

**EFFECT OF POLYACRYLAMIDES ON THE
PHYSICAL PROPERTIES OF SOME LIGHT-
TEXTURED SOILS**

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Summary

The work presented in this thesis represents a combination of laboratory and field experiments designed to explain some field observations I made on some coarse sands in South Australia in 1999: that much of the irrigation water and nutrients applied to the sands under drip-irrigation simply passed through the root zone leaving the crops water-stressed shortly after irrigation events. There was clearly only minimal lateral spread of the water in these coarse sands. However, by applying small concentrations of polyacrylamide or 'PAM' in the irrigation water, the crops seemed to do better. Furthermore the timing of irrigation events appeared to be more flexible on the PAM-treated properties. I found this intriguing and saw an opportunity to increase the lateral spread of water in the root zone and thereby increasing the stored volume and residence time of water. By retaining more water in the rootzone, there was potential to save a considerable amount of costly irrigation water, and also improve crop production and quality. With encouragement from my then employer (Elders Pty Ltd) and from Ciba Specialty Chemicals Australia, I undertook to explore my findings in greater detail and to attempt to explain them based on some 'hard' (experimental) evidence.

Increasing the lateral spread of water under drippers in coarse-textured soils requires water to be retained in the root zone for longer periods during irrigation, but the practical methods for doing this are limited to:

- Altering the pore size distribution to create a finer average range of pore sizes, either by compaction or by stabilization of smaller pores using organic matter or additions of clay.
- Reducing the wettability of the soil so that less water can be taken in and the soil never becomes saturated. (This of course risks surface runoff and suboptimal placement of irrigation water).
- Altering the physical properties of irrigation water (eg. viscosity, surface tension) so that it interacts differently with soil pores and moves through them more slowly.

The aim of the research was therefore to evaluate the potential for some commercially available PAMs to reduce hydraulic conductivity and to increase water retention on some drip-irrigated coarse sandy soils of South Australia and Victoria.

I worked with two commonly available anionic polyacrylamides, designated PAM-1011 and PAM-135, and measured ponded infiltration in laboratory columns of seven different sandy soils from around South Australia and Victoria. I varied the concentration of the polymer within the range typically used in the field (0, 1 and 10 ppm for PAM-1011; 0, 2.5 and 25 ppm for PAM-135) and I also varied the quality of the irrigation water used to mix the PAM solutions in terms of salinity and sodicity (distilled water, 10 and 20 mmol(+) salt/L, using either sodium chloride, calcium chloride, or both). I measured the effects of PAM on pore-size distribution of one of the sands (by the water retention characteristic), on water repellence of the soils (by measuring water droplet penetration times), and the kinematic viscosity of the PAM solutions at various concentrations with various qualities of irrigation water. I also set up transparent cases of sand to observe infiltration and wetting behaviour of the PAM solution. Finally, with some understanding of how the physical and chemical properties of the PAMs, I conducted a field trial to measure the soil water matric potential at various depths and locations around drippers in vine rows receiving PAM in the irrigation water.

Laboratory findings

The polymer PAM-1011 significantly reduced the steady-state infiltration rate in all sands, and it did this with relatively modest concentrations (< 10 ppm). The polyacrylamide PAM-135 was not effective for this purpose, which indicated that the chemical properties of the polymer (not investigated here) influenced its physical behaviour. Further work with PAM-135 was therefore discontinued in favour of PAM-1011.

The effectiveness of PAM-1011 in reducing steady-state infiltration rates was related to changes in the properties of the irrigating solution caused by PAM-1011 rather than by a change in the properties of the soils to which it is applied. For example, PAM-1011 had only minimal (if any) influence on the pore size distribution (water

retention) of a coarse sandy soil and had no significant impact on water repellence (wettability) of another sandy soil. It did, however, have a large impact on the kinematic viscosity of the irrigating solution, and the more PAM-1011 that was dissolved, the more viscous the solutions became.

The effectiveness of PAM-1011 in reducing steady-state infiltration rates was reduced in salty irrigation water, and there was evidence to suggest that cation-effects may have been involved. When PAM-1011 was dissolved in distilled water, infiltration rates were reduced by the greatest amount. When PAM-1011 was dissolved in salty water containing the monovalent cation, sodium, infiltration rates were not reduced as much; furthermore, if the solvent water contained the divalent cation, calcium, PAM-1011 was even less effective than in sodium-rich water. Thus electrolytes affected the physical conformation of PAM-1011 solutions, altering viscosity. To overcome the salt-water effects, higher concentrations of PAM-1011 needed to be used.

The cation-effects were primarily related to the way each cation interacted with the polymer to alter its kinematic viscosity. PAM-1011 in distilled water had the greatest viscosity, while PAM-1011 in sodium-rich water had a lower viscosity, and PAM-1011 in calcium-rich water had the lowest viscosity. A practical implication from this is that irrigators using salty waters will need to dissolve more PAM-1011 in their water-sources to increase the viscosity and thus gain the retarding effects of the polymer on infiltration rates. The data suggest that the amount of polymer required to overcome the salt effects is about 10 ppm PAM-1011. Rates as low as 1 ppm can be used when irrigators have access to high-quality water with < 10 mmol(+) salt/L present. Visual observations of the wetting fronts during infiltration showed that irrigation water containing PAM-1011 at between 1 and 10 ppm reduced the depth of percolation and increased its lateral spread in coarse sands.

Field study

The field work was largely unsuccessful because shortly after the treatments were applied, a 1-in-100 year hailstorm struck that completely wiped out the vegetation on

the vines in the study. I spent most of the season simply trying to keep the vines alive and to recover some of the leaf area for future years.

Overall, however, this work identified the ability of PAM-1011 to reduce water movement through the root zone of coarse sands, and demonstrates the potential to conserve a great deal of water – a significant move toward higher water- and nutrient-use efficiencies on the coarser textured soils in the Murray-Darling Basin.

Declaration

I declare that this thesis contains no material that has been accepted for the award of any other degree or diploma in any university and to the best of my knowledge and belief contains no material previously published or written by another person, except where due reference is made in the text.

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

Signed _____ Date 08/08/2007

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As a part time external student the journey to completion has been a long and slow one. The journey itself would have been impossible without the support of many people who have provided me with invaluable support over the time frame.

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To Cameron Grant and Rob Murray, I am unsure if two better supervisors exist. The positive criticism and continual encouragement along the way was always appreciated. To write on the impact that these two people have had on me, words would probably be inadequate. However from a farming perspective I am a better grower than I was before meeting both Cam and Rob. The thesis was as much about applied mentoring and as such I am eternally grateful for their input into my development.

And to my wife who will no longer have to cringe when people ask her what I am interested in, the journey has come to a close.

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Appendix

Raw infiltration data (on CD)

Appendix

NOTE: Raw infiltration data is available on the CD held with the print copy of the thesis in the University of Adelaide Library.

It is also included with the digital thesis as PDF files.