Effects of long-term subsurface drip irrigation on soil structure

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ABSTRACT

A study was conducted to examine the changes in soil chemical and physical properties. Testing of the soil chemical and physical properties was conducted on a seven-year old SDI system, laid in Wunnamurra Clay soil in the MIA. The site was planted with processing tomatoes, rockmelons and onions on permanent beds spaced at 1.8m. The preliminary investigations showed a change through the bed in soil colour but not in bulk density. This study has determined changes in clay content, cation levels and the pore space around emitters as a result of SDI. These changes could have inhibited the movement of water by altering soil hydraulic properties and reducing the spread of the irrigation wetting-front.

Key words

Subsurface drip irrigation, SDI, soil structure.

INTRODUCTION

Irrigators using subsurface drip irrigation (SDI) systems in the Murrumbidgee Irrigation Area (MIA) are concerned that lateral and vertical-upward water movement decline over several years of irrigation. Researchers of NSW Agriculture had previously examined the site studied in this paper, upon request by the owner, who had observed a decreased in lateral water distribution from the SDI system. They have excavated soil around the SDI emitter and observed a change in soil colour. They collected soil samples and recorded bulk densities throughout the site. However, a reasonable explanation to the problem based on bulk density could not be found and further investigation recommended (Hickey, pers.comm.1999).

This study was designed to determine the long-term SDI factors that may affect the soil’s structure and hydraulic properties. It was hypothesised that the soil chemical and physical properties around the emitter have changed over time resulting in poor subsurface water distribution. This hypothesis was tested by comparing physical and chemical properties of soil just around the emitter with the soil located furthest in the bed from the emitter in the non irrigated region (NIR).

MATERIALS AND METHODS

Six trenches were excavated around randomly selected emitters. The emitters were located 30, 60 , 90, 120, 150 and 180 meters from the downstream (eastern) ends of the laterals and 3 laterals (5.7m) between each trench in a north-south direction. Soil samples were gouged out of each trench face and collected as presented in Figure 1.

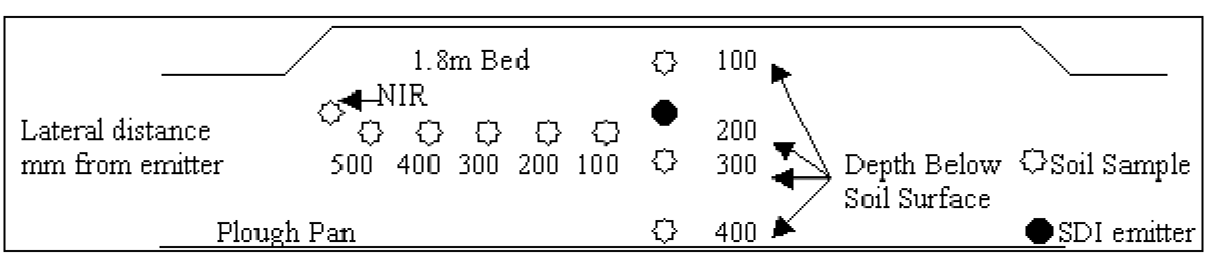

Figure 1. Location of soil samples.

Six soil samples were taken across the bed from the emitter to the shoulder (including a sample at emitter) and three more samples vertically. Another soil sample (NIR) was collected at the bed shoulder perpendicular to the mid point between the examined emitter and the next along the lateral (Figure 1). All the soil samples were collected along a transect in a plane perpendicular to the emitter, except the NIR sample. The soil samples were composites of 100mm increment, e.g. soil sample at 100mm was soil between 50 and 150mm. The treatments of this experiment are 10 positions relative to the emitter and the replicates are the 6 trenches.

The chemical tests undertaken were the to determine the soil's ionic composition (Al, Ca, Mg, Na, K), pH and electrical conductivity at all the sampling points. The physical tests conducted were the Emmerson[1] aggregate test, hanging column pore size distribution and the hydrometer particle size analysis[3] at the emitter and the NIR.

Results and Discussion

The results indicate salt ions leached with high quality water around the emitter in a lateral direction to approximately 350mm. The soil's cation exchange capacity (CEC) is lowest at the emitter and highest around 350mm in a lateral direction. In a vertical direction, the CEC decreases with depth to the emitter and then increases with depth passed the emitter. Soil pH was lowest at the emitter (5.26) and highest 350mm in a lateral direction (6.5), most likely due to the application of mineralised fertilisers, leaching of nitrate nitrogen and system flushing. A combination of these factors along with water logging around the emitter could have reduced the organic content of the soil, which will change the soil's colour and restrict root development. Results of a two way ANOVA[2] indicate the level of significance and trends in the soil across the bed are presented in Table 1.

Table 1: Effect of distance from the emitter on soil chemical properties.

Test Results	Statistical Significance of Sample Variance	Emitter Average	NIR Average	Max. Value and Location Relative to the Emitter
CEC	$P \leq 0.06$	24.45	26.52	26.52 – 350mm & NIR
ESP	$P \leq 0.005$	2.32%	3.03%	3.26% - 350mm
Ca/Mg	$P \leq 0.14$	1.29	1.35.	1.35 – NIR

The qualitative Emmerson dispersion test showed a little slaking but no significant dispersion of the soil either at the emitter, so too at the NIR with possibly greater slaking than at the emitter. This increased slaking at the NIR is most likely due to the higher exchangeable sodium percentage (ESP).

The particle size analysis indicated that the clay content (61.5%) of the soil around the emitter was significantly less than the clay content (65.7%) in the soil within the NIR with a 93% ($P \leq 0.07$) confidence level (C.L.) for a two tail t-test. The clay may have become buoyant and migrated from around the emitter through the profile. The chemical test shows a "bulge" of cations located 350mm from the emitter. This appears to be a result of the additional clay particles accumulating in this region. Such a zone may inhibit water movement away from the emitter in the long-term due to macro-pore blockage with translocated fines.

The hanging column test showed a gravimetric moisture content at the emitter when compared to the NIR indicating a greater percentage of pore space. A two tail t-test showed no significant difference in the pore percentage until the C.L. was reduced to 70% ($P \leq 0.3$). However, the result trend indicates a greater percentage of pores at the emitters (34.4%) than at the NIR (33.9%), possibly due to the movement of fines blocking some of the macro-pores.

Conclusion

The examined soil factors were indicators of soil chemical and physical properties that may have an effect on soil hydraulic properties. Over at least five years of irrigation, increasing clay content, ESP, Ca/Mg ratio with respect to distance from the emitter has had negative effects on the soil's ability to spread water away from the emitter. As the high quality water leaves the emitter it has:

- translocated fine soil particles and decreased lateral water movement
- lowered concentration of ions (Na, K, Ca, Mg, Al) at the emitter decreasing hydraulic conductivity due to decreased flocculation exaggerated by the application of high quality water

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