*

Infiltration rates at control points were often considerably less than under nearby drippers (Figure 3b). Control points were non-irrigated, either bare or under weeds, and were either un-ripped or else ripped during vineyard establishment; there were no clear trends with these variables.

Conclusions

The infiltration rates measured at these sites are sufficiently low to ensure intermittent to persistent waterlogging, consequent aeration problems for plant growth and poor leaching of salts. However, there is little evidence here that these relatively “hostile” subsoil conditions have been created by irrigation. Indeed, compared to the control points, infiltration rates under drippers may have benefited from relict vine root channels at depth but until root length density and other soil structural data are available, no conclusions can be drawn.

Most of the soils at these sites are also known to have poor air-filled porosities (<5%) and high penetration resistances (>2 MPa) at field capacity; both of these effectively reduce available water. This concurs with our common visual observation of roots growing laterally at the texture boundary. The generally poor structural condition of most of these subsoils seems to indicate a need for far better establishment procedures (e.g. better ripping and mounding) and management practices (e.g. deep-rooted cover crops) to promote larger root volumes with potential long term improvements in water and nutrient use efficiency.

References

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